# SESSIONAL PAPERS

## VOLUME 19

## FIRST SESSION OF THE TWELFTH PARLIAMENT

OF THE

# DOMINION OF CANADA

## SESSION 1911-12

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**10*b*.** Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1911. (Part III.—Canadian Trade). Presented by Hon. Mr. Foster, 25th March, 1912.. .. .. .. .. .. .. .. .. ..*Printed for distribution and sessional papers.*

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**10*f*.** Report of Trade and Commerce for fiscal year ended 31st March, 1911. (Part VII.—Trade of Foreign Countries, Treaties and Conventions). Presented by Hon. Mr. Foster.. .. .. .. .. .. .. .. .. .. .. ..*Printed for distribution and sessional papers.*

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**40*a*.** Copy of Order in Council, dated 7th August, 1911, *re* "Consolidated Allowance in lieu of Lodging, Provisions, Fuel, Light, &c., for the Naval Service of Canada." Presented 29th November, 1911 by Hon. Mr. Hazen.. .. .. .. .. .. .. .. .. ..*Not printed.*

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**40*d*.** Return to an Address to His Royal Highness the Governor General of the 29th November, 1911, for a copy of all Correspondence between His Majesty's Government in Canada and His Majesty's Government in England, subsequent to the last Imperial Conference, concerning the Naval Service of Canada, or in any way connected with it. Presented 15th February, 1912.—*Mr. Lemieux.*
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**40*e*.** Copy of Order in Council P.C., 16/168, dated 27th January, 1912, *re* Daily Rates of Pay and allowances for Bandsmen in the Royal Canadian Navy.—(*Senate*).
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**40*g*.** Copy of Order in Council P.C., 16/168 dated 27th January, 1912, *re* Daily Rates of Pay and Allowances for Bandsmen in the Royal Canadian Navy. Presented 27 February, 1912, by Hon. Mr. Hazen.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

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**58.** Statement of Expenditure as bounty to deep-sea fishermen for the year 1910-11, pursuant to Chapter 46 of the Revised Statutes of Canada, 1906, intituled: "An Act to encourage the development of the Sea Fisheries and the building of Fishing Vessels." Presented 5th December, 1911.—*Hon. Mr. Hazen*.. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**59.** Communication from the Right Honourable Baron Strathcona and Mount Royal, G.C.M.G., &c., on the subject of cheaper transmission of press cablegrams, &c.—(*Sessional papers*). Presented 7th December, 1911.—*Hon. Mr. Borden.*
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**60.** Report of the Commissioner, Dominion Police Force, for the year 1911. Presented 10th January, 1912.—*Hon. Mr. Doherty*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**61.** Return to an Order of the House of the 27th February, 1911, showing all Statutes, regulations, reports and proceedings in the courts of the United States or in the counts of any of the respective States, and all other documents, papers and information of every kind touching or concerning the methods and operations of the meat trust and other trusts and combines in the United States, and touching the results both to the producer and to the consumer of such methods and operations, including all departmental proceedings and reports and other proceedings and reports of the Government of the United States or of any department thereof with respect to the matters aforesaid, and in general all available information in respect to the operations of such trusts and combines in the United States. Presented, 10th January, 1912.—*Mr. Meighen*.. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Printed for sessional papers.*

**62.** Return to an Order of the House of the 29th November, 1911, for a copy of all papers, letters, telegrams, and other documents in connection with the acceptance of a tender of the McDiarmid Company, Limited, for the construction of the Moosejaw public building, and the cessation of all construction thereof. Presented 10th January, 1912.—*Mr. Knowles*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**62*a*.** Return to an Order of the House of the 29th November, 1911, for a copy of all papers, telegrams, reports and other documents in connection with the proposed erection of a public building in the town of Aurora. Presented 10th January, 1912.—*Mr. Armstrong (York)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**63.** Return to an Order of the House of the 30th December, 1911, for a detailed statement of the expenses incurred and paid for the Exposition at Paris in 1900, under the title of payments of the Colonial Committee for space, &c., $87,000 (*See* report of the Auditor General, 1899,D—15). Presented 10th January, 1912.—*Mr. Paquet.*
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**64.** Return to an Order of the House of the 6th December, 1911, showing the expenditure for printing pamphlets, circulars and literature with a view to promoting immigration to Canada during each of the years from and including 1900 to 1911; and the expenditure in the interests of each province for printing pamphlets, circulars and literature entirely devoted to each province during each of the years from and including the year 1900 to 1911; and also, whether the printing was done by contract or under what arrangement and the rate charged. Presented 10th January, 1912.—*Mr. Sutherland*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

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**64a.** Return to an Address to His Royal Highness the Governor General of the 30th November, 1911, for a copy of all Orders in Council and other papers relating to the appointment of Arthur Hawkes as a special commissioner in the immigration branch of the Interior Department. Presented 10th January, 1912.—*Mr. Oliver*... .. ..*Not printed.*

**65.** Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 21st December, 1911, appointing Messieurs Alfred Bishop Morine, Guillaume Narcise Ducharme and Richard Stuart Lake, a Royal Commission to investigate and inquire into the operation of the various departments of the government, with a view to securing increased efficiency and a more thorough organization and co-ordination in the said departments. Presented 10th January, 1912.—*Rt. Hon. Mr. Borden*.. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**65.** Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 29th January, 1912, relative to the appointment of two commissioners, namely: Mr. F. C. Gutelius, C.E., of Montreal, and Mr. George Lynch Staunton, K.C., of Hamilton, to investigate all matters bearing on the actual construction of the National Transcontinental Railway between Moncton and Winnipeg. Presented 6th February, 1912.—*Hon. Mr. Cochrane.* *Not printed.*

**65b.** Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 12th February, 1912, appointing the Hon. Sir William Ralph Meredith, Chief Justice of the Common Pleas Division of the High Court of Justice of Ontario, a commissioner to inquire into all the circumstances connected with the organization, management, operation and failure of the Farmer's Bank of Canada. Presented 13th February, 1912.—*Hon. Mr. White.* *Not printed.*

**66.** Return to an Order of the House of the 30th November, 1911, for a copy of all papers, telegrams, reports and other documents in connection with the interpretation and enforcement of the duties on lumber, together with a copy of all instructions or other communications addressed by circular or otherwise to Collectors of Customs, and a copy of any minute or minutes or rulings or decisions of the Board of Customs during the year 1911. Presented 10th January, 1912.—*Mr. Knowles*... ..*Not printed.*

**67.** Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 21st November, 1911, providing for the transfer of the Government Annuities Branch from the Department of Trade and Commerce to the Post Office Department. Presented 10th January, 1912.—*Hon. Mr. Pelletier*... .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**68.** Return relating to lands sold by the Canadian Pacific Railway Company during the year which ended the 1st October, 1911. Presented 11th January, 1912.—*Hon. Mr. Rogers*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**68a.** Return under the provisions of Section 8 of 49 Victoria, Chapter 9, being a list of lands in the "Irrigation Block" of the Canadian Pacific Railway Company in the province of Alberta, sold by that company during the year which ended on the 1st October, 1911. Presented 13th March, 1912.. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**68b.** Return under the provisions of Section 8 of 49 Victoria, Chapter 9, being a list of lands in the province of Alberta, sold by the Canadian Pacific Railway Company during the year which ended on the 1st October, 1911. Presented 13th March, 1912. *Not printed.*

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*Not printed.*

**72*d*.** Return to an Address to His Royal Highness the Governor General of the 4th December, 1911, for a copy of all papers, correspondence and Orders in Council in connection with the awarding of the contract for the building of the Transcontinental Railway Station at Quebec, and all orders suspending work on the same. Presented 15th January, 1912.—*Sir Wilfrid Laurier.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**72*e*.** Statement of work done on the National Transcontinental Railway—Eastern Division—to 31st December, 1911, and estimate of cost of completion. Presented 16th February, 1912—*Hon. Mr. Cochrane.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**72*f*.** Return to an Order of the House of the 5th February, 1912, for a copy of all documents and of all the correspondence exchanged between A. E. Doucet, district engineer, on district B of the Transcontinental Railway, and of all other persons, relating to the selection of sites for railway stations in the parishes of St. Damien and St. Cajetan d'Armagh, in the county of Bellechasse. Presented, 18th March, 1912.—*Hon. Mr. Cochrane.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**72*g*.** Return to an Address to His Royal Highness the Governor General of the 31st January, 1912, for a copy of all minutes of proceedings, records, orders, instructions or other writings made and had, or given or authorized to be made, had or given by the Board of National Transcontinental Railway Commissioners, from the date of the appointment of Mr. R. W. Leonard, as a member of the said Board and chairman thereof, to the present date; also of all letters, telegrams, instructions or other documents made or had or passed, since the said appointment, by and between the Minister of Railways and Canals, or other members of the government, or by any person by authority of the government, and the said Chairman of the Board of National Transcontinental Railway Commissioners, or the Secretary of said Board; also of any Orders in Council relating to the appointment of an asistant chairman or an assistant to the chairman of said Board, together with a copy of all letters, papers, instructions or documents relating thereto; as well as a statement of all payments of monies in the way of salaries or compensation made to the incumbent of the office of assistant chairman or assistant to the chairman of said Board, and of all papers, letters or instructions made, written or received by the said minister or the said chairman, relating to or in any way connected with the payment or authorization of said salary or compensation. Presented 20th March, 1912.—*Hon. Mr. Cochrane.*
*Not printed.*

**72*h*.** Interim Report of the Commissioners of the Transcontinental Railway, being for the nine months ended 31st December, 1911. Presented 22nd March, 1912, by Hon. Mr. Cochrane.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**73.** Return to an Order of the House of Commons of the 29th November, 1911 (so far as the Department of Agriculture is concerned), for a copy of all letters, telegrams, memorials, resolutions and other documents in the hands of the government, or any department thereof, in connection with the taking of the census in the city of Regina, and all complaints and protests in connection with the same; also, all departmental instructions, memoranda, reports and other documents. Presented 15th January, 1912.—*Mr. Knowles.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

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**79e.** Return to an Address to His Royal Highness the Governor General of the 5th February, 1912, for a copy of all letters, complaints, charges, telegrams, petitions, memorials, Orders in Council or other documents in the possession or under control of the government, relating to the dismissal of William A. Hattie, from the position of Preventive Officer at Mulgrave, Nova Scotia, and relating to the appointment of a man to fill the vacancy caused by such dismissal. Presented 12th February, 1912.—*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79f.** Return to an Order of the House of the 31st January, 1912, for a copy of all letters, complaints, telegrams, evidence, reports, or other papers, relating to charges against Robert Leithead, James Blair, Duncan Gillis and Calvin McKenzie, all employees of the Intercolonial Railway in the county of Pictou, for partizanship and to the investigation of said charges. Presented 14th February, 1912.—*Mr. Macdonald*..*Not printed.*

**79g.** Return to an Order of the House of the 24th January, for a copy of all letters, telegrams and all other documents, and of all complaints and charges, in any way relating to the suspension of Joseph Venoit, checker on the Intercolonial Railway at Pictou, Nova Scotia. Presented 14th February, 1912.—*Mr. Macdonald*...*Not printed.*

**79h.** Return to an Order of the House of the 7th February, 1912, for a copy of all charges, letters, and other documents relating to complaints against John Connolly, of New Glasgow, coal inspector, for partizanship, the evidence taken in the investigation before H. P. Duchemin, and all other papers in connection therewith. Presented 14th February, 1912.—*Mr. Macdonald*.. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79i.** Return to an Order of the House of the 5th February, 1912, for a copy of all letters, telegrams, petitions, complaints, charges or other documents in the possession of the Department of Customs relating to the dismissal of S. M. Ferguson, Preventive Officer at Oyster Ponds, county of Guysborough, Nova Scotia, and relating to an appointment of a man to fill the vacancy cause by such dismissal. Presented 19th February, 1912. —*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79j.** Return to an Order of the House of the 22nd January, 1912, for a copy of all correspondence, letters, telegrams or other documents relating to the dismissal of P. J. Veniot, Collector of Custotms at Bathurst, New Brunswick, and the appointment either permanent or temporary of his successor. Presented 19th February, 1912.—*Mr. Turgeon*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79k.** Return to an Order of the House of the 12th February, 1912, for a copy of all letters, telegrams, petitions, charges, complaints, reports and other documents relating to the dismissal of Luke Day, (of the Department of Public Works), of North Sydney, Cape Breton. Presented 19th February, 1912.—*Mr. McKenzie*.. .. .. ..*Not printed.*

**79l.** Return to an Order of the House of the 5th February, 1912, for a copy of all correspondence addressed to the Minister of Public Works in connection with the dismissal of George T. Harbour, superintendent of the work at the deep water wharf at Gaspé. Presented 22nd February, 1912.—*Mr. Lemieux*.. .. .. .. .. .. .. .. .. ..*Not printed.*

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## CONTENTS OF VOLUME 24—*Continued.*

**79v.** Return to an Order of the House of the 19th February, 1912, for a copy of all correspondence, petitions, complaints, charges or other documents in the possession of the Marine and Fisheries Department relating to the dismissal of David S. Hendsbee from the position of weigher at the Reduction Works at Canso, Nova Scotia. Presented 4th March, 1912.—*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79w.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports, recommendations and evidence taken under investigation by Dr. Shurtleff, relating to the dismissal of Anson Sheltus, of St. Armand Station, county of Missisquoi, a Preventive Officer of the Customs Department. Presented 5th March, 1912.—*Mr. Kay*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79x.** Return to an Order of the Senate dated the 30th January, 1912, calling for copies of all letters, papers or other documents in the hands of the government relating to the proposed removal of John Park, postmaster at Orangeville, Ontario.—(*Senate.*)

**79y.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports, telegrams, recommendation and memoranda relating to the dismissal of James McPhee as Customs Officer at West Bay, Nova Scotia, and the appointment of a successor. Presented 6th March, 1912.—*Mr. Chisholm (Inverness)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79z.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports, recommendations and memoranda relating to the dismissal of Allan Kennedy as General Government Telegraph Repairer, Inverness county, and the appointment of his successor. Presented 7th March, 1912.—*Mr. Chisholm (Inverness)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79aa.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports and recommendations relating to the dismissal of Wenceslas Lebel, of Kamouraska, as preventive officer of the Customs Department. Presented 12th March, 1912.—*Mr. Lapointe (Kamouraska)*.. .. .. .. ..*Not printed.*

**79bb.** Return to an Order of the House of the 4th March, 1912, for a copy of all letters, complaints, charges and other documents connected with or giving any information as to the discharge of Thomas Hale, of Westville, Nova Scotia, as correspondent for the *Labour Gazette*. Presented 12th March, 1912.—*Mr. Macdonald*.. ..*Not printed.*

**79cc.** Return to an Order of the House of the 14th February, 1912, for a copy of all letters, petitions, charges, complaints and other documents in the possession of the government or any department thereof, relating to the dismissal of William A. Gerrior, customs preventive officer at Larry's River, N.S., and to the appointment of his successor. Presented 22nd March, 1912.—*Mr. Sinclair*.. .. .. .. .. .. ..*Not printed.*

**77dd.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports and recommendations relating to the dismissal of Auguste Hibert as postmaster at St. Pascal, county of Kamouraska. Presented 19th March, 1912.—*Mr. Lapointe (Kamouraska)*.. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79ee.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports and recommendations relating to the dismissal of Luc Lizotte as postmaster at St. Pacome, county of Kamouraska. Presented 19th March, 1912.—*Mr. Lapointe (Kamouraska)*.. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79ff.** Return to an Order of the House of the 19th February, 1912, for a copy of all correspondence, petitions, complaints or other decuments in the possession of the Post Office Department, relating to the dismissal of Captain Alex. Roberts, postmaster at Canso, N.S., and the appointment of his successor. Presented 19th March, 1912.—*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

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## CONTENTS OF VOLUME 24—*Continued.*

**79*qq*.** Return to an Order of the House of the 24th January, 1912, for a copy of all letters, requests, petitions, telegrams, complaints or charges received by the Post Office Department since 10th October, 1911, relating to the postmaster at Glenelg, N.S. Presented 22nd March, 1912.—*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*rr*.** Return to an Order of the House of the 18th March, 1912, for a copy of all letters, telegrams, complaints and other documents, relating to charges against Jas. W. Matheson, I.C.R. trackman at Meadowville, Pictou county, N.S., of the evidence taken and other proceedings of the investigation held on said charges, the reports thereon and of all representations in regard to the case from the Brotherhood of Trackmen. Presented 22nd March, 1912.—*Mr. Macdonald*.. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*ss*.** Return to an Order of the House of the 26th February, 1912, for a copy of all letters, petitions, reports, charges or other documents in the possession of the Post Office Department relating to the dismissal of J.D. McFarlane, postmaster at Southwest Margaree, Nova Scotia, and the appointment of his successor. Presented 22nd March, 1912.—*Mr. Chisholm (Inverness)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*tt*.** Return to an Order of the House of the 4th March, 1912, for a copy of all papers and correspondence in connection with the removal of the postmaster at Rathburn, township of Mara, county of Ontario, and the change of the location of the post office at said point. Presented 22nd March, 1911.—*Mr. Pardee*.. .. .. .. .. ..*Not printed.*

**79*uu*.** Return to an Order of the House of the 6th March, 1912, for a copy of all papers, complaints, letters and other documents connected with or relating to the dismissal of John McLeod as postmaster at Denmark, Colchester county, N.S., and the appointment or suggested appointment of D. McLeod to the vacancy. Presented 22nd March, 1912—*Mr. Macdonald*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*vv*.** Return to an Order of the House of the 28th February, 1912, for a copy of all documents, letters, requests, reports and recommendations in the possession of the Post Office Department, relating to the dismissal of Doué Daoust, postmaster at Alfred, county of Prescott, and the appointment of his successor. Presented 22nd March, 1912.—*Mr. Proulx*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*ww*.** Return to an Order of the House of the 5th February, 1912, for a copy of all documents, papers, inquiries, letters, &c., relating to the dismissal of Thomas Dionne, as postmaster of Cacouna, also the dismissal of Miss Saindon, of Cacouna, and the reinstallation of the said Thomas Dionne in the post office at Cacouna. Presented 22nd March, 1912.—*Mr. Gauvreau*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*xx*.** Return to an Order of the House of the 7th February, 1912, for a copy of all documents, papers, petitions, recommendations, &c., relating to the request that was made to the Post Office Department for the dismissal of the postmaster at St. Anaclet, county of Rimouski. Presented 22nd March, 1912.—*Mr. Lapointe (Kamouraska)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*yy*.** Return to an Order of the House of the 13th March, 1912, for a copy of all letters, papers, documents, memoranda, telegrams and correspondence relating to the resignation of Donald E. McLean, late postmaster at Inverness, N.S. Presented 25th March, 1912.—*Mr. Chisholm (Inverness)*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**79*zz*.** Return to an Order of the House of the 26th February, 1912, for a Return showing the number of postmasters removed from office in Shefford county since the 1st October, 1911: their names, post office addresses, dates of dismissal, reasons therefor, name of complainant in each case, names of new postmaster appointed to replace them;

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CONTENTS OF VOLUME 24—*Continued.*

**79iii.** Return to an Order of the House of the 20th March, 1912, for a copy of all papers, telegrams, letters, petitions and affidavits, relating to the dismissal of George Bourgoin, employed as statistician on the Lachine canal, also of all letters exchanged between the Minister of Public Works and the Minister of Railways and Canals concerning said dismissal. Presented 28th March, 1912.—*Mr. Lemieux.. ..Not printed.*

**79jjj.** Return to an Order of the House of the 26th February, 1912, for a copy of all documents, letters, requests, reports and recommendations relating to the dismissal of Louis Dechesne, an employee of the Marine Department, on the river Ouelle wharf, county of Kamouraska. Presented 29th March, 1912.—*Mr. Lapointe.. ..Not printed.*

**79kkk.** Return to an Order of the House of the 18th March, 1912, for a copy of all charges against A. M. Hatfield, fishery overseer of the county of Yarmouth, N.S., and of all letters, telegrams, and any other communications between the Minister of Marine and Fisheries or any officer of his department, and any other person, having reference to the same, in relation to the appointment of Mr. Hatfield's successor. Presented 30th March, 1912.—*Mr. Law.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**79lll.** Return to an Order of the House of the 11th March, 1912, for a copy of all letters, requests, complaints, depositions, reports of inquiry and every other document whatsoever, relating to the dismissal of Mr. J. O. Dauphinais as postmaster of Sorel, county of Richelieu, and also of all letters, requests or other documents relating to the appointment of the new postmaster at Sorel. Presented 30th March, 1912.—*Mr. Cardin.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**79mmm.** Return to an Order of the House of the 11th March, 1912, for a copy of all documents, letters, papers, requests, inquiries and reports respecting the dismissal of Mr. Joseph Cloutier, postmaster of St. Adolphe de Dudswell. Presented 30th March, 1912. —*Mr. Tobin.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**80.** Return to an Order of the House of the 17th January, 1912, showing:—1. The quantity in tons of anthracite dust and Culm coal imported into Montreal during the year 1911. 2. The quantities of the same imported into other ports of the province of Quebec during the year 1911. 3. The duty collected on this product, if any, under the ruling of the Customs Department; the rate of duty and amount collected. 4. The value of said product as imported and entered at Montreal and the other ports. 5. The quantity in tons and the value of bituminous slack coal imported during the year 1911 into the port of Montreal and the various other ports, respectively, in the province of Quebec, and the duty collected thereon. Presented 25th January, 1912.—*Mr. Macdonald.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**81.** Return to an Order of the House of the 15th January, 1912, showing the quantities, the different kinds as far as practicable, and prices of all boots and shoes imported into Canada during each of the fiscal years ending respectively 31st March, 1908, 1909 and 1910, together with the several countries from which the same were imported, giving the quantities, &c., from each country for each year. Presented 2nd February, 1912.—*Mr. Carvell.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**82.** Return to an Address to His Royal Highness the Governor General of the 24th January, 1912, for a copy of all the correspondence between the Prime Minister of Canada, or any member of the Government, and Messieurs Fielding and Paterson, during the time the latter gentlemen were in Washington last year, on the subject of the negotiations for a Reciprocity Treaty between Canada and the United States. Presented 2nd February, 1912—*Mr. Bradbury.. .. ..Printed for distribution and sessional papers.*

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**82*a*.** Return to an Address to His Royal Highness the Governor General of the 24th January, 1912, for a copy of all correspondence from the 1st day of January, 1910, to the 1st October, 1911, between the Right Honourable James Bryce, British Ambassador at Washington, and the Government of Canada, or any member thereof with reference to the negotiations for Reciprocity Treaty between Canada and the United States. Presented February, 1912.—*Mr. Bradbury.*
*Printed for distribution and sessional papers.*

**83.** Return to an Address to His Royal Highness the Governor General of the 31st January, 1912, for a copy of the letters patent relating to the office of Governor General of Canada, of the Commission issued to the present Governor General, and of the instructions accompanying the same. Presented 2nd February, 1912.—*Mr. Macdonald.*
*Printed for sessional papers.*

**84.** Return to an Address to His Royal Highness the Governor General of the 22nd January, 1912, for a copy of the treaty between Great Britain, the United States and Russia for the suspension of pelagic sealing, and all correspondence regarding the same from the initial negotiations to the present day. Presented 5th February, 1912. —*Sir Wilfrid Laurier.. .. .. .. .. .. .. .. .. .. .. .. .. ..Printed for sessional papers.*

**85.** Return to an Order of the House of the 22nd January, 1912, showing whether the government or the Montreal Harbour Commission purchased any cement for its different works, from the 1st January, 1905, to the 21st September, 1911; if so, from whom purchased; the price paid, and were tenders called for before purchasing. Presented 5th February, 1912.—*Mr. Boulay.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed*

**86.** Copy Fifth Report of the Commission for the Demarcation of the Meridian of the 141st Degree of West Longitude.—*(Senate).. .. .. .. .. .. ..Printed for sessional papers*

**87.** Return to an order of the House of the 22nd January, 1912, showing:—1. How many farm labourers and domestic servants have been placed by each employment agent in Eastern Canada, or whom a commission has been paid, during each of the years 1907, 1908, 1909, 1910, 1911, and up to date in the month of January, 1912. 2. The total amount of commission paid to each of such agents in each of the years mentioned, and the counties and provinces in which they are located. Presented 5th February, 1912.—*Mr. Sutherland.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ....ot printed.*

**88.** Return to an Order of the House of the 22nd January, 1912, showing how many homestead inspectors were employed in the province of Saskatchewan by the Department of the Interior on 1st October, 1911, and what were their names; names of any of these inspectors who have been dismissed from office; reasons for dismissal; names of persons appointed to the positions so vacanted, giving their previous occupations, respectively. Presented 8th February, 1912.—*Mr. Thompson.. .. .. .. .. .. ..Not printed.*

**89.** Return to an Order of the House of the 22nd January, 1912, for a copy of all papers, letters, telegrams and other documents relative to prosecutions under the Fishery Act against John McCabe, David Porter, Joseph Foster and Duncan Murray, in the county of Pictou; and also, relating to a suit of Porter *vs.* Murray in the County Court of District No. 5, Nova Scotia, and the connection of the department with the same. Presented 9th February, 1912.—*Mr. Macdonald.. .. .. .. .. .. ..Not printed.*

**90.** Copy P.C. 19/168 certified extract from the minutes of a meeting of the Treasury Board, held on the 22nd January, 1912, approved by His Royal Highness the Governor General in Council on the 27th January, 1912.—*(Senate)... .. .. .. .. .. .. ..Not printed.*

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**91.** Return to an Address to His Royal Highness the Governor General on the 5th February, 1912, for a copy of all papers, letters, Orders in Council and other documents respecting the superannuation of the Honourable Judges Sir Alexandre Lacoste, J. A. Ouimet and C. J. Doherty. Presented 9th February, 1912.—*Mr. Ethier.*
*Not printed.*

**92.** Return showing certain dates returned to Senate by Messrs. A. E. Forget, &c.—(*Senate*).
*Not printed.*

**93.** Return to an Order of the House of the 22nd January, 1912, for a copy of all letters, correspondence, reports or other documents relating to the erection of an armoury at the town of Sarnia, Ontario. Presented 13th February, 1912.—*Mr. Pardee.*
*Not printed.*

**94.** Return to an Address to His Royal Highness the Governor General of the 22nd January, 1912, for a copy of all correspondence between the Government of Canada and the Government of the province of Quebec, with regard to the extension of the boundaries of the said province. Presented 13th February, 1912.—*Sir Wilfrid Laurier.*
*Printed for distribution and sessional papers.*

**95.** Return to an Order of the House of the 29th January, 1912, for a copy of all correspondence, representations, estimates, letters, telegrams and other documents received by the Right Honourable Prime Minister, or by any member of the Government, in any way relating to the subject of a car ferry service between the province of Prince Edward Island and the mainland, across the Straits of Northumberland, and the widening of the gauge of the Prince Edward Island Railway; and also, as to the estimated cost of all such work. Presented 13th February, 1912.—*Mr. Emmerson.*
*Not printed.*

**95*a*.** Supplementary Return to an Order of the House, of the 29th January, 1912, for a copy of all correspondence, representations, estimates, letters, telegrams and other documents received by the Right Honourable Prime Minister, or by any member of the Government, in any way relating to the subject of a car ferry service between the province of Prince Edward Island and the mainland, across the Straits of Northumberland, and the widening of the gauge of the Prince Edward Island Railway and also as to the estimated cost of all such work. Presented 7th March, 1912.—*Mr. Emmerson*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**95*b*.** Return to an Order of the House of the 5th February, 1912, for a copy of all letters, telegrams, or other documents containing applications or requests for the establishment of a car ferry service between Prince Edward Island and the mainland and of all correspondence, telegrams, reports, survey, and other documents showing the cost of the same, and of widening the gauge of the Prince Edward Island Railway; together with all other information available as to the desirability or necessity of said projects. Presented 7th March, 1912.—*Mr. Pardee*.. .. .. .. .. .. .. ..*Not printed.*

**96.** Return to an Order of the House of the 17th January, 1912, for a copy of all correspondence between the Department of Railways and Canals, or any official thereof, and the Saint John Railway Company, or the municipality of the city and county of St. John, on the subject of the granting of permission to the Saint John Railway Company, to lay its rails across the track of the Intercolonial Railway at or near the Haymarket Square in the city of St. John. Presented 13th February, 1912.—*Mr. Pugsley*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

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**101.** Return to an Address to His Royal Highness the Governor General of the 15th January, 1912, for a copy of Orders in Council and all correspondence between the Government and the Winnipeg and Hudson's Bay Railway Company and its successor the Winnipeg Great Northern Railway, relative to the proposed route of said Railway to Hudson's Bay, with all accompanying plans and reports; also a copy of all correspondence relative to the offer of Milhurn and Company, Steamship owners, of England, said to have been made to the Government through the said Railway Company to place a line of their steamships on the route between Hudson's Bay and England on the completion of said Railway, and the further offer by the said Milburn and Company to place one of their Baltic steamships at the disposal of the Government for the purpose of making a practical test of the navigability of the route for commercial purposes. Presented 16th February, 1912. —*Mr. Aikins.*
*Not printed.*

**101*a*.** Return to an Order of the House of the 26th February, 1912, for a copy of all reports, surveys, plans and maps made or prepared during the year 1911 or this year, in respect of or in connection with the Hudson Bay Railway or the suggested ports at Nelson or Churchill on the Hudson Bay, or relating to the navigation of the Hudson straits. Presented 4th March, 1912.—*Mr. Aikens.*
*Printed for distribution and sessional papers.*

**102.** Return to an Order of the House of the 5th February, 1912, for a copy of the inquiry made by the Railway Department respecting the accident incurred by Gofirey Bourque, of Lac au Saumon, in the yard of the Intercolonial Railway at Campbellton, in the month of November or December, 1911; also, for all papers and correspondence exchanged since on this subject. Presented 16th February, 1912.—*Mr. Boulay.*
*Not printed.*

**103.** Return to an Order of the House of the 14th February, 1912, for a copy of all correspondence, letters, telegrams, &c., between the King's Printer, the Superintendent of Printing, and the King's Printers' Representatives in Winnipeg, regarding the printing and distribution of the Voters' Lists of the province of Manitoba at the last general elections. Presented 19th February, 1912.—*Mr. Staples.. .. ..Not printed.*

**104.** Return to an Order of the House of the 17th January, 1912, for a copy of the Report of the Board of Engineers appointed for the reconstruction of the Quebec bridge, and of the plans and specifications prepared by them; of all notices calling for tenders; of all tenders received; of the report of the Board on the same, collectively or individually, to the Minister of Railways; of the report of the said minister for the acceptance of tenders, and any Orders in Council awarding contracts for the building of the said bridge. Presented 19th February, 1912.—*Sir Wilfrid Laurier.*
*Printed for sessional papers.*

**105.** Return to an Address to His Royal Highness the Governor General of the 12th February, 1912, for a copy of all Orders in Council passed during the last ten years relating to the abolition or regulation of tolls on canals. Presented 19th February, 1912.—*Mr. Sinclair.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**106.** Return to an Order of the House of the 12th February, 1912, for a copy of all petitions, letters and memorials received by the Minister of Marine and Fisheries since the first day of October, 1911, protesting against the issuing of a fish-trap license to Captain John T. Thorburn, Sand Point, county of Shelburne, Nova Scotia. Presented 22nd February, 1912.—*Mr. Law.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..Not printed.*

**106*a*.** Return to an Order of the Senate, dated 22nd March, 1912, for the production of all petitions and correspondence in relation to the removal of a fish trap at or near McNutts Island, in the harbour of Shelburne.—*(Senate)... .. .. .. .. ..Not printed.*

## CONTENTS OF VOLUME 24—*Continued.*

**107.** Return to an Order of the Senate, dated 15th February, 1912, showing the names, position and pay of all persons appointed to the Intercolonial Railway service in the city of St. John, New Brunswick, from 1st September, 1907, to 1st March, 1911.—*(Senate).* *Not printed.*

**108.** Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 22nd February, 1912, referring certain questions to the Supreme Court of Canada in respect to Bill No. 3, of the First Session of the Twelfth Parliament of Canada, intituled: "An Act to amend the Marriage Act." Presented 23ar February, 1912.—*Hon. Mr. Doherty..Printed for sesional papers.*

**108*a*.** Return to an Order of the House of the 19th February, 1912, for a copy of all letters, petitions, memorials or other documents received by the Prime Minister or any other member of the government, relating to the passage of a federal marriage law or legislation in regard to the so-called effect of the Ne Temere Decree. Presented 25th March, 1912.—*Mr. Macdonald*.. .. .. .. .. .. .. .. .. .. .. ..*Printed for sessional papers.*

**109.** Return to an Order of the House of the 17th January, 1912, for a copy of all papers, letters, recommendations, petitions, ministerial instructions and other documents in the possession of the Department of Marine and Fisheries relating to the price from 31st March, 1911, of Dog Fish scrap. Presented 23rd February, 1912.—*Mr. Sinclair.* *Not printed.*

**110.** Return to an Address of His Royal Highness the Governor General of the 5th February, 1912, for a copy of all correspondence, memorials or communications of any kind between the government of the province of Ontario and the Dominion Government since 1st January, 1908, respecting the extension of the boundaries of the province of Manitoba or the division of the Territory of Keewatin. Presented 23rd February, 1912... .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**110*a*.** Return to an Address to His Royal Highness the Governor General of the 4th December, 1911, for a copy of all papers, letters, telegrams, memoranda or correspondence of any kind had between the Dominion Government and the governments of Manitoba and Saskatchewan, or with the Government of Ontario, as to the settlement of the boundaries of said respective provinces; and also, of any agreement or memo. containing any terms of settlement of the questions relating to the boundaries of said provinces or any part thereof; and also, of any documents, letters or representations made to the Federal Government by any person or persons relative to said settlement or the questions involved therein. Presented 26th February, 1912.—*Mr. Macdonald.* *Printed for sessional papers.*

**110*b*.** Return to an Address of His Royal Highness the Governor General of the 5th February, 1912, for a copy of all correspondence, memorials or communications of any kind between the Government of the province of Ontario and the Dominion Government since 1st January, 1908, respecting the extension of the boundaries of the province of Manitoba or the division of the territory of Keewatin. Presented 26th February, 1912.—*Mr. Meighen*.. .. .. .. .. .. .. .. .. .. ..*Printed for sessional papers.*

**111.** Return to an Address of the Senate, dated 24th January, 1912, for copies of the contracts betweetn the Government of Canada, and the various steamship companies for the carriage of the mails between England, France and Canada, and all the correspondence relating thereto since the first of January, 1909; also, the agreements, if any, for the carriage of mails via New York. Further, any contracts, subsidy agreements, &c., for the conveyance of mail between Canada and Newfoundland, and the correspondence relating thereto since the first of January, 1909.—*(Senate).* *Printed for sessional papers.*

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**119.** Return to an Address to His Royal Highness the Governor General of the 10th January, 1912, for a copy of all Orders or Minutes of Council relating to the appointment of commissioners under the treaty with the United States relating to boundary waters, and questions arising along the boundary between Canada and the United States, signed at Wshington, 11th January, 1909; together with a copy of all despatches, letters and telegrams between the Governor General, or the Government of Canada, or any member thereof, and the British ambassador at Washington, or the British Government, or any member thereof, upon that subject; and also, of all letters and telegrams between any member or department of the government and Sir George Gibbons, Mr. Aimé Geoffrion and Mr. Alexander Barnhill, or either of them, relating to their appointment as such commissioners. Presented 1st March, 1912.—*Mr. Pugsley*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Printed for sessional papers.*

**120.** Return to an Address to His Royal Highness the Governor General of the 29th November, 1911, for a copy of all correspondence since the first of July, 1896, to the present date, between the Government of Canada and the governments of the several provinces on the subject of assistance to provincial railways and other provincial public works. Presented 1st March, 1912.—*Sir Wilfrid Laurier..Printed for sessional papers.*

**121.** Return to an Order of the House of the 26th February, 1912, for a copy of all papers and documents in the case of Rex *vs.* Sheldon and others. Presented 5th March, 1912.—*Mr. McKenzie*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**122.** Return to an order of the House of the 26th February, 1912, for a copy of all papers, correspondence and documents in connection with the case of D. Raymond, petitioner, the Queen's Hotel Company, Limited, respondent, and Guillaume Narcisse Ducharme and others, party defendants. Presented 5th March, 1912.—*Mr. Lemieux.*
*Not printed.*

**123.** Return to an Order of the Senate dated 9th February, 1912, showing the terms of lease to the whaling company or companies for whale fishing on the coast of British Columbia, giving the extent of sea over which exclusive rights are given, rent paid, and restriction as to close season, and all other particulars relating to this subject.—(*Senate*).. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**123*a*.** Return to an Address of the Senate dated 9th February, 1912, for a return showing the term of lease by the government to a company giving rights to exclusive fishing in the fresh water lakes of the Dominion; with all conditions as to time, rent, subletting and close season, and any other information relating to this subject.—(*Senate*).. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**124.** Return to an Address of the Senate, dated 22nd February, 1912, for all correspondence respecting the inefficient postal delivery service at Rothesay, N.B.—(*Senate*).
*Not printed*

**125.** Laid before the House, by command of His Royal Highness the Governor General,—Copy of agreement between His Majesty the King on behalf of the Dominion of Canada, His Majesty on behalf of the province of New Brunswick, and the Saint John and Quebec Railway Company, for the leasing under terms and conditions specified, of the line of railway when completed, of the company, between Grand Falls and Saint John, N.B. Presented 11th March, 1912... .. ..*Not printed.*

**126.** Return to an Order of the House of the 22nd January, 1912, or a copy of all correspondence and papers referring to the granting of special aid to the tobacco growers of La Société Co-opérative de la Vallée de Yamaska. Presented 13th March, 1912.—*Mr. Lemieux*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

## CONTENTS OF VOLUME 24—*Continued.*

**127.** Return to an Order of the House of the 22nd January, 1912, for a copy of all letters, correspondence, reports or other documents relating to the proposed winter harbonr at Sarnia, Ontario. Presented 13th March, 1912.—*Mr. Pardee*.. .. .. ..*Not printed.*

**127a.** Return to an Order of the House of the 26th February, 1912, for a copy of all reports, petitions and correspondence in the possession of the Department of Public Works, relating to the improvement of Port Dover harbour, in Norfolk county, Ontario; together with all papers or documents relating to the connection of the Graud Trunk Railway Company therewith. Presented 29th March, 1912.—*Mr. Charlton.* *Not printed.*

**127b.** Supplementary Return to an Order of the House of the 26th February, 1912, for a copy of all reports, petitions and correspondence in the possession of the Department of Public Works, relating to the improvement of Port Dover harbour, in Norfolk county, Ontario, together with all papers or documents relating to the connection of the Grand Trunk Railway Company therewith. Presented 1st April, 1912.—*Mr. Charlton*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**128.** Certified extract from the Minutes of a meeting of the Treasnry Board held on the 4th March, 1912, approved by His Royal Highness the Governor General in Council on the 9th March, 1912, respecting the term of service and pay of the coustables of the Royal Northwest Mounted Police. Presented 13th March, 1912... .. .. ..*Not printed.*

**129.** Return to an Order of the House of the 5th February, 1912, for a copy of all reports, correspondence and papers, relating to the building of a breakwater at Port Richmond, Nova Scotia. Presented 14th March, 1912.—*Mr. Kyte*.. .. .. .. ..*Not printed.*

**129a.** Return to an Order of the House of the 5th February, 1912, for a copy of all reports, correspondence and papers relating to the building of a breakwater at Charles Forests Cove, Richmond county, Nova Scotia. Presented 18th March, 1912.—*Mr. Kyte.* *Not printed.*

**130.** Return to and Order of the House of the 4th March, 1912, for a copy of all correspondence between the Intercolonial authorities, the Minister of Railways and the Department of Jnstice, and all other persons, relating to a claim of the Metapedia Waterworks Company against the Intercolonial, including therein all plans, designs, inquiries, evidences and other reports concerning this matter; also a copy of all plans, designs, notices and correspondence between the Intercolonial authorities and M. P. Laberge, the Dominion Lumber Company and John Fenderson & Co., relating to the placing of an aqueduct pipe on the land No. 170 of the cadastre of St. Pierre du Lac. Presentd 15th March, 1912.—*Mr. Boulay*.. .. .. .. .. .. .. .. .. .. .. ..*Not printd.*

**131.** Statement of the affairs of the British Loan and Investment Company, as on the 31st December, 1911. Presented 18th March, 1912.. .. .. .. .. .. .. .. .. ..*Not printed.*

**132.** Return to an Order of the House of the 6th March, 1912, for a copy of all letters, complaints, charges, and other papers and documents in the possession of the Post Office Department relating to Tracadie Road Post Office, Guysborough, N.S. Presented 19th March, 1912.—*Mr. Sinclair*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**133.** Return to an Order of the House of the 6th March, 1912, for a copy of the news sent up to date to Magdalen Island by the weekly correspondent appointed by the Postmaster General; also for a copy of the instructions given said correspondent at the time of his appointment. Presented 19th March, 1912.—*Mr. Lemieux*.. ..*Not printed.*

## CONTENTS OF VOLUME 24—*Continued.*

## CONTENTS OF VOLUME 24—*Continued.*

**141.** Return to an Order of the House of the 5th February, 1912, for a copy of all rulings or decisions made by the Minister of Customs, or the Tariff Board of the Department of Customs, since the 10th of October last, in reference to the duty payable in respect to Jute cloth, traction engines and partially dressed lumber, respectively; and likewise in reference to any other articles imported into Canada concerning which there has been any change in the rate of duty exacted at any time since the said date, as compared to the rate of duty exacted on such articles respectively immediately prior to said date. Presented 21st March, 1912.—*Mr. Turriff*.. .. .. .. .. .. ..*Not printed.*

**142.** Return to an Order of the House of the 5th February, 1912, for a copy of all letters, telegrams, petitions or other papers relating to any change or proposed change of postmasters at Powassan between 1st January, 1906, and 1st January, 1912. Presented 22nd March, 1912.—*Mr. Arthurs*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**143.** Return to an Order of the House of the 13th March, 1912, for a return showing the rural mail routes established by the present Government; the number of requests received by the Post Office Department for the establishment of rural mail routes; the number of applications granted; the number not granted, and the reasons therefor. Presented 22nd March, 1912.—*Mr. Lemieux*.. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**144.** Return to an Address to His Royal Highness the Governor General of the 12th February, 1912, for a copy of all Orders in Council, petitions and memorials, passed or received by the Government of Canada, respectively, since 1se July, 1908, relating to foreign shippings engaged in the coastwise trade in Canada; and also a copy of all correspondence between the Government or any departments thereof and any person, company or corporation relating to the same. Presented 25th March, 1912.—*Mr. Kyte*.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

**145.** Return to an Order of the 26th February, 1912, for a return showing the various loans made by the Government of Canada since the year 1900; the periods for which they were made; where contracted; rate of interest; commissions paid and to whom; net proceeds per cent of each loan; will future loans be asked for by public tender, if so where? Presented 25th March, 1912.—*Mr. Lapointe (Montreal)*.. .. .. ..*Not printed.*

**146.** Return to an Order of the House of the 19th February, 1912, for a return showing the number and capacity of cold storage establishments in each of the principal cities of Canada; the kind and quantity, approximate value of food stuff and produce contained in each of these establishments, during the months of November and December, 1911, and January, 1912. Presented 25th March, 1912.—*Mr. Verville.* *Not printed.*

**147.** Return to an Order of the House of the 17th January, 1912, for a copy of the Judgment of the Judicial Committee of the Privy Council in the case of the King *vs.* The Burrard Power Company, and of all Orders in Council for the transmission to the government of the province of British Columbia of the administration of all water rights in the Railway Belt; together with a copy of all correspondence between the Government of British Columbia and the Government of Canada with regard to the same. Presented 25th March, 1912.—*Sir W. Laurier*.. .. .. .. .. .. .. .. .. ..*Not printed.*

**148.** Return to an Address to His Royal Highness the Governor General of the 26th February, 1912, for a copy of all letters, documents and memoranda from the government of British Columbia, and all other papers relating to negotiations affecting the exportation of salmon, the boat rating in canneries, the system of issuing licenses and the restriction of licenses to Asiatics in the province of British Columbia, and all Orders in Council made in regard to any of these matters since 1st October, 1911. Presented 25th March, 1912.—*Mr. Macdonald*.. .. .. .. .. .. .. .. .. .. .. .. .. ..*Not printed.*

## CONTENTS OF VOLUME 24—*Concluded.*

DEPARTMENT OF THE INTERIOR

# ANNUAL REPORT

OF THE

# TOPOGRAPHICAL SURVEYS BRANCH

1910-1911

*PRINTED BY ORDER OF PARLIAMENT.*

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1912

[No. 25b—1912.]

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OF THE

# SURVEYOR GENERAL OF DOMINION LANDS

## 1910-1911

DEPARTMENT OF THE INTERIOR,
TOPOGRAPHICAL SURVEYS BRANCH,
OTTAWA, September 6, 1911.

The Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report of the Topographical Surveys Branch for the year ended March 31, 1911.

During 1910 surveys under the Dominion Lands system were continued in the western provinces under the usual organization. Eighty-eight parties in all were employed, seventy-three of these being regular parties engaged for the season and fifteen being parties organized for special surveys and engaged for short periods only. Of the seventy-three regular parties thirty-nine were employed by the day and thirty-four were working under contract. Those working under contract were engaged exclusively on township subdivision surveys, while, of those employed by the day, five were engaged upon the inspection of surveys executed under contract, eight on base lines and initial meridians and twenty-six on miscellaneous surveys and resurveys.

The weather throughout the season was, on the whole, very favourable for survey operations. In the southerly districts there was an unusually light rainfall but surveyors in outlying districts to the north report that precipitation was ample and that grasses and wild plants, where found, were growing luxuriantly. The amount of work performed by each party during the season compares well with the work of previous years. The following is a statement of the average number of miles of survey per party for the last four seasons :—

| | |
|---|---|
| 1910 | 279 miles. |
| 1909 | 412 " |
| 1908 | 366 " |
| 1907 | 364 " |

The falling off in the mileage for 1910 is accounted for by the fact that during 1907, 1908 and 1909 a large proportion of the surveys were in prairie districts while all the surveys of 1910 were in country more or less wooded.

One hundred and eighty-three whole townships and twenty-three fractional townships were completely subdivided while a partial subdivision was made of four hundred and nine others. Complete resurveys were made of eight townships and a partial resurvey of one hundred and eighty-nine others.

The survey parties employed during the season were distributed as follows :

| Parties. | In Man. | In Sask. | In Alta. | In B. C. | Partly in one Province and partly in another. | Total. |
|---|---|---|---|---|---|---|
| Paid by the day | 1 | 2 | 16 | 10 | 10 | 39 |
| Under contract | 1 | 12 | 21 | | | 34 |
| Engaged for a short time only | | 5 | 4 | 6 | | 15 |
| Total | 2 | 19 | 41 | 16 | 10 | 88 |

SURVEYS OF BLOCK OUTLINES.

Eight surveyors were employed on the surveys of base lines and initial meridians. These lines are situated in outlying portions of the country out of reach of railway transportation and surveyors as a rule make arrangements to have supplies taken in over the winter roads and cached at convenient points in the vicinity of their work. One of their great difficulties is thus overcome and they can push forward with their work without fear of the failure of their food supply for men and horses. In all about nine hundred and ninety miles of governing lines were surveyed during the year. Each surveyor prepares a sketch map showing the topographical features of the country for twelve miles on each side of the base or initial meridian and a report as to its natural resources, etc. In this way the Department is furnished with much valuable information that cannot be obtained otherwise.

Mr. Wm. Christie, D.L.S., completed the survey of the eighteenth base and established the twentieth base across ranges one to nine inclusive, west of the fourth meridian.

Mr. A. W. Ponton, D.L.S., continued the production of the fifth meridian to the north of township 112 and established the twenty-eighth base westerly therefrom across ranges one to seventeen inclusive, and the twenty-ninth base across range one. He began this survey in the summer of 1909 but was retarded considerably by wet weather and by the loss of his supplies and instruments through an accident on Peace river. He found considerable areas along the meridian and on the twenty-eighth base flooded from the heavy rains which were prevalent in that district. The survey of the twenty-eighth base will enable the Department to subdivide the lands in the vicinity of Vermilion under the Dominion Lands system when the necessity arises. Mr. Ponton reports that the soil there is good and the country well suited for agriculture.

Mr. George McMillan, D.L.S., continued the surveys of the sixteenth, seventeenth and twentieth base lines west of the sixth meridian. He remained in the field during the whole year and is now surveying the base lines and outlines of the block of three and one-half millions of acres conveyed by the province of British Columbia to the Dominion. The base lines already surveyed in this block will allow of the subdivision into townships of the district known as Pouce Coupé prairie.

Mr. A. Saint Cyr, D.L.S., surveyed the third meridian from township 60 to the seventeenth base line and established that base westerly across ranges one to twelve. His report shows that there are large areas of valuable timber in that region and extensive stretches of good farming land. On the north shore of Sled river in township 63, range ten, there is a settlement of half-breeds who have cleared the land and are growing all the ordinary vegetables successfully, as well as hay and oats. Fishing is, however, the great industry at present.

Mr. B. J. Saunders, D.L.S., had instructions to survey the nineteenth base line west of the fourth meridian. Owing to the scarcity of supplies, the extreme cold and the great difficulties of making trails he was compelled to abandon the work after the line had been established across five ranges only.

Mr. J. N. Wallace, D.L.S., beginning where he left off in 1909 produced the fourth meridian as far as the northeast corner of section 13, township 95. Mr. Wallace has had many years of experience on the survey of initial meridians and base lines in the western provinces but he states that the difficulties of his surveys of 1910 were greater than any he had ever before encountered. His report which is published as one of the appendices of the report of the Topographical Surveys Branch gives an interesting description of the country through which that portion of the fourth meridian passes. A sketch map of the portion of the fourth meridian surveyed by Mr. Wallace in 1909 was published with the report of the Topographical Surveys Branch last year but as no profile was then ready a sketch map and profile for the whole portion of the line surveyed by Mr. Wallace in both 1909 and 1910 are published with this report.

Mr. A. H. Hawkins, D.L.S., completed the survey of the twenty-first base line west of the fifth meridian. He began at the east boundary of range nineteen and produced the line east as far as the meridian. This base line passes through a fairly level country about sixty per cent of which is fit for agriculture. This percentage can be greatly increased by proper drainage. The soil is good and the surface is covered with a luxuriant growth of grass and pea-vine. All that is necessary to open up this valuable tract of country is railway transportation. Already large gardens are under cultivation at Atekamic and Wabiskaw lakes.

Mr. E. W. Robinson, D.L.S., during the summer of 1910 produced the principal meridian north to lake Winnipeg and established the eighth base east of the principal meridian east to lake Winnipeg and completed the survey of the ninth base west of the principal meridian. The country through which these lines run is mostly swamp and muskeg rendering the surveys very difficult but yet the whole distance of over one hundred miles was completed in six months.

During the winter Mr. Robinson produced the second meridian from township 56 to the sixteenth base and established the fifteenth base west of the principal meridian easterly from the second meridian to range twenty. From this base it will be possible to subdivide into townships under the Dominion Lands system the lands in the vicinity of The Pas as the surveys are required. He reports that at present there is little land in that vicinity fit for cultvation but thinks that, with proper drainage, it will make first-class wheat land.

TOWNSHIP SUBDIVISION SURVEYS.

Where contract rates for township subdivision are not applicable parties under daily pay are employed to make the surveys. During 1910 nine parties were engaged upon these surveys.

Mr. J. R. Akins, D.L.S., subdivided portions of townships twenty-one, twenty-two and twenty-three, range nine, west of the fifth meridian. The object of the subdivision surveys in these townships was to enable the Department to deal with lands covered by applications for coal leases. Before subdivision lines under the Dominion Lands system could be projected into these townships it was first necessary to produce the sixth base line across ranges seven, eight and part of nine from the Elbow to the Kananaskis valley. This was also done by Mr. Akins. The country is very rough and survey operations are carried on under great difficulties. An idea of the accuracy which is obtainable under the present system of making surveys may be gathered from the following statement by Mr. Akins:—

"We at length succeeded in getting both the line and triangulation over into the Kananaskis valley and here we checked our work by measuring the side of a triangle which had already been calculated and we found that the two checked to about a link."

Messrs. W. A. Scott, D.L.S., and J. L. Lang, D.L.S., carried on subdivision surveys in the foot-hills of the Rocky mountains in the vicinity of Livingstone, Oldman and Southfork rivers. Both parties were greatly handicapped by smoke and fire and were obliged to spend considerable time in assisting the Dominion Fire Rangers in fighting the fires. Mr. Scott during the last part of the season was employed on miscellaneous retracement and traverse surveys in southern Saskatchewan.

Messrs. J. Francis, D.L.S., J. B. McFarlane, D.L.S., O. Rolfson, D.L.S., and A. L. McNaughton, D.L.S., subdivided townships along the Sackatchewan, Brazeau and Pembina rivers in which coal claims are located. The country is very rough and covered with fallen timber which renders survey operations slow.

Mr. A. L. Cumming, D.L.S., was engaged in projecting township subdivision westerly along the line of the Grand Trunk Pacific railway from range twenty-five to the sixth meridian.

Mr. W. A. Ducker, D.L.S., made the necessary surveys of township outlines to define the limits of Porcupine Forest reserve west of the north end of lake Winnipegosis.

CORRECTION, RESTORATION AND MISCELLANEOUS SURVEYS.

Traversing lakes and rivers, correcting errors in previous surveys, retracing erroneous lines and restoring obliterated monuments are some of the miscellaneous surveys which are done by parties under daily pay.

Mr. C. F. Aylsworth, D.L.S., was occupied on resurveys in southeastern Saskatchewan and retracement surveys in Manitoba.

Mr. W. F. O'Hara, D.L.S., resurveyed a number of townships along the international boundary in Alberta. He also subdivided the R.N.W.M.P. reserve at Pincher Creek and made a survey of villa lots at Waterton lakes in townships 1, ranges twenty-nine and thirty, west of the fourth meridian.

Mr. P. A. Carson, D.L.S., was employed on small miscellaneous surveys in southern Saskatchewan and Alberta. His work included the correction of errors in the original subdivision, the reestablishment of lost corners, the traverse of water areas and investigation of dried up lakes and resurveys applied for. In all he completed about fifty separate jobs during the season.

After the close of his operations in the mountains of British Columbia, Mr. M. P. Bridgland ,D.L.S., was employed on miscellaneous surveys in Alberta and Saskatchewan, similar to those performed by Mr. Carson.

Messrs. Carl Engler, D.L.S., E. L. Burgess, D.L.S., and F. H. Kitto, D.L.S., all permanent members of the office staff were sent to the field for short periods to make special surveys for the Department.

Mr. Engler determined by latitude observations the position of the northern boundary of Alberta and made a survey of Smith Landing settlement.

Mr. H. W. Selby, D.L.S., made a settlement survey at McMurray and Athabaska Landing and an adjustment of settlers' claims at these places. On his return trip from McMurray Mr. Selby was accidentally drowned in the Athabaska river. He had been connected with Departmental surveys more or less since 1883 and continuously since 1902. He was a devoted public servant and was selected for the difficult task of adjusting claims in these settlements on account of his tact, fidelity and excellent judgment.

Mr. Wm. Ogilvie, D.L.S., surveyed a water-power site for the city of Prince Albert, at Cole falls on Saskatchewan river.

Mr. W. Thibaudeau, C.E., was employed on a reconnaissance of Winnipeg and English rivers to determine the most suitable locations for storage reservoirs for water-power development.

Other surveyors employed for short periods only on miscellaneous surveys such as small traverses, timber berths, etc., were Messrs. G. B. Bemister, D.L.S., H. P. Keith, D.L.S., H. G. Phillips, D.L.S., W. R. Reilly, D.L.S., J. E. Woods, D.L.S., and H. B. Proudfoot, D.L.S,

BRITISH COLUMBIA SURVEYS.

Eight parties continued the subdivision of Dominion lands in the railway belt, British Columbia. They were in charge of Messrs. J. E. Ross, D.L.S., G.H. Blanchet, D.L.S., D. A. Smith, D.L.S., P. B. Street, D.L.S., W. J. Deans, D.L.S., A. Lighthall, D.L.S., T. H. Plunkett, D.L.S., and L. D. N. Stewart, D.L.S.

Mr. A. W. Johnson, D.L.S., continued a survey of villa lots at Woodhaven on the North Arm of Burrard Inlet.

Messrs. A. J. Campbell, D.L.S., and R. D. McCaw, D.L.S., continued the examination and classification of the vacant lands in the valleys of the railway belt, British Columbia. Mr. Campbell worked in the New Westminster district and had under his direction a sub-party in charge of Mr. G. A. Bennett, D.L.S. Mr. McCaw worked in the Kamloops district and had a sub-party in charge of Mr. A. V. Chase, D.L.S., By the classification the lands are divided into fruit lands, farming lands, grazing lands, timber lands and worthless lands.

Mr. M. P. Bridgland, D.L.S., continued the triangulation survey through the Selkirk mountains which had been begun by Mr. P. A. Carson, D.L.S., in 1908 and 1909.

Mr. E. Bartlett, D.L.S., made an investigation of squatters' claims in the railway belt, British Colnmbia, in the vicinity of Golden in the Upper Columbia valley.

Messrs. J. H. Brownlee, D.L.S., P. C. Coates, D.L.S., J. A. Kirk, D.L.S., and G. L. Williams, D.L.S., were employed for short periods on the survey of timber berths.

INSPECTION SURVEYS.

The same five parties as in previous years were engaged the greater part of the season on the inspection of surveys made under contract.

Mr. E. W. Hubbell, D.L.S., was again working in the Prince Albert district. In addition to the inspection of the surveys performed under contract in that district he resnrveyed two townships near Prince Albert. During the season he travelled with his outfit over 1,700 miles by rail and over 1,000 miles by trail, not including the number of miles travelled daily to and from work.

Mr. P. R. A. Belanger, D.L.S., carried on inspection in eastern Manitoba. For a considerable part of the time he was engaged on small miscellaneous surveys in Manitoba and Alberta, which he completed to the number of forty-five. He also made a survey of Bender settlement in township 19, range one, west of the principal meridian.

Mr. C. F. Miles, D.L.S., inspected the contract surveys in the district northwest of Battleford. He also made a restoration survey of two townships north of Maple Creek and a resurvey of three townships near Prince Albert.

Mr. G. J. Lonergan, D.L.S., in addition to inspection made miscellaneous resurveys and traverses in ten townships as well as a resurvey of lots 1 to 6 Lac la Biche settlement.

Mr. L. E. Fontaine, D.L.S., inspected contract surveys west of Edmonton and performed a small number of miscellaneous surveys in that district.

STATEMENT OF MILEAGE SURVEYED.

The following is a comparison of the mileage surveyed every year since 1908.

| Nature of Survey | April 1, 1908 to March 31, 1909. | April 1, 1909 to March 31, 1910. | April 1, 1910 to March 31, 1911. |
|---|---|---|---|
| | Miles. | Miles. | Miles. |
| Township outlines | 2,019 | 2,089 | 2,376 |
| Section lines | 16,985 | 16,326 | 11,849 |
| Traverse | 3,323 | 2,413 | 2,758 |
| Resurvey | 2,175 | 3,876 | 906 |
| Total for season | 24,502 | 24,704 | 17,889 |
| Number of parties | 67 | 60 | 64 |
| Average miles per party | 366 | 412 | 279 |

The following tables show the mileage surveyed by the parties under daily pay and by the parties under contract.

WORK OF PARTIES UNDER DAILY PAY.

| Nature of Survey. | April 1, 1908, to March 31, 1909. | April 1, 1909, to March 31, 1910. | April 1, 1910, to March 31, 1911. |
|---|---|---|---|
| | Miles. | Miles. | Miles. |
| Township outlines | 512 | 861 | 1,178 |
| Section lines | 1,004 | 1,066 | 1,487 |
| Traverse | 1,158 | 1,324 | 462 |
| Resurvey | 2,175 | 3,808 | 835 |
| Total for season | 4,849 | 7,059 | 3,962 |
| Number of parties | 36 | 34 | 30 |
| Average miles per party | 135 | 208 | 132 |

WORK OF PARTIES UNDER CONTRACT.

| Nature of Survey. | April 1, 1908, to March 31, 1909. | April 1, 1909, to March 31, 1910. | April 1, 1910, to March 31, 1911. |
|---|---|---|---|
| | Miles. | Miles. | Miles. |
| Township outlines | 1,507 | 1,228 | 1,198 |
| Section lines | 15,981 | 15,260 | 10,362 |
| Traverse | 2,165 | 1,089 | 2,296 |
| Resurvey | ...... | 68 | 71 |
| Total for season | 19,653 | 17,645 | 13,927 |
| Number of parties | 31 | 26 | 34 |
| Average miles per party | 634 | 679 | 410 |

NOTE:—Owing to the nature of their work the parties under Messrs. E. Bartlett, P. R. A. Belanger, G. B. Bemister, E. L. Burgess, J. H. Brownlee, A. J. Campbell, P. C. Coates, C. Engler, L. E. Fontaine, E. W. Hubbell, A. W. Johnson, H. P. Keith, J. A. Kirk, F. H. Kitto, G. J. Lonergan, C. F. Miles, R. D. McCaw, W. Ogilvie, H. G. Phillips, H. B. Proudfoot, W. R. Reilly, H. W. Selby, W. Thibaudeau and G. L. Williams are not included in the statement of mileage for the year ended March 31, 1911.

## COST OF SURVEYS.

The following statement shows the average cost per mile of surveys executed by surveyors under daily pay and by surveyors under contract:

| — | Surveyed under daily pay. | Surveyed under contract. |
|---|---|---|
| Total mileage surveyed | 3,962 | 13,927 |
| Total cost | $388,600 | $376,477 |
| Average cost per mile | $98.08 | $27.03 |

The high average cost per mile of $27.03 for contract surveys as compared with $17.97 for 1909 is due to the fact that all the townships subdivided during 1910 were wooded while of those subdivided in 1909, 169 were open prairie; the relative rates per mile for surveys in open prairie and in solid bush are as $7.50 to $31.

The average cost per mile for surveys performed under day pay increased from $49.33 in 1909 to $98.44 in 1910. The average per mile for block outline surveys was $175 as compared with $167 in 1909. When the party under Mr. B. J. Saunders, D.L.S., is omitted from the calculation the average cost per mile for block outline surveys is found to be about ten dollars per mile lower in 1910 than in 1909. Mr. Saunders was compelled to abandon the survey of the nineteenth base line west of the fourth meridian when only a few miles had been run, but after all the initial expenses of organization, travel, &c., had been incurred. Other factors to increase the average cost of the surveys in 1910 were the larger number of parties working in the foot-hills in Alberta and in the railway belt in British Columbia and the smaller number engaged upon miscellaneous surveys, resurveys and restoration surveys in other parts of Alberta and in Saskatchewan and Manitoba. Owing to the nature of the country surveys in the foot-hills and in British Columbia are much more difficult than in the level and settled districts, and consequently slower and much more expensive. The average cost per mile of surveys in the foot-hills in Alberta during 1910 was $79, and in British Columbia $85, while the cost in Saskatchewan and Manitoba and other parts of Alberta was $33 per mile.

## DESCRIPTIONS OF TOWNSHIPS.

Descriptions of the townships subdivided during the year have been compiled from the surveyors' reports and will be published in a separate volume.

The subdivision surveys performed prior to March 31, 1910, those made between that date and March 31, 1911, and the resurveys executed during the same period are shown in colours upon the map which accompanies this report.

## MANUAL OF SURVEY.

The seventh edition of the Manual of Survey which at the time of the issue of last year's report was in the hands of the printers has since been published and distributed to Dominion Land Surveyors and to the members of the office staff.

CONFERENCE OF SURVEYORS GENERAL.

At the Colonial Conference held in 1907, the following resolution was adopted:—

"That it is desirable that reciprocity should be established between the respective Governments and examining authorities throughout the Empire with regard to the examination and authorization of land surveyors, and that the memorandum of the Surveyors' Institution on this subject be commended to the favourable consideration of the several Governments.

At the suggestion of the Surveyors' Institution, of London, a conference of the Surveyors General of the Colonies was called by the Imperial Government to meet in London on the 24th of October, 1910, to discuss the question of reciprocity in the authorization and examination of surveyors throughout the Empire. By order in council of the 21st July, 1910, I was authorized to attend the Conference and proceeded to London for that purpose. At the last moment it was found that circumstances in connection with the establishment of the Union of South Africa prevented the representation of the Union at the Conference. Moreover, the New Zealand Ministers and the State Governments of Australia expressed the wish that the Conference should be postponed to the next year and it was postponed accordingly.

CORRESPONDENCE.

The correspondence of this Branch consisted of:

| | |
|---|---|
| Letters received | 11,304 |
| Letters sent | 13,580 |

ACCOUNTS.

The Accountant's record shows:

| | |
|---|---|
| Number of accounts dealt with | 876 |
| Amount of accounts | $961,340 |
| Number of cheques forwarded | 3,298 |

OFFICE STAFF.

The office staff of the Topographical Surveys Branch at Ottawa consists of one hundred and twenty-six employees, or an increase of thirteen over last year. A list of the staff is given as Appendix No. 9 of this report.

Eighteen appointments were made to the staff, three employees were transferred to other branches of the Department and two resigned.

The appointments were Messrs. M. T. O'Meara, A. C. Pick, R. C. McCully, J. N. H. Gagnon, E. E. La Beree, C. S. Jones, C. P. Dubuc, C. H. Cagnat, O. E. Fournier, C. M. Ross, A. H. Beaubien, C. Baril, Jas. Howie, W. A. Purdy, J. H. Brigley, B. J. Roe, J. A. Watson and H. E. Hare. Messrs. A. L. Cumming and G. C. Webb resigned while Mr. A. Paquette was transferred to the Registration Branch, and Messrs. F. H. H. Williamson and B. E. Norrish to the Railway Lands Branch.

CHIEF DRAUGHTSMAN'S OFFICE.

*(P. B. Symes, Chief Draughtsman.)*

The six sections into which the draughtsmen are divided have continued during the past year on the same lines as before with very little change in the nature of the work or the methods of handling it.

The sketch maps now furnished by surveyors of base lines give valuable information and together with the sketches acompanying progress reports from other surveyors in the field, now made to supply more information than formerly, provide better material for mapping the country and arranging for subsequent surveys than was previously available.

The number of township plans compiled and drawn for printing is considerably in excess of the number issued in previous years. This is due chiefly to the greater proficiency attained by the draughtsmen employed, as the number of men available has been about the same as last year ; there are still, however, large arrears to be made up before this part of the work can be brought down to date. We have been unable to continue the issue of topographical plans of the townships owing to the pressure of other work, although a considerable amount of compiling has been done ; one plan covering four townships was printed as an experiment. It is hoped that this very desirable series of plans can be proceeded with before long.

The miscellaneous business, inquiries as to surveys made or proposed, areas, corner monuments, actual or supposed errors in lines, petitions for resurveys, etc., continues to steadily increase.

Details of work in the different sections are given in the reports below by the several heads of sections, and the usual schedule of work executed during the twelve months is added in Appendix No. 5.

## CHIEF DRAUGHTSMAN'S OFFICE.

### FIRST SECTION.

### SURVEY INSTRUCTIONS AND GENERAL INFORMATION.

*(T. E. Brown, Chief of Section.)*

Twenty-one men are employed in this section, the work in general being the preparation of instructions for the surveyors who are engaged in field operations, the care of the office registers, the issuing of preliminary plans, the answering of enquiries from settlers and others and the preparation of the annual report of the Branch.

During the winter months sketches showing previous surveys are compiled for those districts where it is probable that subdivision surveys will be extended during the following season. In addition information is collected as to the nature of the country, Hudson's Bay company's posts, Indian reserves, trails, etc. In March and April as a rule we are notified of the surveyors selected to take charge of parties under daily pay and of those to whom contracts are awarded. Notifications are at once sent out informing each surveyor of the nature and location of his surveys ; detailed instructions are furnished later. During the year one hundred and eighty-two drafts of instructions were prepared involving the compiling of 1,115 sketches, and 35 maps and tracings.

While in the field surveyors are required to furnish to the office sketches showing the progress of their work. Entries in the office registers show that 1,206 progress sketches were received and that surveyors furnished also 466 books of field notes for township surveys, 294 books and 509 plans, sketches, etc., for miscellaneous surveys, 278 timber reports, 123 statutory declarations of settlers and returns for 987 magnetic observations and for 48 timber berths. General reports on their survey operations were received from forty-three surveyors.

Their examination having been completed 772 books of field notes were placed on record together with 273 plans of miscellaneous surveys and 123 statutory declarations.

Plans of 740 townships and of 13 settlements or townsites were received from the lithographic office, entered in the registers and distributed, as well as 84 sectional maps and 184 miscellaneous plans.

Preliminary plans were issued for 347 townships.

Eighteen hundred and twenty-seven communications from settlers and others and inquiries from other branches were received and dealt with ; to do this required the preparation of 2,606 sketches, 99 maps and tracings and the copying of 627 pages of field notes. Thirteen descriptions of parcels of land were drafted.

The compilation of a set of maps to illustrate discrepancies in the surveys and to show closings of township surveys was continued throughout the year ; six new sheets were made and twenty-one revised and brought up to date.

Two thousand four hundred and twenty-five files were received from the Correspondence Branch for use in the work of this Branch. Four thousand eight hundred and thirty-one draft letters and memoranda were written.

Eight hundred copies of the seventh edition of the Manual of Instructions were distributed.

## CHIEF DRAUGHTSMAN'S OFFICE.

### SECOND SECTION

### SURVEYS IN MANITOBA, SASKATCHEWAN AND ALBERTA.

*(T. S. Nash, Chief of Section.)*

The examination of surveys in the Yukon Territory has been added to the work of this section so that now the section has charge of the examination of the survey returns of all Dominion lands except those in the railway belt of British Columbia. The average strength of the staff for the year was twenty-four men.

In connection with subdivision surveys, sketches sent in by surveyors showing the progress of the work in the field are examined to see that the surveys are being made correctly and in accordance with the instructions. These sketches form the basis for the advances made to contractors. During the year, 978 progress sketches were received and examined, 411 having been sent in by surveyors employed by the day, 403 by contractors and 164 by inspectors.

When a surveyor's final returns are received, a cursory examination is made of them to detect any serious discrepancies or omissions, and, if necessary, they are returned to the surveyor for correction. Compiled plans are then made from these returns. Plans of 805 townships were compiled and sent to the draughtsmen to be drawn for reproduction, which number includes the first edition plans of 234 townships. An examination was made of 314 subdivision surveys, 260 township outline surveys and 142 miscellaneous surveys. Compiled plans of 13 miscellaneous surveys were also sent to the draughtsmen, including a plan of McMurray settlement in northern Alberta and a plan of resurvey of St. Albert settlement.

When compiling, a very careful examination of the returns of the new survey is made, and a memorandum of any discrepancies or omissions is sent to the surveyor: 408 such memoranda were sent and 374 replies were received, and the necessary corrections made in the final returns.

Twelve hundred and seventy letters in connection with the year's work were drafted.

On May 25 the work of examining Yukon Territory surveys was transferred from the fifth section, as the staff there was not large enough to attend to this work. The examination of these returns is up to date though the plotting is not, owing to a lack of proper connections and base line surveys. Throughout the year 118 group lot surveys were examined including 47 received the previous year: 21 base line surveys were also examined 8 of which were previously received. Of these, 45 group lots and four base lines were plotted on the Yukon Territory plans.

The question of issuing plans of the Yukon survey for the convenience of the public has been under consideration and it is proposed to undertake this work during the coming year.

The reports of the inspectors of contract surveys are examined and dealt with in this section; a detailed description of the method of inspection was published in the report of last year. Reports on the inspection of 29 contracts were received during the year and 30 contract accounts were prepared and closed.

The number of odd jobs dealt with by this section is steadily increasing. One hundred and ninety-five requests for information concerning surveys were received from other branches of the Department involving the calculation of 990 areas. Two hundred and twenty-nine plans of road diversions submitted by the provincial governments of Saskatchewan and Alberta were examined.

The plans and notes of 33 timber berths were examined comprising 152 blocks whose boundaries totalled 1,202 miles of survey and whose area is approximately 770 square miles.

Fifty-five plans of right of way of railways were examined, the mileage of which amounted to 1,268 miles. As several of these plans were in duplicate or triplicate the gross mileage of plans examined was 3,016.

## CHIEF DRAUGHTSMAN'S OFFICE.

### THIRD SECTION—DRAWING FOR REPRODUCTION.

*(C. Engler, Chief of Section.)*

The staff of this section, during the past year, has been steadily engaged in the preparation of plans for printing and nothing has interrupted the work. The personnel of the staff is fourteen, one more than last year, as two new appointments were made and one clerk was transferred to the second section.

The work is steadily increasing as may be seen from a comparison of the number of township plans issued during the last four years.

| | | |
|---|---|---|
| 1907-08 | plans issued | 568 |
| 1908-09 | " " | 612 |
| 1909-10 | " " | 713 |
| 1910-11 | " " | 808 |

Besides township plans many plans of townsites, settlements and other surveys were made as well as work done of a miscellaneous character. The total number of such plans and odd jobs was 231; this includes maps to accompany the report of the Branch, the Astronomical field tables, diagrams showing altitude of Polaris, and plans to accompany orders in council.

The small printing-press is constantly in use printing foot-notes and titles for plans, labels and forms for office use, and many kinds of lettering formerly done by hand

The method of preparing plans for printing has been fully described in former reports, and no important changes have been introduced during the year. The copying of the plan by means of the tracing frame, the addition of all letters and figures by means of type held in a small tripod, and the addition of all foot-notes, titles, etc., by means of the small printing-press are still followed. An effort is now being made to print such foot-notes and titles directly on the plans instead of printing them on slips of paper which are then pasted to the plans. This, of course, is possible only with the smaller plans as the larger plans cannot be put into the press.

Among the members of the staff of this section are an engraver, a lithographic artist and a mechanical draughtsman. Though not employed by the Department in these capacities their services are made use of when the occasion arises. During the past year the engraver numbered all the technical instruments such as transits, watches, cameras, etc., in the possession of the Branch, the artist has been called upon frequently to design coloured covers for pamphlets issued by the Department, and the mechanical draughtsman makes the drawings of alterations in instruments, etc. Another clerk is an engrosser, and although there is not much necessity for such work, it has occasionally been found useful in adding titles to photographic albums.

CHIEF DRAUGHTSMAN'S OFFICE

FOURTH SECTION—BRITISH COLUMBIA SURVEYS.

(*E. L. Rowan-Legg, Chief of Section.*)

The work of this section has been the examination of surveyors' field notes, subdivision surveys, timber berths, mineral claims and miscellaneous surveys. Township and quarter township plans have been compiled, the latter supplanting the former in greater number each year as the information required to be shown increases. The work of compiling some of these plans is difficult and tedious on account of the number of field notes of both Dominion and Provincial surveys which have to be consulted.

Much time is often taken up replying to requests for information; in many cases a simple question requires a long search through field notes and correspondence on files.

As the number of surveyors engaged on subdivision was double that of the previous year, the work of preparing instructions and making sketches to accompany the same was greatly increased.

In 1909 Mr. A. W. Johnson made a survey of villa lots at Woodhaven in sections 23, 24 and 25, fractional township west of township 39, west of the coast meridian, and a plan of the survey was compiled in this office. Considerable trouble and delay arose in compiling this plan; the returns were only pencil field notes as the surveyor had to undertake other important work before completing his returns of the survey, and a large number of calculations had to be made by the compiler. A plan to accompany a pamphlet on Woodhaven was also made.

Plans of the towns of Yale and Golden were issued during the year.

The staff of this section consists of nine men, which is the same as last year.

The work of this section consisted of:—

| | |
|---|---|
| Preliminary plans issued | 56 |
| Township plans compiled | 113 |
| Townsite plans compiled | 2 |
| Plans and sketches made | 312 |
| Returns of township subdivision examined.— | |
| Books | 27 |
| Plans | 31 |
| Returns of miscellaneous surveys examined.— | |
| Books | 8 |
| Plans | 15 |
| Returns of timber berths examined | 31 |
| Returns of mineral claims examined | 16 |
| Letters and memoranda written | 1,064 |
| Return of timber berths made | 1 |
| Requests for various information dealt with | 841 |
| Letters of instructions drafted | 109 |

### CHIEF DRAUGHTSMAN'S OFFICE

### FIFTH SECTION—MAPPING.

*(J. Smith—Chief of Section.)*

The staff of this section has been increased from ten to thirteen: but the amount of absence, due to sickness, has been equivalent to the absence of one man the whole year.

The only Yukon work done by this section was the registering of returns of surveys received and the examination and correction of about four hundred photo-copies of plans that are filed in the Dawson office. On May 25, 1910, all the Yukon work was transferred to the second section.

The sectional map work is as follows:—

| | |
|---|---|
| Sectional maps, 3 miles to an inch, reprinted | 38 |
| Sectional maps, 3 miles to an inch, revised | 56 |
| Sectional maps, 6 miles to an inch, reprinted | 46 |
| New tracings, 2 miles to an inch | 16 |
| Proofs examined | 45 |
| Letters and memoranda written | 366 |
| Letters and memoranda received | 163 |
| Returns of timber berth surveys used in compiling | 248 |
| Township plans used in compiling | 568 |
| Plans of railways used in compiling | 51 |
| Field books of surveys used in compiling | 215 |
| Plans of surveyed roads used in compiling | 377 |
| Plans of Indian Reserves used in compiling | 46 |
| Post-office names and positions checked and compiled | 758 |

The following miscellaneous work was also done by this section:

A plan of the subdivision of Woodhaven was plotted and two tracings made, together with a small key-map showing the position of Woodhaven.

A revised and enlarged index map was made as copy for the engraving of a new map which includes the "Peace River Block" and as far north as lake Athabaska.

The work of reproducing A. O. Wheeler's map of part of the Rocky mountains was prepared for the photographer, and a portion of the map of the Selkirk range was traced for the same purpose.

### CHIEF DRAUGHTSMAN'S OFFICE

### SIXTH SECTION—SCIENTIFIC AND TOPOGRAPHICAL WORK.

*(G. B. Dodge, Chief of Section.)*

#### CORRESPONDENCE.

| | |
|---|---|
| Letters received and referred to this section | 435 |
| Letters of instructions prepared | 44 |
| Draft letters prepared | 546 |
| Office memoranda sent | 278 |

#### LEVELS.

All the surveyors on base lines are required to run levels. Bench-marks are established at intervals not greater than one mile apart. Whenever it is at all possible these bench-marks are cut in the rock, a mark being cut with the cold-chisel. Where rock is not available trees may be used, the trees being blazed and the letters B.M.

with the number of the bench-mark being cut on the tree. The descriptions of the bench-marks are given and they are referenced by the chainage on the line and the approximate distance north or south. The difference of elevation between successive bench-marks is checked either by a second independent line or by a system of double turning points, these differences of elevation being required to check within 0.2 feet per mile, not a very high grade of accuracy, but probably sufficient for most practical purposes, and it was not considered advisable to ask for too high a standard at the initial stages of the work. Surveyors this past year have been requested to take aneroid readings conjointly with the levels to enable us to obtain approximate data until ties can be made with railway levels. These aneroid readings have not yet been reduced so that no statement can be made of their probable accuracy.

| | |
|---|---|
| Level returns for 1910 received to date.......... | 648 miles |
| Previous levels.......................... | 854 miles |
| Total levels to date...................... | 1,502 miles |
| Total level returns examined and profiles plotted..... | 1,304 miles |

### MAGNETIC OBSERVATIONS.

The subject of Terrestrial Magnetism has received a great deal of attention within recent years among the civilized countries of the world. Magnetic surveys are being conducted in several countries. The United States have now very complete information over their whole country and are able to publish a fine isogonic map. For some time past we have felt the need of such a map for the district covered by our own work and have received numerous enquiries from others for the same. This office is most advantageously situated to gather this information. Having a large staff of surveyors in the field every year, scattered over a large area, we are able to collect in a short time and at no additional expense a large amount of magnetic information. All surveyors employed by the day are required to take these observations. The magnetic needles now supplied are especially designed for this work and with few exceptions are very sensitive. Through the courtesy of Mr. R. F. Stupart, the Director of the Meteorological Service, the compasses are all tested by the officer in charge of the Magnetic Observatory at Agincourt and the index correction determined. Where the needles are found to be anything but first class, a new compass is furnished the surveyor.

In the reduction of the observations to a common epoch we are very much handicapped by the absence of a magnetic observatory in the territory covered by the observations. Two of the staff of this division were placed at widely separated points in the Northwest this past season taking hourly declination readings for a whole month. These observations were afterwards plotted and compared with the daily photographic trace of the declinometer at Agincourt. Investigation of the results appear to show that the reduction of our declination observations by means of the Agincourt records is well worth the trouble, the precision of the resulting declination being apparently increased about two and one-half times. It is realized, however, that this is really not much more than a makeshift, and that what we require for proper reductions are the records of an observatory in the Northwest. This matter is now under consideration by the Director of the Meteorological Service who states that he may possibly be able to establish one there this coming season.

| | |
|---|---|
| Declination returns for 1910, received to date......... | 987 |
| Previous returns.......................... | 1,104 |
| Total returns to date........................ | 2,091 |
| Declination observations, 1910, for comparison with Agincourt | 908 |
| Dip observations, 1910...................... | 94 |
| Total force observations, 1910................. | 72 |

### TRIANGULATION

Owing to an insufficient staff and press of other work, the office computations of the triangulation in the railway belt in British Columbia is entirely in arrears, nothing whatever having been done with it. The office needs the information which the triangulation will give and we are also receiving outside requests for information. A special effort will be made this coming year to get the work up, and we hope to be able to state in our next report that the computations are up to date.

### ASTRONOMICAL WORK.

All the returns of azimuth observations from block surveyors for the year 1909 have been examined and checked.

The latitude observations of Mr. C. Engler, D.L.S., taken at Fort Smith in 1910 have been examined and checked.

The astronomical field tables for twelve months have been computed.

### STAR DIAGRAMS FOR LATITUDE OBSERVATIONS.

Rapid settlement of the country has compelled the abandonment for some years past of the old ideal system of running base lines in blocks across four ranges. In order to keep sufficiently in advance not to retard the subdivision, block surveyors have been required to run the base lines right across between adjacent meridians. There is thus no closing on their work for a distance of perhaps 150 miles or more. The positions of the base lines again are dependent on the meridians. For this reason the new model base line transit has been designed and fitted with accessories for the purpose of taking latitude observations by Talcott's method. Surveyors on meridians will in future be expected to take frequent latitude observations to provide an efficient independent check against any considerable error in chainage. Perhaps the most tedious part of a latitude observation by Talcott's method is the preparation of the observing list, especially when several star catalogues have to be consulted. To facilitate the preparation of these observing lists and save the surveyor's time, star charts were compiled in 1908 and were described in the report for that year. These charts contain stars to the fifth magnitude only. It was found last year that the telescopes on the latest base line transits were sufficiently powerful to observe most stars marked up to the seventh magnitude without difficulty. Our observing lists were, therefore, very much restricted when made from the star charts. The stars had been plotted directly from the different catalogues, that is to say, the positions had not been referred to a common epoch but to the epoch of the catalogue from which they had been taken, so that some stars were plotted for epoch 1890, some for 1900 and some for 1908. It was therefore, decided to entirely replot the charts, reducing all star places to epoch 1910, and embracing all stars up to the seventh magnitude. This has now been completed and the charts have been printed. The charts contain all stars within the desired limits of declination given in the Nautical Almanac, Berliner Jahrbuch, Connaissance des Temps, Star List of American Ephemeris, Greenwich Second Nine-Year Catalogue for 1900, Greenwich second Ten-Year Catalogue for 1890, Ambronn Sternverzeichnis, 1900. There are 6,740 stars in all. We have now in hand the preparation of a star list to be used in conjunction with the star charts. This list will give the mean places for 1910 of all the stars plotted and is intended to take the place of different catalogues.

### TOPOGRAPHICAL WORK.

Topographical plans of 156 townships were compiled.

TESTING LABORATORY.

The testing laboratory, the absence of which has prevented the proper testing of surveyors' instruments, is at last under construction and will be finished shortly.

PHOTOGRAPHIC OFFICE.

*(J. Woodruff, Chief Photographer.)*

The work of the chief photographer has greatly increased. Especially is this noticeable in velox printing in which department 4,770 prints were made. Last year the velox were included in the bromide work, but are now classed separately.

The purchase of a new velox printing machine fitted with a mercury vapour lamp enables one to turn out velox and artura prints expeditiously.

Increases are shown in dry plate developing and in solio printing. Blue prints also show a marked increase. The process of bromide enlarging has been greatly expedited by the installation of a five-tube mercury vapour lamp, by means of which enlargements or lantern transparencies can be made at any time, and not be dependent on the sunlight as hitherto.

Last summer the chief photographer visited Quebec, Father Point and Rimouski, where he obtained negatives of shipping, incoming immigrants, landing of the mails, etc. He also visited many places in the Eastern Townships and took photographs of cattle, farms and farming operations, for the use of the Immigration Branch.

The total of work executed during the year shows an increase of 50 per cent over that of the year previous. The staff is the same as that of last year.

PHOTOGRAPHIC OFFICE—PROCESS WORK.

*(H. K. Carruthers, Process Photographer.)*

The new frame for hanging copying camera and copying board mentioned in last year's report has given excellent satisfaction and during the past year representatives of outside firms visited the office to inspect this most up-to-date apparatus. Two firms outside the city are copying this camera to use in their photographic studios.

With the removal of the printing department from this office to the Imperial building we will have more room at our disposal and hope in the course of the next two or three months to be able to make our large size negatives of 24″ x 32″.

We are installing in the basement of the Imperial building the machinery for a photo-engraving plant transferred to us by the Public Works Department and when this is installed, any half-tone and line cuts required for our Branch can be made in this office.

An interesting piece of photo-lithography was started this year, the reproduction in colours of Mr. A. O. Wheeler's map of the main range of the Rocky Mountains with parts of the Dogtooth and Selkirk Mts. This will require the making of about fifty negatives 16″ x 18″ and a considerably larger number of photo-lithographs. The expense of reproducing this will be less than one-quarter the cost of engraving it on stone.

BOARD OF EXAMINERS FOR DOMINION LAND SURVEYORS.

*(F. D. Henderson, Secretary.)*

The Board of Examiners for Dominion Land Surveyors held two meetings during the year. The first was a special meeting lasting from April 30 to June 6 (inclusive), 1910, during which examinations were held at Ottawa, Montreal, Toronto, Winnipeg and Vancouver. The second was the regular annual meeting called for by section 9 of the Dominion Lands Surveys Act. It began on Monday, February 13, 1911, and lasted until March 30, 1911. During this meeting examinations were held at Ottawa, Halifax, Montreal, Kingston, Toronto, Winnipeg, Calgary, Edmonton and Vancouver. The total number of candidates for examination was 257. Of these 186 tried the preliminary examination as against 362 in 1909-10. Sixty-nine tried the final, and two tried the examination for Dominion Topographical Surveyor. Sixty-four candidates were successful at the preliminary examination as follows :

PRELIMINARY EXAMINATION.

Alexander, Walter C., Ottawa, Ont
Aslat, Edward K. S., Northminster, Sask.
Bolton, Lambert E. B., Wiarton, Ont.
Bowman, James Thornley, London, Ont.
Bradley, James Dennis, Ottawa, Ont.
Brown, Lindsay, O., Ottawa, Ont.
Cameron, Max, G., Peterborough, Ont.
Chisholm, Kenneth, Gordon, Halifax, N.S.
Clark, H. Jackson, Wellington, Ont.
Coltham, George, William, Aurora, Ont.
Cordukes, John Patrick, Ottawa, Ont.
Coté, J. Aurèle, Ottawa, Ont.
Cousineau, Aimé, Ottawa, Ont.
Dawson, Irvin Harrison, St. Catharines, Ont.
Dennis, Thomas Clinton, Ottawa, Ont.
Dimock, Clarence Lewis, Upper Newport, N.S.
Earle, Henry Arthur, Toronto, Ont.
Edgecombe, G. Harold, Ottawa, Ont.
Elliott, George Reginald, Goderich, Ont.
Ford, John W. H. London, Ont.
Fredette, Joseph Frédelin, Ottawa, Ont.
Gibson, Colin W. G., Toronto. Ont.
Goodman, Hyman Meyer, Toronto, Ont.
Gordon, Heber, Leduc, Alta.
Gorman, Edwin, Buckingham, P.Q.
Haggen, Geoffrey Loosmore, Revelstoke, B.C.
Hotchkiss, Cyrus Percival, Edmonton, Alta.
Huether, Alvin, D., Wiarton, Ont.
Jarvis, Ralph Hemsworth, Toronto, Ont.
Johnson, Hubert Colpoys, Ottawa, Ont.
King, Arthur Harry, Edmonton, Alta.
Kingston, Kenneth J., Ottawa, Ont.
LaBeree, Edwin E., Ottawa, Ont.
Macdonald, Alexander Gilmour, Toronto, Ont.
Macpherson, Harold Nolan, Kemptville, Ont.
Marshall, Joseph A. P., London, Ont.
Meikle, Angus Urquhart, Kingston, Ont.
Moulton, Hazen Parker, Ottawa, Ont.
MacLaurin, James Gladstone, Vankleek Hill, Ont.
MacLeod, David Douglas, Parkhill, Ont.
McCloskey, Michael D'Arcy, Chelsea, P.Q.
McCully, Robert Chesley, Ottawa, Ont.
McKay, Robert B., Vancouver, B.C.
Norrish, Wilbert Henry, Guelph, Ont.
Perron, Hermel Marie, Edmonton, Alta.
Prevost, Raoul de M., St. Jerome, P.Q.
Ratz, John Earl, Elmira, Ont.
Richardson, Colin Esdaile, Toronto, Ont.
Roberts, Otto B., Kingston, Ont.
Roberts, George Rowland, Winnipeg, Man.
Ross, Charles Cathmer, Ottawa, Ont.
Sibbett, William Algernon, Bracebridge, Ont.
Smith, K. Harold, Harrow, Ont.
Smith, Neville Herbert, Ottawa, Ont.
Surette, Germain Augustin, West Pubnico, N.S.
Vickers, Newell, Renwick, Ont.
Von Edeskuty, Joseph Otto, Calgary, Alta.
Wadlin, Lorenzo Norette, Ottawa, Ont.
Warrington, George Albert, Cornwall, Ont.
White, Donald Alexander, Ottawa, Ont.
Wight, Edmund James, Ottawa, Ont.
Workman, Thomas Oswald, Ottawa, Ont.
Wright, James Goldwin, Valleyfield, P.Q.
Zinkan, William Edward, Southampton, Ont.

Thirty-eight candidates were successful at the final examination as follows :

FINAL EXAMINATION.

Bartlett, Ernest, Smithville, Ont.
Bennett, George Arthur Eden Ont.
Bush, Clayton E., Toronto, Ont.
Chartrand Donat Emile, Ottawa, Ont.
Chase, Albert Victor, Orillia, Ont.
Cowper, George Constable, Welland, Ont.
Dawson, Frederick, James, Ashcroft, B.C.
Day, Harry Samuel, St. John, N.B.
Dennis, William Melbern, Ottawa, Ont.
Dillabough, James Vidal, St. Boniface, Man.
Eagleson, Francis Merwin, Gorrie, Ont.
Evans, Stanley Livingstone, Athens, Ont.
Glover, Arthur Edward, Beaverton, Ont.
Grassie, Charles Andrew, Welland Ont.
Gray, James Edward, Uxbridge, Ont.
Heuperman, Frederick Justinus, Calgary, Alta.
Hoar, Charles Millard, Ottawa, Ont.
Johnston, William James, St. Catharines, Ont.
Keith, Homer Pasha, Edmonton, Alta.
Lee, Roger Melville, Galt, Ont.
Martindale, Ernest Smith, Kingsmill, Ont.
Martyn, Oscar William, Mitchell, Ont.
Menzies, James Mellon, Ottawa, Ont.
Miller, Henry Belfrage, Montreal, P.Q.
Murray, Ernest William, Seaforth, Ont.
McElhanney, William George, Vancouver, B.C.
McMaster, William A. A., Palmerston, Ont.
Pearce, Seabury Kains, Calgary, Alta.
Pequegnat, Marcel, Berlin, Ont.
Powell, William Hall, Little Harbor, N.S.
Rainboth, George Louis, Ottawa, Ont.
Ransom, John Thomas, Toronto, Ont.
Roy, Joseph Emile, Quebec, P.Q.
Seibert, Frederick V., Southampton, Ont.
Taylor, William Emerson, Owen Sound, Ont.
Walker, Claude Melville, Guelph, Ont.
White, Walter Russel, Ottawa, Ont.
Wilson, Reginald Palisser, Winnipeg, Man.

One candidate, Wilmot Maxwell Tobey, Ottawa, passed the examination for Dominion Topographical Surveyor.

As in former years, the time of the Board at both meetings was largely taken up with the reading and valuation of the candidates' answers, and in the preparation of sets of question papers for the next examination.

In addition to this the evidence submitted by candidates at the final examination, in proof of their eligibility therefor, had to be examined. This evidence consisted of certificates of Provincial Land Surveyors, and of affidavits of service under articles of apprenticeship.

Section 22 of the Dominion Lands Surveys Act provides for a shortening of the term of service from three years to one year for men holding diplomas or certificates from technical colleges; and it is provided that "it shall rest with the Board to decide whether the course of instruction in such college or university meets the requirements of this section."

Applications for admission to the privileges of section 22 are being constantly received. Several such from graduates of Canadian, British, and foreign universities and colleges were considered by the Board, and decisions reached in regard to graduates of these institutions which will guide the Board in dealing with similar applications in future.

Oaths of office and allegiance, and bonds for the sum of one thousand dollars each, as required by section 25 of the Act, were received from, and commissions as Dominion Land Surveyors issued to, thirty-six surveyors.

Every Dominion Land Surveyor is required to be in possession of a subsidiary standard of length (D. L. S. Act Sec. 35). Thirty-eight new standards were issued to surveyors, two, which had changed hands, were re-tested, and fifty-four were sent to the Surveyor General of British Columbia for the use of British Columbia surveyors. A list of surveyors who have been furnished with standard measures up to March 31, 1911, will be found in Appendix No. 10.

The correspondence of the Board was as follows :

| | |
|---|---|
| Letters received | 1,705 |
| Letters sent | 950 |
| Circular letters, pamphlets and parcels sent | 1,512 |

## APPENDICES.

The following schedules and statements are appended :

No. 1. Schedule of surveyors employed and work executed by them from April 1, 1910, to March 31, 1911.

No. 2. Schedule showing for each surveyor employed from April 1, 1910, to March 31, 1911, the number of miles surveyed of township section lines, township outlines, traverses of lakes and rivers and resurvey ; also the cost of the same.

No. 3. List of lots in the Yukon Territory surveys of which have been received from April 1, 1910, to March 31, 1911.

No. 4. List of miscellaneous surveys in the Yukon Territory returns of which have been received from April 1, 1910, to March 31, 1911.

No. 5. Statement of work executed in the office of the chief draughtsman.

No. 6. List of new editions of sectional maps issued from April 1, 1910, to March 31, 1911.

No. 7. Statement of work executed in the photographic office from April 1, 1910, to March 31, 1911.

No. 8. Statement of work executed in the lithographic office from April 1, 1910, to March 31, 1911.

No. 9. List of employees of the Topographical Surveys Branch at Ottawa giving the name, classification, duties of office and salary of each.

No. 10. List of Dominion Land Surveyors who have been supplied with standard measures.

Nos. 11 to 51. Reports of surveyors employed.

MAPS AND PROFILES.

The following maps and profiles accompany this report:

Map showing subdivision surveys and resurveys made from April 1, 1910, to March 31, 1911.

Maps to accompany reports of surveyors.

Profiles of certain base lines.

I have the honour to be, Sir,

Your obedient servant.

E. DEVILLE,

*Surveyor General.*

# TOPOGRAPHICAL SURVEYS BRANCH

## SCHEDULES AND STATEMENTS

### APPENDIX No. 1.

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911.

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| Akins, J. R. | Ottawa, Ont. | Production of the sixth base line across ranges 7, 8 and part of 9; part subdivision of township 24, range 6 and townships 21 and 22, range 9; part resurvey of township 23, range 9 and township 24, range 6, west of the fifth meridian. |
| Aylsworth, C. F., | Madoc, Ont. | Retracement survey in township 13, range 6, townships 13 and 14, range 7 and township 13, range 8, east of the principal meridian; township 20, range 21 and township 29 range 32 west of the principal meridian; townships 30, ranges 1 and 2, townships 27 and 28, range 5 and township 2, range 12 west of the second meridian.<br>Traverse in township 30, range 1, west of the second meridian, and subdivision survey and resurvey in townships 30 and 31, range 31, west of the principal meridian. |
| Baker, J. C. | Kingston, Ont. | Contract No. 13 of 1910. Subdivision of townships 57, 58, 59 and 60 ranges 26 and 27, west of the third meridian. |
| Bartlett, E. | Smithville, Ont. | Investigation of squatters' claims in the railway belt of British Columbia in the upper Columbia Valley in the vicinity of Golden. |
| Belanger, P. R. A. | Ottawa, Ont. | Inspection of part of contract No. 19 of 1909; reinspection of contract No. 33 of 1907, and inspection of mounding in contract No. 6 of 1909.<br>Miscellaneous surveys in townships 22, 23 and 24, range 3, townships 22 and 23, range 4, townships 16, ranges 7 and 12 township 1, range 13, east of the principal meridian; townships 15 and 19, range 1, townships 15 and 24, range 2, townships 18 and 19, range 3, township 21, range 4, townships 14 and 22, range 6, township 21, range 7, township 22, range 8, township 30, range 9, townships 15 and 18, range 10, townships 9 and 18, range 11, township 30, range 15, township 32, range 18 and township 34, range 20, west of the principal meridian; townships 31 and 32, range 15, townships 44, 45 and 46, range 16, townships 45 and 46, range 17, township 37, range 19, township 38, range 21 and township 36, range 23 west of the fourth meridian; township 60, range 4, townships 58 and 60, range 5 and township 58, range 6 west of the fifth meridian.<br>Survey of Bender settlement in township 19, range 1, west of the principal meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| Bemister, G. B... .. | Winnipeg, Man.. .. .. | Survey of blocks 1, 2 and 3 of timber berth No. 1713 in township 50, range 32, west of the principal meridian, and townships 48, 49 and 50, range 1 and townships 48 and 49, range 2, west of the second meridian. |
| Blanchet, G. H... .. | Ottawa, Ont... .. .. | Survey in townships 20 and 21, range 29, west of the fifth meridian; townships 21 and 23 range 1, township 23, range 2, township 21, range 6, townships 20, 22 and 23, range 8, township 23, range 9, and townships 21 and 22, range 11, west of the sixth meridian.<br>Traverse in townships 20 and 21, range 29, west of the fifth meridian; township 21, range 1, township 23, range 2, township 21, range 6, and township 23, range 8, west of the sixth meridian.<br>Resurvey in townships 20 and 21, range 29, west of the fifth meridian; township 21, range 1, township 23, range 2, township 21, range 6, township 23, range 8 and township 22, range 11, west of the sixth meridian. |
| Bridgland, M. P.. .... | Calgary, Alta.. .. .. | Subdivision of part of the northeast quarter of section 18, township 24, range 1 west of the fifth meridian.<br>Miscellaneous surveys in townships 7 and 8, range 31 and township 13, range 32, west of the principal meridian; townships 5 and 7, range 19, township 5, range 20, township 9, range 23 and township 15, range 26, west of the second meridian; township 12, range 12 and township 18, range 14, west of the third meridian; township 10, range 14, townships 10 and 11, range 19, township 10, range 20, townships 9, ranges 22 and 23 and township 21, range 27 west of the fourth meridian; townships 24 and 31, range 1 and township 24, range 2, west of the fifth meridian. Survey of burial plot for R.N.W.M. Police in township 7, range 29, west of the third meridian.<br>Triangulation surveys in the railway belt of B.C. |
| Brownlee, J. H... .. | Vancouver, B.C... .. | Survey of timber berth No. 529 in township 4, range 28, west of the sixth meridian, and block A in the south half of section 2, township 5, range 5, west of the seventh meridian. |
| Burgess, E. L... .. .. | Ottawa, Ont.. .. .. .. | Resurvey and levelling in township 55, range 22, west of the fourth meridian. |
| Campbell, A. J. .. .. | Calgary, Alta... .. .. | Examination of land in the New Westminster district for the purpose of classification into fruit land, farming land, grazing land, timber land and worthless land. |
| Carson, P. A... .. .. | Ottawa, Ont... .. .. .. | Miscellaneous resurveys in townships 21 ranges 3 and 4, township 22, range 6, townships 23, ranges 7 and 11, township 27, range 14, township 31, range 16, township 34, range 18, township 45, range 22 and township 46, |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| | | range 23 west of the second meridian; townships 43 and 43A, range 2, townships 34 and 43, range 3, township 39, range 4, townships 33 and 49, range 5, township 47, range 16, townships 39 and 40, range 22, townships 37, ranges 23 and 24, townships 37 and 47, range 25, and township 48, range 27, west of the third meridian. Investigation in township 43, range 2, township 33, range 3, township 38, range 4, townships 33 and 50, range 5, and townships 37, ranges 25 and 26, west of the third meridian. Traverse in township 21, range 4, township 34, range 18, townships 37, 38 and 42, range 21, townships 38 and 39, range 22, and township 38, range 23, west of the second meridian; townships 34 and 36, range 2, township 31, range 3, township 33, range 6, township 39, range 14, township 43, range 16 and township 40, range 26, west of the third meridian. Resurvey of "lot 1, group 267" in Red Pheasant Indian reserve in township 41, range 15, west of the third meridian. |
| Cautley, R. H. | Edmonton, Alta. | Contract No. 30 of 1910. Subdivision of townships 55 and 56, range 17, townships 55, ranges 18, 19 and 20, and the north third of townships 54, ranges 17, 18, 19 and 20, west of the fifth meridian. |
| Chilver, C. A. | Walkerville, Ont. | Contract No. 17 of 1910. Subdivision of township 69 range 15, townships 68 and 69, ranges 16 and 17, and township 67, range 18, west of the fourth meridian. |
| Christie, W. | Prince Albert, Sask. | Survey of the eighteenth base line across ranges 1 to 12 and the twentieth base line across ranges 1 to 9 west of the fourth meridian. |
| Coates, P. C. | Whaletown, B. C. | Survey of timber berth No. 356 in townships 23 and 24, range 1, west of the sixth meridian. |
| Coté, J. L. | Edmonton, Alta. | Contract No. 19 of 1910. Subdivision of townships 68 and 69, ranges 21, 22 and 23, west of the fourth meridian. |
| Cumming, A. L. | Cornwall, Ont. | Survey of township 52, range 26, and part survey of townships 49, 50 and 51, range 25 and township 51, range 26, west of the fifth meridian.<br>Traverse in township 50, range 26, townships 49 and 50, range 27, townships 47, 48 and 49 range 28, west of the fifth meridian, and township 47, range 1, west of the sixth meridian. |
| Davies, T. A. | Edmonton, Alta. | Contract No. 24 of 1910. Subdivision of townships 61, 62 and 63, ranges 21 and 22, west of the fourth meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| Deans, W. J. | Brandon, Man. | Sudivision in townships 25 and 26, ranges 20 and 21, west of the fifth meridian; townships 23 and 24, ranges 7 and 8, and township 22, range 10, west of the sixth meridian.<br>Traverse in townships 25 and 26, range 21, west of the fifth meridian; township 24, range 7, townships 23 and 24, range 8 and township 22, range 10, west of the sixth meridian.<br>Resurvey in townships 25 and 26, range 21, west of the fifth meridian; townships 21 and 22, range 10, west of the sixth meridian. |
| Dumais, P. T. C. | Hull, Que. | Contract No. 20 of 1910. Subdivision of townships 64, 65 and 66, range 16 and townships 65 and 66, range 17, west of the fourth meridian. Survey of timber berth No. 1243 in townships 45 and 46, range 7, west of the fifth meridian. |
| Ducker, W. A. | Winnipeg, Man. | Survey of the east outlines of township 40, range 28, townships 38, 39 and 40 range 29, and townships 39 and 40, range 30, and the south outlines of townships 39, ranges 30, 31 and 32, west of the principal meridian. |
| Engler, C. | Ottawa, Ont. | Survey of the north boundary of Alberta across Slave river; survey of Smith Landing settlement on Slave river. |
| Fairchild, C. C. | Brantford, Ont. | Contract No. 27 of 1910. Subdivision of townships 63, 64, 65, 66 and part of 62, range 1, and township 65 and the east outlines of townships 67 and 68, range 2, west of the fifth meridian. |
| Fawcett, A. | Gravenhurst, Ont. | Contract No. 11 of 1910. Subdivision of townships 54, 55, 56 and 57, range 22, townships 57 and 58 and the east outlines of townships of 59 and 60, range 23, west of the third meridian. |
| Findlay, A | Winnipeg, Man. | Contract No. 28 of 1910. Snbdivision of townships 62, 63 and 64, range 2, and townships 62 and 63, range 3, west of the fifth meridian. Survey of blocks 1 and 2 of timber berth No. 1015 situated on the east shore of lake Winnipeg, near Bloodvein bay, Man., and blocks 1 and 2 of timber berth No. 1134, situated on Bloodvein river, Manitoba. |
| Fontaine, L. E. | Lévis, Que. | Inspection of contracts Nos. 9, 10, 16, 22, 23 and 25 of 1909; reinspection of contract No. 12 and additions to Nos. 18 and 25 of 1908. Miscellaneous resurveys in townships 55 and 56, range 7, townships 54, ranges 8 and 12 and township 52, range 22, west of the fifth meridian. |
| Francis, J. | Portage la Prairie, Man. | Subdivision surveys in township 45, range 20, townships 44 and 45, range 21, township 49, range 23, townships 48 and 49, range 24, and townships 48 and 50, range 25, west of the fifth meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| Green, T. D. | Ottawa, Ont. | Contract No. 34 of 1910. Subdivision of township 31, range 6, townships 29, 31 and 32, range 7, and township 40, ranges 8 and 9, west of the fifth meridian. |
| Hawkins, A. H. | Listowel, Ont. | Survey of the twenty-first base line across ranges 1 to 18, west of the fifth meridian. Miscellaneous surveys in township 29, range 7, and townships 40, ranges 8 and 9, meridian; township 45, range 4, township 48, range 22, and township 51, range 27, west of the fourth meridian. Traverse in township 58, range 11, township 53, range 25, and township 80, range 26 west of the fourth meridian; townships 47 and 52, range 1, west of the fifth meridian. |
| Heathcott, R. V. | Edmonton, Alta. | Contract No. 31 of 1910. Subdivision of townships 54 and 55, range 21, the south two-thirds of township 54, range 22 and the north two-thirds of townships 51, ranges 18, 19, 20, 21, 22 and 23, and survey of the east outlines of townships 56 ranges 21 and 22, west of the fifth meridian. |
| Holcroft, H. S. | Toronto, Ont. | Contract No. 12 of 1910. Subdivision of townships 57, 58 and 59, range 24, and townships 57, 58, 59 and 60, range 25, and survey of the east outline of township 60, range 24, west of the third meridian. |
| Hopkins, M. W. | Edmonton, Alta. | Contract No. 17 of 1910. Subdivision of townships 65 and 66, ranges 1, 2, 3, 4 and 5, and survey of the east outlines of townships 67 and 68, ranges 2, 3, 4, 5 and 6, west of the fourth meridian. |
| Hubbell, E. W. | Ottawa, Ont. | Inspection of contract No. 32 of 1907. Contracts Nos. 13, 17 and part of 19 of 1909. Contracts Nos. 4, 5, 6 and 7 of 1910. Resurvey in township 48, range 21 and township 49, range 27 west of the second meridian. Traverse in townships 42 ranges 9, 10, 13 and 14, townships 52 and 53, ranges 12 and 13, and township 49, range 26 west of the second meridian. |
| Johnson, A. W. | Kamloops, B.C. | Survey of villa lots at Woodhaven on north arm of Burrard Inlet. |
| Keith, H. P. | Edmonton, Alta. | Survey of timber berth No. 1705 in townships 50 and 51, ranges 22 and 23, west of the fifth meridian; timber berth No. 1706 in township 51, range 22, west of the fifth meridian, and of timber berth No. 1707 in township 50, range 23, west of the fifth meridian. |
| Kimpe, M. | Edmonton, Alta. | Contract No. 15 of 1910. Subdivision of townships 49, 50 and 51, range 8, townships 50 and 51, ranges 9 and 10, and part of township 52, range 9, and survey of the east outlines of townships 49, ranges 9, 10 and 11 west of the fifth meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| Kirk, J. A. | Revelstoke, B.C. | Survey of timber berth No. 401 in townships 29, ranges 21 and 22, west of the fifth meridian; timber berth No. 415 in townships 30 and 31, range 30, west of the fifth meridian, and of timber berth No. 416 in township 30, range 20 west of the fifth meridian. |
| Kitto, F. H. | Ottawa, Ont. | Miscellaneous resurveys in St. Albert settlement and in townships 53, ranges 25 and 26 west of the fourth meridian. |
| Knight, R. H. | Edmonton, Alta. | Contract No. 26 of 1910. Subdivision of townships 65, 66, 67 and 68, range 26, and townships 63, 64, 65, 66, 67 and 68, range 27, west of the fourth meridian. |
| Lang, J. L. | Sault Ste. Marie, Ont. | Subdivision in townships 5, 6 and 7, range 4, and townships 7 and 8, range 5, west of the fifth meridian. Resurvey in townships 5, 7 and 8, range 1, township 5, range 2, and townships 6 and 7, range 3, west of the fifth meridian. |
| Laurie, R. C. | Battleford, Sask. | Contract No. 35 of 1910. Subdivision of townships 54, 55 and 56, range 23, west of the third meridian. |
| Lightball, A. | Ottawa, Ont. | Survey in townships 3 and 4, range 3, west of the seventh meridian; townships 18, 21, 40 and 41, east of the coast meridian; township 39, west of the coast meridian. Traverse in township 4, range 3, and township 6, range 7, west of the seventh meridian; townships 40 and 41, east of the coast meridian. Resurvey in townships 3 and 4, range 3, west of the seventh meridian; townships 18, 21, 40 and 41, east of the coast meridian; township 39, west of the coast meridian. Survey of timber berth No. 535 in township 39, west of the coast meridian; timber berth No. 536 in township 40, east of the coast meridian, and timber berth No. 537 in township 6, range 5, west of the seventh meridian. |
| Lonergan, G. J. | Buckingham, Que. | Inspection of contract No. 26 of 1909, and contracts Nos. 16, 17, 18, 19, 21, 23, 24 and 34 of 1910. Resurvey in township 53, range 3, township 68, range 16, township 54, range 21, township 53, range 23, and townships 54, ranges 27 and 28, west of the fourth meridian. Traverse in township 53, range 3, townships 51, ranges 6 and 7, townships 64 and 65, range 22, townships 52 and 53, range 26, and townships 53 and 54, range 27, west of the fourth meridian. Resurvey of lots 1 to 6, Lac la Biche settlement in township 68, range 16, west of the fourth meridian. |
| Miles, C. F. | Toronto, Ont. | Reinspection of contract No. 8 of 1909, inspection of contracts Nos. 8, 9, 10, 11, 12, 13 and 35 of 1910. Resurvey in township 49, range 24 and townships 48, ranges 27 and 28 west of the second meridian; township 48, range 1, townships 14 and 15, range 25, and |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| | | townships 13 and 14, range 30, west of the third meridian; townships 13 and 14, range 1, west of the fourth meridian. Traverse in townships 48 and 49, range 24, and townships 48, ranges 27 and 28, west of the second meridian; township 15, range 25, west of the third meridian; townships 13 and 14, range 1, west of the fourth meridian. |
| Mitchell, B. F. | Edmonton, Alta. | Contract No. 21 of 1910. Subdivision of township 63, range 16, and townships 61, 62, 63 and 64, range 17, west of the fourth meridian. |
| Montgomery, P. H. | Prince Albert, Sask. | Contract No. 5 of 1910. Subdivision of township 51, range 5, townships 51 and 52, range 6, townships 50, 51, 52 and 53, range 7, and townships 49, 50, 51 and 52, range 8, west of the third meridian. |
| Morrier, J. E. | Ottawa, Ont. | Contract No. 4 of 1910. Subdivision of townships 44, ranges 7, 8, 9 and 10, and the northerly two-thirds of township 45, range 3, west of the second meridian. |
| McCaw, R. D. | Calgary, Alta. | Examination of land in the Kamloops district for the purpose of classification into fruit land, farming land, grazing land, timber land and worthless land. |
| McFarlane, J. B. | Toronto, Ont. | Subdivision in townships 39 and 40, range 16, township 39, range 17, township 40, range 18, township 41, range 19, township 44, range 21, townships 45 and 46, range 22, township 46, range 23, and township 50, range 26, west of the fifth meridian. |
| McFarlane, W. G. | Toronto, Ont. | Contract No. 33 of 1910. Subdivision of township 83, range 23, and the parts north of Peace river of townships 83, ranges 21 and 22, and township 82, range 23, survey of the east outlines of townships 84, ranges 22, 23 and 24, all west of the fifth meridian. Subdivision of townships 81 and 82, range 1, townships 81 ranges 2 and 3, township 70, range 9, the west half of township 72 and the northerly two-thirds of the west half of township 71, range 2, the northerly two-thirds of township 70, and the southerly third of townships 71, ranges 7 and 8, and the southerly third of township 71, range 9; survey of the north outline of township 84, range 1, and the east outlines of townships 83 and 84, range 2, and townships 69, ranges 7, 8 and 9, all west of the sixth meridian. Traverse in township 82, range 26, west of the fifth meridian, and in township 71, range 3, west of the sixth meridian. Survey of blocks 1 and 2 of timber berth 1272 in Peace river district, Alberta. |
| McGrandle, H. | Wetaskiwin, Alta. | Contract No. 29 of 1910. Subdivision of townships 52, ranges 13 and 14, township 56, range 15, townships 55 and 56, and the north third of township 54, range 16, west of the fifth meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of Work. |
|---|---|---|
| McMillan, Geo. | Ottawa, Ont. | Survey of the sixteenth base line across ranges 5 to 13, the seventeenth base line across ranges 9 to 14, and the twentieth base line across ranges 13 to 17, west of the sixth meridian. |
| McNaughton, A. L. | Cornwall, Ont. | Subdivision in townships 45 and 46, range 18, townships 46 and 47, range 19, township 47, range 20, townships 48 and 49, range 21, township 49, range 22, and survey of the east outlines of townships 48, ranges 19 and 20, west of the fifth meridian. Survey of timber berth No. 1709 in township 53, range 10, west of the fifth meridian. |
| Ogilvie, W. | Ottawa, Ont. | Survey of a water-power site for the city of Prince Albert, at Cole falls, on Saskatchewan river. |
| O'Hara, W. F. | Ottawa, Ont. | Resurvey in townships 2 ranges 7, 8 and 19, townships 1 and 2, range 20, township 1, range 27, townships 1 and 2, range 29, and township 1, range 30, west of the fourth meridian. Survey in the town of Pincher Creek and of villa lots around Waterton lakes. |
| Ord, L. R. | Hamilton, Ont. | Contract No. 22 of 1910. Subdivision of townships 61, 62, 63, 64 and 65, range 18, west of the fourth meridian. |
| Phillips, H. G. | Saskatoon, Sask. | Resurvey in township 23, range 7, west of the third meridian. |
| Plunkett, T. H. | Toronto, Ont. | Survey in townships 19 and 20, range 5, townships 19, ranges 6 and 7, townships 23, ranges 9 and 10, townships 22 and 23 range 11, township 23, range 12, townships 21, 22 and 23, range 13, townships 22 and 23, range 25. Traverse in townships 19 and 20, range 5, and townships 21, 22 and 23, range 13, west of the sixth meridian. Resurvey in township 23, range 10, townships 22 and 23, range 11, township 23, range 12, townships 21 and 23, range 13, townships 21, ranges 14 and 24, and townships 22 and 23, range 25, west of the sixth meridian. |
| Ponton, A. W. | Edmonton, Alta. | Survey of the fifth meridian from the northeast corner of township 106 to the northeast corner of township 112; survey of the twenty-eighth base line across ranges 1 to 17, the twenty-ninth base line across range 1, part subdivision of township 109, range 10, west of the fifth meridian, and the production of the principal meridian across lake Winnipeg from the northeast corner of section 12, township 35, to the northeast corner of township 48. |
| Proudfoot, H. B. | Saskatoon, Sask. | Survey of block 24 of timber berth No. 1048 near Green lake, berth No. 1050 on the shores of Namew lake, Goose lake and Amisk lake, blocks 1 and 2 of berth No. 1237 northeast of Hudson Bay Junction and berth No. 1672 in township 43, range 27, west of the principal meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Description of Work. | Surveyor. | Address. |
|---|---|---|
| Reilly, W. R. .. .. .. | Regina, Sask. .. .. .. | Traverse of Swan lake in township 10, range 8, west of the second meridian. |
| Robinson, E. W. .. .. | Ottawa, Ont. .. .. .. | Survey of the eighth base line across ranges 1 to 5, east of the principal meridian; survey of the principal meridian from the eighth base line to lake Winnipeg; survey of the ninth base line across ranges 1 to 7, west of the principal meridian; survey of the fifteenth base line from the northeast corner of section 35, range 21, west of the principal meridian to the second meridian; survey of the second meridian from the fifteenth base line to the northeast corner of township 61. |
| Rolfson, O. .. .. .. .. | Walkerville, Ont. .. | Subdivision in townships 43 and 44, range 20, and township 44, range 21, west of the fifth meridian. |
| Ross, J. E. .. .. .. .. | Kamloops, B.C. .. .. | Survey in townships 19, ranges 13 and 14, township 22, range 17, townships 17, 18, 19, 21 and 22, range 18, townships 21 and 22, range 19, townships 21 22, 23 and 24 range 20, townships 19, 22, 23 and 24, range 21, townships 19, 20, 22 and 23, range 22, and township 20, range 23, west of the sixth meridian. Traverse in township 22, range 17, townships 18, 19 and 22, range 18, township 21, range 19, township 22, range 20, and townships 22, 23 and 24, range 21, west of sixth meridian. Resurvey in township 22, range 17, townships 18, 20 and 21, range 18, townships 20 and 21, range 19, township 24, range 21, and township 22, range 22, west of the sixth meridian. |
| Roy, G. P. .. .. .. .. | Quebec, Que. .. .. .. | Contract No. 8 of 1910. Subdivision of townships 53, 54 and 55, range 17, and townships 53, 54, 55 and 56, range 18; survey of the east outline of township 56, range 17, west of the third meridian. |
| Saint Cyr, A. .. .. .. | Ottawa, Ont. .. .. .. | Survey of the third meridian from the northeast corner of township 60 to the northeast corner of township 64, and the seventeenth base line across ranges 1 to 12, west of the third meridian. |
| Saunders, B. J. .. .. .. | Edmonton, Alta. .. .. | Survey of the nineteenth base line across ranges 1 to 5, west of the fourth meridian. |
| Scott, W. A. .. .. .. .. | Galt, Ont. .. .. .. .. | Surveys in township 10, range 30, west of the fourth meridian; township 10, range 1, townships 11 and 13, range 2, township 8, range 3, and townships 10, 11 and 12, range 4, west of the fifth meridian. Resurvey in township 28, range 12, and township 16, range 13, west of the third meridian. Traverse in townships 27, ranges 17 and 18, west of the second meridian, and in townships 10 and 11, range 3, west of the fifth meridian. Survey of the north boundary of Peigan timber limit in township 9, range 30, west of the fourth meridian. Investigation in township 7, range 10 west of the second meridian. |

## APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911—*Continued.*

| Surveyor. | Address. | Description of work. |
|---|---|---|
| Selby, H. W. | (Died Aug., 1910) | Settlement surveys at Athabaska Landing and McMurray. Traverse of part of Athabaska river from McMurray to McKay. |
| Seymour, H. L. | Edmonton, Alta. | Contract No. 23 of 1910. Subdivision of townships 61, 62 and 63, ranges 19 and 20, west of the fourth meridian. |
| Smith, D. A. | Claude, Ont. | Survey in township 25 range 20, west of the fifth meridian; townships 24, 25 and 26, range 7, and townships 25 and 26, range 8, west of the sixth meridian. Traverse in townships 25, ranges 7 and 8, west of the sixth meridian. Resurvey in township 25, range 20, west of the fifth meridian. |
| Smith, J. H. | Edmonton, Alta. | Contract No. 32 of 1910. Subdivision of township 77, range 19, township 76, and the north third of township 75, ranges 20 and 21, and townships 76 and 77, and the north third of township 75, ranges 22 and 23, west of the fifth meridian. |
| Steele, I. J. | Ottawa, Ont. | Contract No. 25 of 1910. Subdivision of townships 64, 65, 66, 67 and 68, range 25, and township 64, range 26, west of the fourth meridian. |
| Stewart, L. D. N. | Collingwood, Ont. | Survey in townships 22 and 23, ranges 9 and 10, west of the sixth meridian. Traverse in township 23, range 9, and townships 22 and 23, range 10, west of the sixth meridian. Resurvey in township 23, range 9, west of the sixth meridian. |
| Stewart, W. M. | Saskatoon, Sask. | Contract No. 9 of 1910. Subdivision of townships 54, 55, 56 and 57, range 19, and townships 57, ranges 20 and 21, west of the third meridian. |
| Stock, J. J. | Ottawa, Ont. | Contract No. 10 of 1910. Subdivision of townships 54, 55 and 56, ranges 20 and 21, west of the third meridian. |
| Street, P. B. | Toronto, Ont. | Survey in township 27, range 21, and townships 27 and 28, range 22, west of the fifth meridian; townships 22 and 23, range 1, townships 22, 23 and 24, range 2, and townships 26, ranges 7 and 8, west of the sixth meridian. Traverse in township 22, range 1, townships 22 and 24, range 2 and townships 26, ranges 7 and 8, west of the sixth meridian. Resurvey in townships 27, ranges 21 and 22, west of the fifth meridian; townships 22 and 23, range 1, and townships 26, ranges 7 and 8, west of the sixth meridian. |
| Teasdale, C. M. | Concord, Ont. | Contract No. 3 of 1910. Subdivision of townships 44, 46, 47, 48 and the north third of 45, range 11, west of the second meridian. |
| Thibaudeau, W. | Montreal, Que. | Reconnaissance survey of Winnipeg and English rivers to determine the most suitable locations for storage reservoirs. |

## APPENDIX No. 1.—*Concluded.*

SCHEDULE of Surveyors employed and work executed by them, from April 1, 1910, to March 31, 1911.—*Concluded.*

| Surveyor. | Address. | Description of work. |
|---|---|---|
| Tyrrell, J. W. .. .. .. | Hamilton, Ont... .. .. | Contract No. 2 of 1910. Subdivision of townships 26, 27, 29 and 30, range 1, townships 26, 27, 28, 29 and 30, range 2, and townships 26, ranges 3 and 4, east of the principal meridian. |
| Waddell, W. H. .. .. .. | Edmonton, Alta. .. .. | Contract No. 16 of 1910. Subdivision of townships 65 and the south two-thirds of townships 66, ranges 10, 11 and 12, and townships 69, ranges 13 and 14, west of the fourth meridian. Survey of timber berth No. 1305 in townships 60 and 61, ranges 11 and 12, west of the fifth meridian. |
| Waldron, J. .. ....... | Moosejaw, Sask........ | Contract No. 18 of 1910. Subdivision of townships 68 and 69, ranges 18, 19 and 20, west of the fourth meridian. |
| Wallace, J. N. .. .. .. | Calgary, Alta. .. .. .. | Survey of the fourth meridian from the northeast corner of township 80 to the northeast corner of section 13, township 95. |
| Warren, Jas. .. .. .. | Walkerton, Ont. .. .. | Contract No. 7 of 1910. Subdivision of townships 52 and 53, range 14, township 53, range 15, and townships 53 and 54, range 16, west of the third meridian. |
| Watt, G. H. .. .. .. .. | Ottawa, Ont. .... .. .. | Contract No. 6 of 1910. Subdivision of townships 48 and 49, range 10, township 49, range 11, townships 50 and 51, ranges 12 and 13, and survey of the east boundary of township 52, range 12, west of the third meridian. |
| Williams, G. L. .. .. | Enderby, B.C. .. .. .. | Survey of blocks 4 and 5 of timber berth No. 253, near Revelstoke, B.C. |
| Woods, J. E. .. .. .. .. | Pincher Creek, Alta. | Traverse of Southfork river in township 6, range 3, west of the fifth meridian. |

## APPENDIX No. 2.

SCHEDULE showing for each surveyor employed from April 1, 1910, to March 31, 1911, the number of miles surveyed of township section lines, township outlines, traverses of lakes and rivers and resurvey, also the cost of the same.

| Surveyor. | Miles of Section Lines. | Miles of Outlines. | Miles of Traverse. | Miles of Resurvey. | Total Mileage. | Total Cost. | Cost per Mile. | By Day Work or by Contract. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $ | $ | |
| Akins, J. R | 82 | 18 | 9 | 11 | 120 | 8,662 | 72 19 | Day. |
| Aylsworth, C. F | 26 | | 1 | 185 | 212 | 9,652 | 45 53 | „ |
| Baker, J. C | 362 | 45 | 122 | | 529 | 13,911 | 26 29 | Contract. |
| Blanchet, G. H | 87 | | 18 | 32 | 137 | 13,649 | 99 63 | Day. |
| Bridgland, M. P | | | 23 | 31 | 54 | 1,378 | 25 52 | „ |
| Carson, P. A | | | 40 | 123 | 163 | 4,302 | 26 39 | „ |
| Cautley, R. H | 328 | 61 | | 11 | 400 | 12,533 | 31 33 | Contract. |
| Chilver, C. A | 281 | 18 | 62 | | 361 | 9,830 | 27 23 | „ |
| Christie, W | | 126 | | | 126 | 14,414 | 114 40 | Day. |
| Coté, J. L | 272 | 18 | 63 | | 353 | 9,883 | 28 00 | Contract. |
| Cumming, A. L | 126 | 22 | 109 | | 257 | 13,230 | 51 48 | Day. |
| Davies, T. A | 286 | 30 | 36 | 3 | 355 | 10,171 | 28 65 | Contract. |
| Deans, W. J | 100 | | 31 | 31 | 162 | 10,802 | 66 68 | Day. |
| Ducker, W. A | 17 | 32 | | | 49 | 4,785 | 97 65 | „ |
| Dumais, P. T. C | 234 | | 132 | | 366 | 8,487 | 23 19 | Contract. |
| Fairchild, C. C | 257 | 44 | 64 | 9 | 374 | 10,458 | 27 96 | „ |
| Fawcett, A | 288 | 30 | 71 | | 389 | 10,148 | 26 09 | „ |
| Findlay, A | 247 | 18 | 47 | | 312 | 8,587 | 27 52 | „ |
| Francis J | 106 | 21 | 30 | | 157 | 11,037 | 70 30 | Day. |
| Green, T. D | 278 | | 46 | | 324 | 9,045 | 27 91 | Contract. |
| Hawkins, A. H | | 109 | 13 | 25 | 147 | 14,519 | 98 77 | Day. |
| Heathcott, R. V | 327 | 58 | 41 | | 426 | 12,824 | 30 10 | Contract. |
| Holcroft, H. S | 301 | 51 | 144 | | 496 | 12,455 | 25 11 | „ |
| Hopkins, M. W | 466 | 117 | 62 | | 645 | 17,107 | 26 52 | „ |
| Kimpe, M | 363 | 54 | 80 | | 497 | 13,861 | 27 89 | „ |
| Knight, R. H | 290 | 36 | 60 | | 386 | 10,653 | 27 60 | „ |
| Lang, J. L | 51 | 2 | 3 | 33 | 89 | 7,807 | 87 72 | Day. |
| Laurie, R. C | 146 | 18 | 51 | | 215 | 5,222 | 24 29 | Contract. |
| Lighthall, A | 47 | | 18 | 9 | 74 | 9,237 | 124 82 | Day. |
| Mitchell, B. F | 247 | 24 | 71 | | 342 | 9,073 | 26 53 | Contract. |
| Montgomery, R. H | 480 | 50 | 197 | | 727 | 18,140 | 24 95 | „ |
| Morrier, J. E | 202 | | 65 | | 267 | 6,788 | 25 42 | „ |
| McFarlane, J. B | 90 | 47 | 17 | 3 | 157 | 13,333 | 84 92 | Day. |
| McFarlane, W. G | 537 | 99 | 91 | 48 | 775 | 18,224 | 23 51 | Contract. |
| McGrandle, H | 252 | 9 | 2 | | 263 | 7,933 | 30 16 | Contract. |
| McMillan, Geo | | 114 | | | 114 | 28,472 | 249 75 | Day. |
| McNaughton, A. L | 93 | 40 | 11 | | 144 | 14,152 | 98 28 | „ |
| O'Hara, W. F | 24 | | 10 | 237 | 271 | 8,015 | 29 58 | „ |
| Ord, L. R | 234 | | 88 | | 322 | 7,780 | 24 16 | Contract. |
| Plunkett, T. H | 113 | | 25 | 32 | 170 | 12,063 | 70 96 | Day. |
| Ponton, A. W | 4 | 225 | | 2 | 231 | 28,625 | 123 92 | „ |
| Robinson, E. W | 14 | 199 | | 1 | 214 | 22,186 | 103 67 | „ |
| Rolfson, O | 63 | 14 | 25 | 4 | 106 | 13,350 | 125 94 | „ |
| Ross, J. E | 146 | | 22 | 6 | 174 | 10,568 | 60 74 | „ |
| Roy, G. P | 326 | 38 | 58 | | 422 | 12,522 | 29 67 | Contract. |
| Saint Cyr, A | 22 | 85 | | | 107 | 26,833 | 250 77 | Day. |
| Saunders, B. J | | 30 | | | 30 | 23,160 | 772 00 | „ |
| Scott, W. A | 61 | 6 | 7 | 29 | 103 | 7,677 | 74 53 | „ |
| Seymour, H. L | 288 | 30 | 50 | | 368 | 10,345 | 28 11 | Contract. |
| Smith, D. A | 70 | | 6 | 16 | 92 | 10,218 | 111 06 | Day. |
| Smith, J. H | 392 | 58 | 55 | | 505 | 14,500 | 28 71 | Contract. |
| Steele, I. J | 276 | 12 | 87 | | 375 | 9,544 | 25 45 | „ |
| Stewart, L. D. N | 69 | | 13 | 9 | 91 | 9,915 | 108 96 | Day. |
| Stewart, W. M | 288 | 54 | 15 | | 357 | 10,866 | 30 44 | Contract. |
| Stock, J. J | 286 | 36 | 24 | | 346 | 10,056 | 29 07 | „ |
| Street, P. B | 76 | | 19 | 16 | 111 | 9,283 | 83 63 | Day. |

## APPENDIX No. 2.—*Concluded.*

SCHEDULE showing for each surveyor employed from April 1, 1910, to March 31, 1911, the number of miles surveyed of township section lines, township outlines, traverses of lakes and rivers and resurvey, also the cost of the same.—*Concluded*

| Surveyor. | Miles of Section Lines. | Miles of Outlines. | Miles of Traverse. | Miles of Resurvey. | Total Mileage. | Total Cost. | Cost per Mile. | By Day Work or by Contract. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $ | $ cts. | |
| Teasdale, C. M | 202 | 18 | 14 | ...... | 234 | 7,042 | 30 10 | Contract. |
| Tyrrell, J. W | 468 | 44 | 46 | ...... | 558 | 15,528 | 27 83 | " |
| Waddell, W. H | 326 | 48 | 196 | ...... | 570 | 13,345 | 23 41 | " |
| Waldron, J | 273 | 18 | 71 | ...... | 362 | 9,971 | 27 55 | " |
| Wallace, J. N | ...... | 88 | ...... | ...... | 88 | 27,065 | 307 56 | Day. |
| Warren, Jas | 214 | 32 | 24 | ...... | 270 | 7,687 | 28 47 | Contract. |
| Watt, G. H | 345 | 30 | 61 | ...... | 436 | 11,958 | 27 43 | " |
| Woods, J. E | ...... | ...... | 12 | ...... | 12 | 211 | 17 58 | Day. |
| Total | 11,849 | 2,376 | 2,758 | 906 | 17,889 | 765,077 | | |

SESSIONAL PAPER No. 25b

## APPENDIX No. 3.

LIST of lots in the Yukon Territory, survey returns of which have been received from April 1, 1910, to March 31, 1911.

GROUP No. 1.

| Lot No. | Acres. | Surveyor. | Year of Survey. | Date of Approval. | Claimant. | Remarks. |
|---|---|---|---|---|---|---|
| 45 | 346·86 | C. S. W. Barwell | 1909 | Dec. 12, 1910 | Northern Light, Power and Coal Co. | Right of way for Transmission Line. |

GROUP No. 2.

| Lot No. | Acres. | Surveyor. | Year of Survey. | Date of Approval. | Claimant. | Remarks. |
|---|---|---|---|---|---|---|
| 11 | 18·86 | James Gibbon | 1910 | May 26, 1910 | N. A. T. and T. Co. | Surface Resurvey. |
| 25 | 5·00 | " | 1910 | Nov. 25, 1910 | W. E. Sprague | Surface Block 35. |
| 381 | 50·4 | " | 1907 | Nov. 25, 1910 | E. Nichol et al | "Oro" Mineral Claim. |
| 382 | 41·5 | " | 1907 | Nov. 25, 1910 | E. Nichol et al | "Bernice" Mineral Claim. |
| 390 | 51·65 | " | 1908 | Feb. 23, 1911 | Agnes J. Kinsey | "Clara" " " |
| 419 | 43·56 | " | 1909 | July 15, 1910 | Jas. J. Lloyd | "Sunrise" " " |
| 439 | 51·64 | " | 1909 | Nov. 25, 1910 | Jas. Cameron et al | "Hunker" " " |
| 440 | 51·65 | " | 1909 | Feb. 23, 1911 | Malcolm John Campbell et al | "Kitchener" " " |
| 441 | 40·7 | " | 1909 | Feb. 23, 1911 | Malcolm John Campbell et al | "Roberts" " " |
| 447 | 36·5 | " | 1909 | Feb. 23, 1911 | Jas. Cameron et al | "Summit" " " |
| 448 | 47·74 | " | 1910 | Nov. 25, 1910 | Chas. Lauder et al | "Rattler" " " |
| 449 | 32·83 | " | 1909 | Nov. 25, 1910 | Jas. Cameron et al | "Le Roy" " " |
| 453 | 38·58 | " | 1909 | Nov. 25, 1910 | James Cameron | "Florodoro" " " |
| 454 | 41·32 | " | 1909 | June 2, 1910 | Malcolm John Campbell et al | "Eureka" " " |
| 455 | 41·23 | " | 1909 | Nov. 25, 1910 | Otto F. Kastner | "Dawson" " " |
| 459 | 51·65 | " | 1909 | Nov. 25, 1910 | James Cameron et al | "Calumet" " " |
| 460 | 42·7 | " | 1909 | June 6, 1910 | F. R. Elliott | "Welcome" " " |
| 465 | 35·2 | " | 1909 | June 6, 1910 | James Richard Irvine | "Dundas" " " |
| 466 | 42·53 | " | 1909 | Feb. 23, 1911 | Chas. Lauder et al | "Eclipse" " " |
| 467 | 19·38 | " | 1909 | Nov. 25, 1910 | Robert Greaves et al | "Franklin" " " |
| 476 | 11·35 | " | 1909 | Nov. 25, 1910 | Malcolm John Campbell | "Gold Run" " " |
| 477 | 51·56 | " | 1910 | Nov. 25, 1910 | W. O. Smith | "Golden Age" " |
| 478 | 29·8 | " | 1910 | Feb. 23, 1911 | H. H. Honnon et al | "Kenwood" " " |
| 479 | 5·1 | " | 1910 | Dec. 21, 1910 | Joseph Albert Segber | "Mary" Fractional Mineral |
| 480 | 9·3 | " | 1910 | Dec. 21, 1910 | Joseph Albert Segber | "Rebecca" " " |
| 481 | 31·1 | " | 1910 | Feb. 23, 1911 | H. H. Honnon et al | "Silver Knight" Mineral Claim. |
| 482 | 32·7 | " | 1910 | Feb. 23, 1911 | H. H. Honnon et al | "Tiger No. 2" " " |
| 483 | 41·9 | " | 1910 | Nov. 25, 1910 | Joseph Albert Segber | "Broken Hill" " " |
| 484 | 69·2 | " | 1910 | | Northern Light and Power Co | "Right of Way" " " |
| 503 | 36·69 | N. A. Burwash | 1909 | June 15, 1910 | J. H. McConnell | "Primrose" " " |
| 504 | 27·53 | " | 1909 | Nov. 25, 1910 | Jane S. Orrell et al | "Review" " " |

## APPENDIX No. 3 *Continued*

List of lots in the Yukon Territory, survey returns of which have been received from April 1, 1910 to March, 31, 1911—*Continued.*

GROUP No. 2—*Continued.*

| Lot. No. | Acres. | Surveyor. | Year of Survey. | Date of Approval. | Claimant. | Remarks. |
|---|---|---|---|---|---|---|
| 505 | 44·44 | " | 1909 | June 10, 1910 | Jane S. Orrell et al. | "Central" Mineral Claim. |
| 506 | 50·34 | " | 1909 | June 10, 1910 | Jane S. Orrell et al. | "Yellow Jacket" " |
| 507 | 47·74 | N. A. Burwash | 1909 | June 10, 1910 | James Lloyd et al. | "Exchange" " |
| 508 | 51·65 | " | 1909 | June 10, 1910 | " " | "Rosaline" " |
| 510 | 43·76 | " | 1909 | June 10, 1910 | M. Campbell | "Empire" " |
| 511 | 51·65 | " | 1909 | June 10, 1910 | A. A. Knorr | "Fearless" " |
| 512 | 32·90 | " | 1909 | June 10, 1910 | G. H. Lawrence et al. | "Mountain Maid" " |
| 513 | 50·16 | " | 1909 | Nov. 25, 1910 | D. R. Marshall | "Maple Leaf" " |
| 514 | 35·95 | " | 1909 | June 10, 1910 | David Bauer | "Pacific" " |
| 515 | 26·00 | " | 1909 | June 10, 1910 | Jane S. Orrell et al. | "Tiger" " |
| 516 | 51·65 | " | 1909 | June 10, 1910 | J. J. Lloyd et al. | "B. C." " |
| 517 | 50·71 | " | 1909 | May 31, 1910 | " " | "Deadwood" " |
| 518 | 51·65 | " | 1909 | May 31, 1910 | " " | "Doloris" " |
| 519 | 48·57 | " | 1909 | May 31, 1910 | " " | "O. K." " |
| 520 | 25·03 | " | 1909 | June 10, 1910 | Joseph Fournier | "Belle chasse" " |
| 521 | 17·19 | " | 1909 | June 10, 1910 | Louis Martin et al. | "Chicoutimi" " |

GROUP No. 5.

| Lot. No. | Acres. | Surveyor. | Year of Survey. | Date of Approval. | Claimant. | Remarks. |
|---|---|---|---|---|---|---|
| 163 | 50·29 | H. G. Dickson | 1909 | Nov. 25, 1910 | D. C. Campbell | "Bell" Mineral Claim. |
| 164 | 49·28 | " | 1909 | Nov. 25, 1910 | Dan Gilles | "Little May" Mineral Claim. |
| 165 | 44·93 | " | 1909 | Nov. 25, 1910 | R. Unsworth | "Caroline" " |
| 166 | 40·68 | " | 1909 | Nov. 25, 1910 | Gilbert Fowler | "Black Diamond" " |
| 167 | 83·72 | " | 1909 | Aug. 7, 1910 | A. B. Palmer | "Palmer No. 1" " |
| 168 | 39·10 | " | 1909 | Aug. 7, 1910 | " | "Skookum" " |
| 169 | 29·02 | " | 1910 | Aug. 7, 1910 | Ernest Burwash | "Ruby" " |
| 172 | 51·59 | " | 1910 | Nov. 29, 1910 | C. H. Johnston | "Grafter Annex" " |
| 189 | 51·21 | N. A. Burwash | 1909 | June 10, 1910 | L. V. Wilson | "Everrett" " |
| 197 | 155·67 | " | 1910 | | H. K. Burwash | "Real Thing" " |
| 198 | 47·03 | " | 1910 | June 10, 1910 | D. Ross | "Rothsay" " |

GROUP NO. 6.

| | | | | | | |
|---|---|---|---|---|---|---|
| 60 | 9·82 | H. G. Dickson | 1909 | Nov. 25, 1910 | W. S. McGee | "Blue Grouse" Mineral Claim. |
| 104 | 51·65 | " | 1909 | Nov. 25, 1910 | H. E. Porter | "Empire" " |
| 105 | 160·00 | " | 1909 | Nov. 25, 1910 | " | Surface lot. |
| 106 | 34·63 | " | 1909 | Nov. 25, 1910 | " | "Excelsior" Mineral Claim. |
| 107 | 51·65 | " | 1909 | Nov. 25, 1910 | " | "Porter" " |
| 109 | 51·65 | " | 1909 | Nov. 25, 1910 | Edward A. Dixon | "Evening" " |
| 110 | 50·19 | " | 1909 | July 7, 1910 | T. H. Kerrnish | "Little Jack" " |
| 111 | 45·91 | " | 1009 | Nov. 25, 1910 | Samuel E. Chambers | "Shamrock" " |
| 112 | 51·65 | " | 1910 | | H. W. Vance | "North Star" " |
| 113 | 51·53 | " | 1910 | | " | "Lucky Ell" " |
| 114 | 51·22 | " | 1910 | | Elvin J. Edwards | "Venus No. 3" " |

GROUP No. 10.

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | 47·37 | H. G. Dickson | 1910 | | Angus S. Fraser | "Remy" Mineral Claim. |

## APPENDIX No. 4.

LIST of miscellaneous surveys in the Yukon Territory, returns of which have been received from April 1, 1910, to March 31, 1911.

| Year. | Surveyor. | Description of Survey. |
|---|---|---|
| 1910.... | H. G. Dickson.... | Reference traverse from Carmack up Nordenskiold valley. |
| 1906.... | James Gibbon.... | Base line on Guysboro gulch, a tributary of Klondike river. |
| 1906.... | " .... | " " on Belcher " " " " |
| 1906.... | " .... | " " on Rabbit " " " " |
| 1906.... | " .... | " " on Twenty " " Hunker Creek. |
| 1906.... | " .... | " " on Twenty-one " " " " |
| 1906.... | " .... | " " on Hattie " " " " |
| 1906.... | " .... | " " on Thirty-seven " " " " |
| 1907 ... | " ... | Base and side lines on part of Sixtymile river, a tributary of Yukon river. |
| 1907.. . | " .... | " " " " on Bedrock creek, a tributary of Sixtymile river. |
| 1907.... | " .... | " " " " on Big Gold creek, a tributary of Sixtymile river. |
| 1907.... | " .... | " " " " on Glacier creek, a tributary of Big Gold creek. |
| 1910... | C. W. MacPherson | Base line on Goring gulch, a tributary of Klondike river. |

## APPENDIX No. 5.

STATEMENT of work executed in the office of the Chief Draughtsman:—

| | |
|---|---|
| Letters of instructions to surveyors | 335 |
| Progress sketches received and filed | 1.206 |
| Declarations of settlers received and filed | 123 |
| Returns of timber berths received | 48 |
| Plans received from surveyors | 509 |
| Field books received from surveyors | 760 |
| Timber reports received | 278 |
| Observations for magnetic declination received | 987 |
| Dip observations received | 94 |
| Total force observations received | 72 |
| Preliminary township plans prepared | 355 |
| Sketches made | 4,033 |
| Maps and tracings made | 134 |
| Plans of Yukon lots received | 71 |
| Plans of miscellaneous Yukon surveys received | 13 |
| Yukon lots reduced to 40 chains to 1 inch and plotted on group plans | 45 |
| Returns of surveys examined— | |
| Township subdivision | 372 |
| Township outline | 260 |
| Road plans | 229 |
| Railway plans | 55 |
| Yukon lots | 118 |
| Miscellaneous Yukon surveys | 21 |
| Mineral claims | 16 |
| Timber berths | 64 |
| Correction and other miscellaneous surveys | 165 |
| Township plans compiled | 918 |
| Topographical township plans compiled | 156 |
| Townsite, settlement and other plans compiled | 15 |
| Proofs of plans examined | 108 |
| Township plans printed | 740 |
| Townsite and settlement plans printed | 13 |
| Miscellaneous plans printed | 197 |
| Descriptions written | 13 |
| Pages of field notes copied | 627 |
| Applications for various information dealt with | 2.863 |
| Files received and returned | 2.469 |
| Letters and memoranda drafted | 8.355 |
| Books received from Record Office and used in connection with office work | 4.969 |
| Books returned to Record Office | 4,869 |
| Plans other than printed township plans received from Record Office and used in connection with office work | 654 |
| Plans returned to Record Office | 673 |

**APPENDIX No. 5.**—*Concluded.*

| | |
|---|---|
| Volumes of plans received from Record Office and used in connection with office work | 92 |
| Volumes of plans returned to Record Office | 85 |
| Books sent to Record Office to be placed on record | 772 |
| Plans other than township plans sent to Record Office to be placed on record | 273 |
| Sectional maps (3 miles to 1 inch)— | |
| Revised | 56 |
| Reprinted | 38 |
| Sectional maps (6 miles to 1 inch)— | |
| Reprinted | 46 |

## APPENDIX No. 6.

LIST of new editions of Sectional Maps issued from April 1, 1910, to March 31, 1911.

SCALE 3 MILES TO ONE INCH.

| No. | Name. | No. | Name. | No. | Name. | No. | Name. |
|---|---|---|---|---|---|---|---|
| 15 | Lethbridge. | 115 | Blackfoot. | 172 | Fairford. | 313 | Brulé. |
| 16 | Milk River. | 116 | Rainy Hills. | 215 | Red Deer. | 314 | St. Ann. |
| 17 | Cypress. | 117 | Red Deer Forks. | 217 | Tramping Lake. | 315 | Edmonton. |
| 19 | Willowbunch. | 118 | Rush Lake | 218 | Saskatoon. | 317 | Fort Pitt. |
| 20 | Souris. | 162 | Seymour. | 219 | Humboldt. | 364 | Fort Assiniboine. |
| 66 | Medicine Hat. | 164 | Morley. | 220 | Nut Mt. | 365 | Victoria. |
| 67 | Maple Creek. | 166 | Sounding Creek. | 263 | Jasper. | 415 | Tawatinaw. |
| 69 | Moosejaw. | 167 | Bad Hills. | 265 | Peace Hills. | 416 | La Biche. |
| 73 | Winnipeg. | 168 | The Elbow. | 267 | Battleford. | | |
| 113 | Spillimacheen. | 171 | Duck Mt. | 269 | Carlton. | | |

SCALE 6 MILES TO ONE INCH.

| No. | Name. | No. | Name. | No. | Name. | No. | Name. |
|---|---|---|---|---|---|---|---|
| 14 | Pincer Creek. | 74 | Cross Lake. | 168 | The Elbow. | 313 | Brulé. |
| 15 | Lethbridge. | 113 | Spillimacheen. | 171 | Duck Mt. | 314 | St. Ann. |
| 16 | Milk River. | 115 | Blackfoot. | 172 | Fairford. | 315 | Edmonton. |
| 17 | Cypress. | 116 | Rainy Hills. | 215 | Red Deer. | 316 | Vermilion. |
| 19 | Willowbunch. | 117 | Red Deer Forks. | 216 | Sullivan Lake. | 317 | Fort Pitt. |
| 22 | Dufferin. | 120 | Qu'Appelle. | 217 | Tramping Lake. | 364 | Fort Assiniboine. |
| 66 | Medicine Hat. | 164 | Morley. | 220 | Nut Mt. | 365 | Victoria. |
| 67 | Maple Creek. | 165 | Rosebud. | 263 | Jasper. | 415 | Tawatinaw. |
| 68 | Swiftcurrent. | 166 | Sounding Creek. | 264 | Brazeau. | 416 | La Biche. |
| 73 | Winnipeg. | 167 | Bad Hills. | 265 | Peace Hills. | | |

# APPENDIX No. 7.

STATEMENT of work executed in the Photographic Office from April 1, 1910, to March 31, 1911.

| | 3¼ x 3¼ | 3¼ x 5½ | 5 x 7 | 8 x 10 | 10 x 12 | 11 x 14 | 16 x 18 | 18 x 20 | 20 x 24 | 24 x 30 | 30 x 36 | 36 x 42 | 42 x 48 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry plate negatives | | 830 | 684 | 2 | | 21 | | | | | | | | 1,540 |
| Bromide prints | | 13 | 35 | 29 | 31 | 45 | 120 | 67 | 26 | 20 | 46 | 37 | 2 | 471 |
| Solio prints | | 1,923 | 4,373 | 473 | 1 | 32 | | | | | | | | 6,802 |
| Velox prints | | 3,438 | 1,256 | | | 76 | | | | | | | | 4,770 |
| Artura prints | | | 1,595 | 228 | | 44 | | | | | | | | 1,867 |
| Vandyke prints | | | 43 | 9 | 10 | 113 | 73 | 186 | 121 | 50 | 51 | 79 | 14 | 749 |
| Blue prints | | | | 4 | 32 | 17 | 34 | 51 | 66 | 125 | 18 | 58 | 21 | 426 |
| Lantern transparencies | 465 | | | | | | | | | | | | | 465 |
| Photographs mounted | | 495 | 282 | 60 | | | 59 | | | | | | | 896 |
| Wet plate negatives | | | | 83 | | 171 | 986 | 159 | 36 | | | | | 1,435 |
| Photo-litho plates | | | | | | | | 1131 | 8 | | | | | 1,142 |
| Totals | 465 | 6,699 | 8,268 | 888 | 74 | 522 | 1,272 | 1,597 | 257 | 195 | 115 | 174 | 37 | 20,563 |

## APPENDIX No. 8.

STATEMENT of work executed in the Lithographic Office from April 1, 1910, to March 31, 1911.

| Month. | | Maps. | | | Townships. | | | Forms. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Copies. | Impressions. | No. | Copies. | Impressions. | No. | Copies. | Impressions. |
| April | 1910 | 9 | 8,085 | 22,190 | ..... | ........ | ........ | 4 | 339 | 339 |
| May | " | 22 | 191,125 | 716,575 | 63 | 12,600 | 13,800 | 3 | 1,070 | 1,070 |
| June | " | 16 | 6,811 | 7,036 | 138 | 27,600 | 27,800 | ..... | ........ | .. |
| July | " | 4 | 900 | 900 | 12 | 2,400 | 2,400 | 2 | 700 | 700 |
| August | " | 15 | 6,725 | 11,750 | ..... | ........ | ........ | 9 | 11,475 | 11,725 |
| September | " | 5 | 2,075 | 2,225 | 75 | 15,000 | 15,000 | 5 | 3,380 | 3,480 |
| October | " | 23 | 9,500 | 9,575 | 96 | 19,200 | 20,300 | 6 | 1,590 | 1,590 |
| November | " | 30 | 11,800 | 11,875 | 164 | 32,800 | 33,000 | 7 | 11,635 | 11,635 |
| December | " | 4 | 725 | 725 | ..... | ........ | ........ | 1 | 300 | 300 |
| January | 1911 | 5 | 935 | 1,145 | 51 | 10,200 | 10,200 | 6 | 7,130 | 9,630 |
| February | " | 11 | 73,075 | 205,025 | 20 | 3,804 | 4,204 | 7 | 25,200 | 25,200 |
| March | " | 17 | 107,650 | 284,475 | 121 | 24,200 | 24,200 | 5 | 10,700 | 12,700 |
| Total | | 161 | 419,406 | 1,273,496 | 740 | 147,804 | 150,901 | 55 | 73,519 | 78,369 |

RECAPITULATION.

| —— | No | Copies. | Impressions. | Cost. |
|---|---|---|---|---|
| | | | | $ cts. |
| Maps | 161 | 419,406 | 1,273,496 | 3,356 68 |
| Townships | 740 | 147,804 | 150,904 | 5,301 20 |
| Forms | 55 | 73,519 | 78,369 | 1,032 12 |
| Grand total | 956 | 640,729 | 1,502,769 | 9,690 00 |

## APPENDIX No. 9.

List of employees of the Topographical Surveys Branch at Ottawa, giving the name, classification, duties of office and salary of each. (Metcalfe street, corner of Slater.)

| Name. | Classification. Division. | Sub-division. | Duties of Office. | Salary. |
|---|---|---|---|---|
| | | | | $ |
| Deville, E., D.T.S., LL.D. | 1 | A | Surveyor General. | 3,550 |
| | Correspondence. | | | |
| Brady, M. | 1 | B | Secretary. | 2,300 |
| Cullen, M. J. | 3 | A | Stenographer | 1,200 |
| Moran, J. F. | 3 | A | Typewriter and clerk | 900 |
| Williams, E. R. | 3 | A | Correspondence clerk | 900 |
| Addison, W. G. | 3 | B | Typewriter. | 750 |
| Pegg, A. | | | Messenger | 800 |
| O'Meara, M. T. | | | " | 500 |
| Pick, A. C. | | | " | 500 |
| | Accounts. | | | |
| Hunter, R. H. | 2 | A | Accountant | 2,050 |
| Wilkinson, Percy | 3 | A | Asst. Accountant. | 1,050 |

Chief Draughtsman's Office—General direction and supervision of the technical work.

| | | | | |
|---|---|---|---|---|
| Symes, P. B. | 1 | B | Chief draughtsman. | 2,350 |
| Shanks, T., B.A.Sc., D.L.S. | 1 | B | Asst. chief draughtsman | 2,450 |

## APPENDIX No. 9.—*Continued.*

### Chief Draughtsman's Office, First Section—Survey instructions and general information.

| Name. | Classification. Division | Sub-division. | Duties of Office. | Salary. |
|---|---|---|---|---|
| | | | | $ cts. |
| Brown, T. E., B.A | 1 | B | Chief of section | 2,450 00 |
| Umbach, J. E., Grad. S.P.S., D.L.S | 2 | A | Asst. chief of section | 1,850 00 |
| Barber, H. G., Grad. S.P.S | 2 | A | " " | 1,850 00 |
| Rice, F. W., Grad. School of Mining | 2 | A | " " | 1,850 00 |
| Belleau, J. A., D.L.S | 2 | A | " " | 1,950 00 |
| Sylvain, J | 2 | A | " " | 1,650 00 |
| McRae, A. D., B.A., B. Sc | 2 | B | Draughtsman | 1,350 00 |
| Carroll, M. J., Grad. S.P.S | 2 | B | " | 1,550 00 |
| Grant, A. W., B.A | 2 | B | " | 1,350 00 |
| Peaker, W. L., Grad. S.P.S | 2 | B | " | 1,250 00 |
| Grant, A. M., B. Sc | 2 | B | " | 1,250 00 |
| Milliken, J. B., B.A., B. Sc | 2 | B | " | 1,250 00 |
| MacMillan, J. P., B.E. | 2 | B | " | 1,250 00 |
| Cordukes, J. P., B. Sc | 2 | B | " | 1,150 00 |
| Wadlin, L. N., B. Sc | 2 | B | " | 1,150 00 |
| Hayward, H. E., B. Sc | 2 | B | " | 1,250 00 |
| McCully, R. C., B.A | 2 | B | " | 1,000 00 |
| Gagnon, J. N. H., B.A. S | 2 | B | " | 1,000 00 |
| Rochon, E. C | 2 | B | " | 1,350 00 |
| Holbrook, C. H | 3 | A | Clerk | 950 00 |
| Burkholder, F. L. | 3 | A | " | 900 00 |

### Chief Draughtsman's Office, Second Section—Surveys in Manitoba, Saskatchewan, Alberta and Yukon.

| Name. | Division | Sub-division | Duties of Office. | Salary. |
|---|---|---|---|---|
| Nash, T. S., Grad. S.P.S., D.L.S. | 1 | B | Chief of section | 2,400 00 |
| Burgess, E. L., Grad. S.P.S., D.L.S., O.L.S | 2 | A | Asst. chief of section | 1,850 00 |
| Dennis, E. M., B. Sc | 2 | A | " " | 1,870 00 |
| Elder, A. J., Grad. S.P.S., D.L.S | 2 | A | " " | 1,850 00 |
| Henderson, F.D., Grad. S.P.S., D.L.S. | 2 | A | " " | 1,870 00 |
| Hill, S. N., Grad. S.P.S. | 2 | A | " " | 1,850 00 |
| Genest, P.F.X., Q L.S. | 2 | A | " " | 1,850 00 |
| Robertson, D.F., Grad. S.P.S | 2 | A | " " | 1,650 00 |
| Sutherland, H.E., B. Sc. | 2 | B | Draughtsman | 1,350 00 |
| Kitto, F. H., D.L.S. | 2 | B | " | 1,450 00 |
| McClennan, W. D | 2 | B | " | 1,600 00 |
| Roger, A., O.L.S. | 2 | B | " | 1,600 00 |
| Spreckley, R. O. | 2 | B | " | 1,450 00 |
| Goodday, Leonard | 2 | B | " | 1,350 00 |
| Bray, R. P | 2 | B | " | 1,350 00 |
| Harrison, E. W. | 2 | B | " | 1,250 00 |
| Ault, H. W. | 2 | B | " | 1,250 00 |
| Lytle, W. J. | 2 | B | " | 1,000 00 |
| La Beree, E. E. | 2 | B | " | 1,000 00 |
| Jones, G. S., Grad. S.P.S., O.L.S | 2 | B | " | 1,000 00 |
| Bradley, J. D | 2 | B | " | 1,000 00 |
| Dubuc, C.P., Q.L.S. | 2 | B | " | 1,000 00 |
| Cagnat, G. H | 2 | B | " | 1,000 00 |
| Fournier, O. E., B A.S. | 2 | B | " | 1,000 00 |
| Ross, C. M., B. Sc. | 2 | B | " | 1,200 00 |
| Macdonald, J. A. | 3 | B | Clerk | 800 00 |

## APPENDIX No. 9.—*Continued.*

Chief Draughtsman's Office, Third Section—(Imperial Building, Queen street). Copying plans for reproduction.

| Name. | Classification. Division | Sub-division. | Duties of Office. | Salary. $ cts. |
|---|---|---|---|---|
| Engler, Carl, B.A., D.L.S. | 2 | A | Chief of section | 2,000 00 |
| May, J. E. | 2 | A | Asst. " | 1,850 00 |
| O'Connell, J. R. | 2 | A | " " | 1,650 00 |
| Moule, W. J. | 2 | B | Draughtsman | 1,600 00 |
| Helmer, J. D. | 2 | B | Clerk | 1,050 00 |
| Archambault, E. | 2 | B | " | 1,050 00 |
| Dawson, R. J. | 2 | B | " | 1,050 00 |
| Watters, James. | 3 | A | Printer | 1,200 00 |
| Tremblay, A. | 3 | A | Clerk. | 900 00 |
| Brown, A. | 3 | A | " | 900 00 |
| Ebbs, E. J. | 3 | A | " | 900 00 |
| Beaubien, A. H. | 3 | B | " | 700 00 |
| Baril, C. | 3 | B | " | 700 00 |
| Marchand, C. E. | 3 | B | Engrosser | 500 00 |

Chief Draughtsman's Office, Fourth Section—(Metcalfe street, corner of Slater). British Columbia surveys.

| | | | | |
|---|---|---|---|---|
| Rowan-Legg, E. L. | 2 | A | Chief of section | 2,000 00 |
| Gillmore, E. T. B., Grad. R.M.C. | 2 | A | Asst. chief " | 1,950 00 |
| Lawe, H. D.L.S. | 2 | A | " " | 1,850 00 |
| MacIlquham, W. L., B. Sc. | 2 | A | " " | 1,850 00 |
| Morley, R. W. | 2 | A | " " | 1,850 00 |
| Weld, W. E. | 2 | A | " " | 1,850 00 |
| Wilson, E. E. D. | 2 | A | " " | 1,600 00 |
| Osmond, H. A.K.C. | 2 | B | Draughtsman | 1,250 00 |
| Harris, K. D. | 2 | B | " | 1,250 00 |

Chief Draughtsman's Office, Fifth Section—(Imperial Building, Queen street). Mapping.

| | | | | |
|---|---|---|---|---|
| Smith, J. | 1 | B | Chief of section. | 2,450 00 |
| Begin, P. A. | 2 | A | Asst. chief " | 1,900 00 |
| Flindt, A. H. | 2 | A | " " | 1,650 00 |
| Blanchet, A. E. | 2 | B | Draughtsman | 1,600 00 |
| Davies, T. E. S. | 2 | B | " | 1,550 00 |
| Perrin, V. | 2 | B | " | 1,550 00 |
| d'Orsonnens, A. | 2 | B | " | 1,550 00 |
| Davy, E. | 2 | B | " | 1,350 00 |
| Villeneuve, E. | 2 | B | " | 1,050 00 |
| Bergin, W. | 2 | B | " | 1,050 00 |
| Howie, Jas. | 2 | B | " | 1,000 00 |
| Purdy, W. A. | 2 | B | " | 1,100 00 |
| Brigly, J. H. | 2 | B | " | 1,300 00 |

## APPENDIX No. 9.—*Concluded.*

### Chief Draughtsman's Office, Sixth Section—(Imperial Building, Queen street). Scientific and topographical work.

| Name. | Classification. Division | Sub-division | Duties of Office. | Salaries. |
|---|---|---|---|---|
| | | | | $ cts. |
| Dodge, G.B., D.L.S | 1 | B | Chief of section | 2,450 00 |
| Coté, J. A., Grad. R.M.C | 2 | A | Asst. chief of section | 1,600 00 |
| Blanchard, J. F | 2 | B | Draughtsman | 1,000 00 |
| Chartrand, D. E., B.Sc | 2 | B | " | 1,050 00 |
| Cousineau, A., B.A.Sc | 2 | B | " | 1,050 00 |
| Dozois, L. O. R., Grad. R.M.C | 2 | B | " | 1,050 00 |
| Fredette, J. F | 2 | B | " | 1,000 00 |
| Hoar, C. M., B.Sc., D.L.S | 2 | B | " | 1,000 00 |
| Roe, B. J | 2 | B | " | 1,000 00 |
| Lynch, F. J | 3 | B | Typewriter | 800 00 |
| Watson, J. A | 3 | B | Clerk | 700 00 |

### Geographic Board (Woods Building, Slater street).

| | | | | |
|---|---|---|---|---|
| Whitcher, A. H., F.R.G.S., D.L.S | 2 | A | Secretary | 2,100 00 |

### Photographic Office (Metcalfe street, corner Slater street).

| | | | | |
|---|---|---|---|---|
| Carruthers, H. K | 2 | A | Process photographer | 1,850 00 |
| Woodruff, John | 2 | A | Chief " | 1,850 00 |
| Whitcomb, H. E | 3 | A | Photographer | 1,200 00 |
| Morgan, W. E | 3 | A | " | 1,150 00 |
| Kilmartin, A | 3 | A | Asst. photographer | 900 00 |
| Devlin, A | 3 | B | " | 800 00 |
| Ouimet, E. G | 3 | B | " | 800 00 |

### Lithographic Office (unclassified) (Metcalfe street, corner Slater street).

| Name. | Occupation. | Salaries. |
|---|---|---|
| | | $ |
| Moody, A | Foreman | 25 00 per week. |
| Burnett, E | Lithographer | 25 00 " |
| Thicke, C. R | " | 22 00 " |
| Deslauriers, J. H | Transferrer | 20 00 " |
| Bergin, J | Printer | 20 00 " |
| Thicke, H. S | " | 18 00 " |
| Boyle, S | Stone polisher | 14 00 " |
| Gagnon, J | Press feeder | 11 00 " |
| Kane, P | " | 8 00 " |
| Easton, H. M | Printer | 18 50 " |
| Hare, E. H | Asst. photographer | 14 00 " |

## APPENDIX No. 10.

List of Dominion Land Surveyors who have been supplied with Standard Measures.

| Name. | Address. | Date of Birth. | Date of Appointment or of Commission. | Remarks. |
|---|---|---|---|---|
| Akins, James Robert | Kinburn, Ont. | Sept. 2, '76 | Mar. 14, '10 | |
| Allison, Calvin Bruce | South Woodslee, Ont | June 16, '84 | Mar. 28, '10 | |
| Ashton, Arthur Ward | Ottawa, Ont | Nov. 5, '80 | May 29, '08 | |
| Austin, George Frederick | Not known. | ...... | April 14, '72 | |
| Aylen, John | North Bay, Ont | ...... | May 29, '85 | |
| Aylsworth, Charles Fraser | Madoc, Ont | April 21, '62 | May 13, '86 | O. L. S. |
| Baker, James Clarence | Vermilion, Alta | May 12, '78 | May 18, '06 | |
| Baker, Mason Hermon | St. Thomas, Ont | July 9, '84 | Aug. 6, '08 | O. L. S. |
| Bayne, George A | Winnipeg, Man | Oct. 25, '50 | April 14, '72 | M. L. S. |
| Beatty, David | Parry Sound, Ont | Dec. 22, '42 | April 14, '72 | O. L. S. |
| Begg, William Arthur | Hamilton, Ont | July 15, '82 | June 8, '09 | |
| Belanger, Phidime Roch Arthur | Ottawa, Ont | Mar. 5, '53 | May 17, '80 | Inspector of Surveys, Topographical Surveys Branch, Dept. of the Interior. |
| Belleau, Joseph Alphonse | Ottawa, Ont | Sept. 30, '56 | May 15, '83 | Topographical Surveys Branch, Dept. of the Interior. |
| Bemister, George Bartlett | Winnipeg, Man | ...... | June 11, '78 | M. L. S. Engineering Dept. C.N.R. |
| Bennett, George Arthur | Eden, Ont | May 18, '86 | Aug. 25, '10 | |
| Bigger, Charles Albert | Ottawa, Ont | Aug. 15, '53 | Mar. 30, '82 | B. C. L. S., O. L. S., Assistant Superintendent Geodetic Survey. |
| Bingham, Edwin Ralph | Fort William, Ont | — '78 | Oct. 25, '06 | O. L. S. |
| Blanchet, Guy Houghton | Ottawa, Ont | Feb. 12, '84 | Mar. 10, '10 | |
| Boswell, Elias John | Not known | ...... | Mar. 18, '03 | O. L. S., M. L. S. |
| Bourgeault, Armand | St. Jean Port Joli, Que | Feb. 23, '58 | Mar. 29, '83 | Q. L. S. |
| Bourgault, Charles Eugene | St. Jean Port Joli, Q. | Sept. 6, '61 | Feb. 21, '88 | |
| Bourget, Charles Arthur | Lauzon, Que | Aug. 26, '51 | May 14, '84 | Q. L. S. |
| Bowman, Herbert Joseph | Berlin, Ont | June 18, '65 | Feb. 16, '88 | O. L. S. |
| Brabazon, Alfred James | Ottawa, Ont | ...... | May 13, '82 | Boundary Survey, Dept. of the Interior. |
| Brady, James | Golden, B.C | Nov. 24, '40 | April 14, '72 | O. L. S., B. C. L. S. |
| Bray, Samuel | Ottawa, Ont | Nov. 5, '46 | Nov. 14, '83 | O. L. S., Chief Surveyor, Dept. of Indian Affairs. |
| Bray, Lennox Thomson | Amherstburg, Ont. | Mar. 14, '77 | Feb. 18, '03 | O. L. S |
| Brenot, Lucien | Ottawa, Ont | Aug. 31, '87 | Mar. 18, '10 | |
| Bridgland, Morrison Parsons | Calgary, Alta | Dec. 20, '78 | Mar. 10, '05 | |
| Broughton, George Henry | Penticton, B.C. | Aug. 12, '86 | June 3, '09 | B. C. L. S. |
| Brown Charles Dudley | Winnipeg, Man | Feb. 25, '83 | April 4, '10 | |
| Brown, Thomas Wood | Edmonton, Alta | ...... | June 21, '09 | |
| Brownlee, James Harrison | Vancouver, B.C | Mar. 22, '56 | April 15, '87 | M. L. S., B. C. L. S. |
| Bucknill, Walter Birch | Vancouver, B. C | May 8, '73 | Mar. 19, '08 | B. C. L. S. |
| Burgess, Edward LeRoy | Ottawa, Ont | May 5, '78 | Feb. 23, '05 | O. L. S., T. S. Branch, Dept. of Interior. |
| Burnet, Hugh | Victoria, B.C | ...... | June 22, '85 | O. L. S., B. C. L. S. |
| Burwash, Nathaniel Alfred | Whitehorse, Y.T. | Sept. 28, '79 | Mar. 6, '07 | O. L. S. |
| Burwell, Herbert Mahlon | Vancouver, B.C | Oct. 23, '63 | Feb. 17, '87 | B. C. L. S. |
| Campbell, Alan John | Sidney, B.C | Oct. 1, '82 | April 13, '09 | |
| Campbell, Alexander Stewart | Kingston, Ont | Mar. 7, '80 | Mar. 6, '09 | |
| Carbert, Joseph Alfred | Medecine Hat, Alta. | Feb. 4, '56 | May 12, '80 | O.L.S., District Engineer and Surveyor, Dept. of Public Works, Alberta. |
| Carpenter, Henry Stanley | Regina, Sask. | Feb. 8, '74 | Feb. 20, '01 | Dept. of Public Works, O. L. S. |
| Carroll, Cyrus | Prince Albert, Sask. | Dec. 6, '34 | April 14, '72 | O. L. S. |
| Carson, Percy Alexander | Ottawa, Ont | Dec. 25, '77 | Feb. 22, '06 | |
| Carthew, William Morden | Edmonton, Alta | Oct. 19, '86 | Mar. 29, '10 | |

## APPENDIX No. 10—*Continued.*

LIST of Dominion Land Surveyors who have been supplied with Standard Measures—*Continued.*

| Name. | Address. | Date of Birth. | Date of Appointment or of Commission. | Remarks. |
|---|---|---|---|---|
| Cautley, Reginald Hutton | Edmonton, Alta | Dec. 6, '79 | May 1, '05 | |
| Cautley, Richard William | Edmonton, Alta | Aug. 3, '73 | Sept. 2, '96 | |
| Cavana, Allan George | Orillia, Ont | Jan. 22, '58 | Nov. 16, '76 | O.L.S. |
| Charlesworth, Lionel Clare | Edmonton, Alta | Nov. 17, '73 | Mar. 24, '03 | O.L.S., Dept. of Public Works for Alberta. |
| Chilver, Charles Alonzo | Walkerville, Ont | Feb. 8, '83 | Feb. 22, '07 | |
| Christie, William | Prince Albert, Sask | Feb. 13, '76 | Mar. 22, '06 | |
| Clarke, Charles Wentworth | Regina, Sask | Nov. 19, '75 | Mar. 24, '10 | |
| Cleveland, Ernest Albert | Vancouver, B.C. | May 12, '74 | June 27, '99 | B.C.L.S. |
| Coates, Preston Charles | Golden, B.C. | May 16, '81 | Apr. 19, '07 | B.C.L.S. |
| Cokely, Leroy S. | Merritt, B.C. | Nov. 23, '84 | Mar. 22, '10 | |
| Côté, Joseph Adélard | Prince Albert, Sask | June 5, '64 | May 14, '84 | |
| Côté, Jean Léon | Edmonton, Alta | May 6, '67 | Mar. 21, '90 | |
| Cotton, Arthur Frederick | New Westminster, B.C. | Aug. 8, '52 | May 11, '80 | O.L.S., B.C.L.S. |
| Craig, John Davidson | Ottawa, Ont | Jan. 30, '76 | Feb. 24, '02 | Boundary Surveys, Dept. of the Interior. |
| Cumming, Austin Lewis | Cornwall, Ont | Aug. 25, '82 | Feb. 3, '10 | |
| Cummings, Alfred | Fernie, B.C. | July 3, '80 | Mar. 3, '09 | B.C.L.S. |
| Cummings, John George | Cranbrook, B.C. | Nov. 19, '73 | Feb. 17, '04 | B.C.L.S. |
| Dalton, John Joseph | Weston, Ont | June 12, '54 | Apr. 17, '79 | O.L.S., D.T.S. |
| Davies, Thomas Attwood | Edmonton, Alta | ....... | Feb. 22, '06 | |
| Dawson, Frederick James | Ashcroft, B.C. | Sept. 22, '86 | Sept. 12, '10 | |
| Day, Harry Samuel | St. John, N.B. | Nov. 14, '85 | Mar. 9, '10 | |
| Deans, William James | Brandon, Man | May 4, '60 | May 13, '86 | O.L.S. |
| de la Condamine, C. | High River, Alta | Feb. 13, '75 | May 4, '10 | |
| Dennis, John Stoughton | Calgary, Alta | Oct. 22, '56 | Nov. 19, '77 | D.T.S. |
| Denny, Herbert C. | Not known | ....... | Apr. 1, '82 | |
| Dickson, Henry Godkin | Whitehorse, Y.T. | Mar. 29, '64 | Mar. 19, '89 | M.L.S. |
| Dickson, James | Fenelon Falls, Ont | Oct. 30, 34 | Apr. 14, '72 | O.L.S. |
| Dobie, James Samuel | Thessalon, Ont | Oct. 15, '73 | Mar. 22, '06 | O.L.S. |
| Doupe, Jacob Lonsdale | Winnipeg, Man | Sept. 14, '67 | Oct. 6, '88 | M.L.S., Asst. Land Commissioner for C.P.R. |
| Drewry, William Stewart | Nelson, B.C. | Jan. 20, '59 | Nov. 14, '83 | O.L.S., B.C.L.S. |
| Driscoll, Alfred | Edmonton, Alta | July 2, '65 | Feb. 23, '87 | B.C.L.S. |
| Drummond, Thomas | Montreal, P.Q. | 1856 | June 24, '78 | D.T.S. |
| Ducker, William A. | Winnipeg, Man | Apr. 4, '52 | Mar. 30, '83 | O.L.S., M.L.S. |
| Dumais, Paul T. Concorde | Hull, P.Q. | Jan. 2, '47 | Mar. 29, '82 | Q.L.S. |
| Edwards, George | Ponoka, Alta | June 13, '42 | Apr. 14, '72 | O.L.S. |
| Edwards, William Milton | Lethbridge, Alta | June 21, '79 | Apr. 5, '10 | |
| Ellacott, Charles Herbert | Victoria, B.C. | Dec. 24, '66 | Feb. 22, '99 | B.C.L.S. |
| Empey, John Morgan | Calgary, Alta | Apr. 16, '74 | Feb. 23, '05 | O.L.S. |
| Engler, Carl | Ottawa, Ont | Sept. 30, '72 | Feb. 23, '05 | T.S., Branch, Dept. of Interior. |
| Fairchild, Charles Courtland | Brantford, Ont | Feb. 21, '67 | Feb. 20, '01 | O.L.S. |
| Farncomb, Alfred Ernest | Lacombe, Alta | May 22, '73 | Mar. 12, '02 | O.L.S. |
| Fawcett, Thomas | Toronto, Ont | Oct. 28, '48 | Nov. 18, '76 | O.L.S., D.T.S. |
| Fawcett, Adam | Gravenhurst, Ont | ....... | Feb. 22, '93 | |
| Ferguson, George Hendry | Toronto, Ont | Jan. 20, '83 | June 2, '09 | |
| Findlay, Allan | Winnipeg, Man | Oct. 15, '80 | Mar. 21, '08 | |
| Fontaine, Louis Elie | Levis, P.Q. | Oct. 3, '68 | Nov. 30, '92 | |
| Francis, John | Portage la Prairie, M | Dec. 22, '52 | June 17, '75 | M.L.S. |
| Garden, James Ford | Vancouver, B.C. | Feb. 19, '47 | May 13, '80 | B.C.L.S. |
| Garden, George H | Lethbridge, Alta | ....... | Apr. 14, '72 | Deputy Surveyor for N.B. |
| Garden, Charles | Not known | ....... | Apr. 14, '72 | Deputy Surveyor for N.B. |
| Garner, Albert Coleman | S. Qu'Appelle, Sask. | Sept. 6, '78 | May 27, '07 | |
| Gauvreau, Louis Pierre | Not known | ....... | Apr. 14, '72 | |
| Gibbon, James | Dawson, Y.T. | June 25, '60 | Feb. 12, '91 | O.L.S. |
| Gordon, Maitland Lockhart | Vancouver, B.C. | ....... | Feb. 18, '04 | B.C.L.S. |
| Gordon, Robert John | Lethbridge, Alta | June 18, '69 | Mar. 12, '02 | |
| Gore, Thomas Sinclair | Victoria, B.C. | 1852 | Apr. 19, '79 | B.C.L.S. |
| Graham, John Robertson | Ottawa, Ont | April 18, '87 | May 26, '10 | |
| Green, Alfred Harold | Nelson, B.C. | Jan. 20, '79 | Feb. 23, '05 | B.C.L.S. |

## APPENDIX No. 10—*Continued.*

LIST of Dominion Land Surveyors who have been supplied with Standard Measures—*Continued.*

| Name. | Address. | Date of Birth. | Date of Appointment or of Commission. | Remarks. |
|---|---|---|---|---|
| Green, Thomas Daniel | Prescott, Ont. | Dec. 21, '57 | May 19, '84 | O.L.S. |
| Green, Frank Compton | Nelson, B.C. | .... | May 8, '03 | B.C.L.S. |
| Grover, George Alexander | Norwood, Ont. | .... | Feb. 18, '04 | |
| Hamilton, James Frederick | Lethbridge, Alta. | Apr. 4, '69 | June 2, '09 | |
| Harris, John Walter | Winnipeg, Man. | Feb. 26, '45 | Apr. 14, '72 | O.L.S., M.L.S., City Surveyor. |
| Harrison, Edward | Belleville, Ont. | .... | May 14, '10 | |
| Harvey, Charles | Kelowna, B.C. | May 5, '76 | Feb. 17, '04 | B.C.L.S. |
| Hawkins, Albert Howard | Listowel, Ont. | July 27, '62 | Mar. 6, '06 | |
| Heaman, John Andrew | Winnipeg, Man. | June 3, '75 | July 15, '09 | O.L.S. |
| Heathcott, Robert Vernon | Edmonton, Alta. | July 7, '81 | May 13, '07 | |
| Henderson, Walter | Not known | .... | Nov. 17, '83 | |
| Heuperman, Lambertus Fred. | Calgary, Alta. | Sept. 20, '81 | Mar. 29, '10 | |
| Holcroft, Herbert Spencer | Toronto, Ont. | Sept. 4, '77 | Feb. 18, '03 | O.L.S. |
| Hopkins, Marshall Willard | Edmonton, Alta. | May 24, '61 | Feb. 20, '01 | O.L.S. |
| Hubbell, Ernest Wilson | Ottawa, Ont. | Nov. 5, '62 | May 19, '84 | Inspector of Surveys, Topographical Surveys Branch, Dept. of Interior. |
| James, Silas | Toronto, Ont. | June 19, '34 | Apr. 14, '72 | O.L.S. |
| Jephson, Richard Jermy | Brandon, Man. | Feb. 5, '54 | May 12, '80 | O.L.S., B.C.L.S. |
| Johnson, Alfred William | Kamloops, B.C. | Feb. 23, '74 | Mar. 12, '02 | B.C.L.S. |
| Keith, Homer Pasha | Edmonton, Alta. | Aug. 30, '85 | Feb. 1, '11 | |
| Kimpe, Maurice | Edmonton, Alta. | Jan. 17, '76 | May 13, '07 | |
| King, William Frederick | Dominion Observatory, Ottawa, Ont. | Feb. 19, '54 | Nov. 21, '76 | D.T.S., Chief Astronomer Dept. of Interior. |
| Kirk, John Albert | Summerland, B.C. | Jan. 9, '54 | May 11, '80 | O.L.S., B.C.L.S. |
| Kitto, Franklin Hugo | Ottawa, Ont. | Mar. 28, '80 | Mar. 6, '08 | Topographical Surveys Br., Dept. of Interior. |
| Klotz, Otto Julius | Dominion Observatory, Ottawa, Ont. | Mar. 31, '52 | Nov. 19, '77 | O.L.S., D.T.S., Astronomer, Dept., of Interior. |
| Knight, Richard H. | Edmonton, Alta. | June 7, '77 | Feb. 18, '04 | |
| Lang, John Leiper | Toronto, Ont. | .... | Oct. 14, '08 | |
| Latimer, Frank Herbert | Penticton, B.C. | May 23, '60 | Nov. 13, '85 | |
| Laurie, Richard C. | Battleford, Sask. | Jan. 31, '58 | April 27, '83 | |
| Lawe, Henry | Ottawa, Ont. | Feb. 28, '38 | April 14, '72 | O.L.S., M.L.S. Topographical Surveys Branch, Dept. of Interior. |
| Lemoine, Charles Errol | Ville Montcalme, P.Q. | .... | Mar. 31, '82 | Q.L.S. |
| Lendrum, Robert Watt | Strathcona, Alta. | July 24, '34 | May 15, '80 | O.L.S. |
| Lighthall, Abram | Vankleek Hill, Ont. | Mar. 30, '78 | Dec. 25, '09 | |
| Lonergan, Gerald Joseph | Buckingham, P.Q. | Oct. 8, '71 | Feb. 28, '01 | Q.L.S. Inspector of Surveys, Dept. of Interior. |
| Lumsden, Hugh David | Ottawa, Ont. | Sept. 7, '44 | April 14, '72 | O.L.S. |
| MacLennan, Alexander L. | Toronto, Ont. | May 10, '78 | Feb. 23, '05 | |
| MacPherson, Charles Wilfrid | Dawson, Y.T. | Sept. 6, '71 | Mar. 7, '00 | O.L.S. Director of Surveys, Y.T. |
| Magrath, Charles Alexander | Lethbridge, Alta. | April 22, '60 | Nov. 16, '81 | B.A.Sc., O.L.S., B.C.L.S., D.T.S. |
| Martyn, Oscar William | Mitchell, Ont. | Dec. 2, '88 | Mar. 11, '11 | |
| Meadows, William Walter | Maple Creek, Sask. | May 27, '73 | Feb. 23, '05 | O.L.S. |
| Miles, Charles Falconer | Toronto, Ont. | Jan. 30, '38 | Apr. 14, '72 | O.L.S. Inspector of Surveys, Dept. of Interior. |
| Mitchell, Benjamin Foster | Calgary, Alta. | June 16, '80 | April 16, '08 | |
| Moberly, Harford Kenneth | Moosomin, Sask. | —— '69 | April 21, '03 | |
| Molloy, John | Winnipeg, Man. | Jan. 13, '40 | April 14, '72 | M.L.S. |
| Montgomery, Royal Harp. | Prince Albert, Sask. | May 20, '82 | Feb. 23, '05 | O.L.S. |
| Moore, Herbert Harrison | Calgary, Alta. | Dec. 1, '69 | Feb. 17, '04 | |
| Morrier, Joseph Eldege | Ottawa, Ont. | Aug. 29, '74 | May 16, '07 | |
| McArthur, James Joseph | Ottawa, Ont. | May 9, '56 | April 17, '79 | Boundary Survey, Dept. of Interior. |
| McCaw, Robert Daniel | Sidney, B.C. | May 24, '83 | Mar. 23, '09 | |

## APPENDIX No. 10—*Continued.*

List of Dominion Land Surveyors who have been supplied with Standard Measures—*Continued.*

| Name. | Address. | Date of Birth. | Date of Appointment or of Commission. | Remarks. |
|---|---|---|---|---|
| McColl, Gilbert Beebe | Winnipeg, Man | Oct. 8, '82 | Mar. 20, '07 | M.L.S., D.T.S. |
| McDiarmid, Stuart Stanley | Vancouver, B.C. | Aug. 4, '81 | Feb. 23, '05 | B.C.L.S. |
| McFadden, Moses | Vancouver, B.C. | Aug. 26, '26 | April 14, '72 | O.L.S., M.L.S. |
| McFarlane, Walter Graham | Toronto, Ont | Sept. 28, '75 | May 19, '05 | |
| McFarlane, John Baird | Claremont, Ont | Feb. 25, '79 | June 3, '08 | |
| McFee, Angus | Red Deer, Alta | July 14, '46 | April 19, '79 | |
| McGeorge, William Graham | Chatham, Ont | Mar. 22, '87 | Mar. 21, '10 | |
| McGrandle, Hugh | Wetaskiwin, Alta | Mar. 12, '57 | Mar. 30, '83 | O.L.S. |
| McKenna, John Joseph | Dublin, Ont | | April 14, '72 | O.L.S. |
| McKenzie, John | New Westminster, B.C. | Oct. 31, '47 | Nov. 18, '87 | |
| McLean, James Keachie | Ottawa, Ont | Dec. 19, '51 | April 1, '82 | O.L.S. Dept. of Indian Affairs. |
| McMillan, George | Finch, Ont | Dec. 9, '69 | Feb. 22, '06 | |
| McNaughton, Alexander L | Cornwall, Ont | Sept. 30, '81 | Feb. 23, '05 | O.L.S., B.C.L.S |
| McPherson, Archibald John | Regina, Sask | —— '70 | Feb. 21, '01 | |
| McPhillips, George | Winnipeg, Man | April 26, '48 | June 17, '75 | O.L.S., M.L.S. |
| McPhillips, Robert Charles | Winnipeg, Man | April 24, '56 | May, 17, '80 | |
| McVittie, Archibald W | Victoria, B.C | May 5, '58 | Mar. 30, '82 | B.C.L.S. |
| Nash, Thomas Sanford | Ottawa, Ont | July 2, '75 | Feb. 18, '04 | Topographical Surveys Branch, Dept. of Interior |
| Ogilvie, William | Ottawa, Ont | April 7, '46 | April 14, '72 | O.L.S. |
| O'Hara, Walter Francis | Ottawa, Ont | | Feb. 19, '95 | O.L.S. |
| Ord, Lewis Redman | Hamilton, Ont | Oct. 17, '56 | April 1, '82 | O.L.S. |
| Parsons, Johnstone Lindsay R. | Regina, Sask | Jan. 18, '76 | Feb. 23, '05 | O.L.S. |
| Patrick, Allan Poyntz | Calgary, Alta | July 18, '49 | Nov. 19, '77 | B.C.L.S., D.T.S. |
| Patten, Thaddeus James | Little Current, Ont | Feb. 4, '59 | Mar. 29, '83 | O.L.S. |
| Pearce, William | Calgary, Alta | Feb. 1, '48 | May 10, '80 | O.L.S., B.C.L.S. |
| Pequegnat, Marcel | Berlin, Ont | April 27, '86 | June 6, '10 | |
| Peters, Frederic Hatheway | Calgary, Alta | Nov. 4, '83 | Mar. 4, '10 | Commissioner of Irrigation |
| Phillips, Edward Horace | Saskatoon, Sask | Dec. 19, '78 | Feb. 24, '02 | |
| Phillips, Harold Geoffrey | Saskatoon, Sask | Sept. 3, '87 | April 23, '10 | |
| Pierce, John Wesley | Haileybury, Ont | | Dec. 24, '09 | |
| Plunkett, Thomas Hartley | Meaford, Ont | June 1, '78 | Mar. 12, '08 | |
| Ponton, Archibald William | Edmonton, Alta | Jan. 25, '59 | May 18, '81 | O.L.S. |
| Proudfoot, Hume Blake | Saskatoon, Sask | June 23, '58 | Mar. 28, '82 | O.L.S. |
| Rainboth, Edward Joseph | Ottawa, Ont | | May 19, '81 | Q.L.S., O.L.S. |
| Ransom, John Thomas | Toronto, Ont | Aug. 24, '88 | Jan. 14, '11 | |
| Reid John Lestock | Prince Albert, Sask | Sept. 12, '41 | April 14, '72 | Dept. of Indian Affairs. |
| Reilly, William Robinson | Regina, Sask | Aug. 16, '57 | Nov. 17, '81 | O.L.S., M.L.S. |
| Richard, Joseph Francois | Ste. Anne de la Pocatière, P.Q. | | May 13, '82 | |
| Rinfret, Raoul | Montreal, P.Q | July 16, '56 | Feb. 20, '00 | Q.L.S. |
| Ritchie, Joseph Frederick | Prince Rupert, B.C | May 23, '63 | Jan. 7, '89 | B.C.L.S. |
| Robertson, Henry H. | N. Temiskaming, P.Q. | Sept. 13, '47 | Apr. 14, '72 | Q.L.S. |
| Roberts, Sydney Archibald | Victoria, B.C. | April 10, '48 | May 16, '85 | B.C.L.S. |
| Roberts, Vaughan Maurice | Goderich, Ont | Mar. 22, '64 | May 17, '86 | |
| Robinson, Ernest Walter P. | Ottawa, Ont | May 8, '80 | May 1, '08 | |
| Robinson, Franklin Joseph | Regina, Sask | Oct. 20, '70 | Feb. 20, '00 | Deputy Minister of Public Works. |
| Rolfson, Orville | Walkerville, Ont | Feb. 26, '85 | July 11, '08 | |
| Rombough, Marshall Bedwell | Morden, Man | Oct. 14, '35 | April 14, '72 | M.L.S. |
| Rorke, Louis Valentine | Toronto, Ont | Feb. — '65 | Aug. 13, '91 | O.L.S. Inspector of Surveys for Ontario. |
| Ross, George | Welland, Ont | June 12, '53 | Nov. 21, '82 | O.L.S. |
| Ross, Joseph Edmund | Kamloops, B.C | Jan. 9, '61 | Feb. 12, '91 | O.L.S., B.C.L.S. |
| Routly, Herbert Thomas | Haileybury, Ont | Jan. 20, '78 | Feb. 15, '11 | |
| Roy, George Peter | Quebec, P.Q | Oct. 1, '52 | Nov. 17, '81 | Q.L.S. |
| Roy, Joseph George Emile | Quebec, P.Q | Mar. 14, '86 | May 25, '10 | |
| Saint Cyr, Jean Baptiste | Montreal, P.Q | Dec. 17, '66 | Feb. 17, '87 | Q.L.S. |
| Saint Cyr, Arthur | Ottawa, Ont | Nov. — '60 | Feb. 17, '87 | |

## APPENDIX No. 10—*Concluded.*

List of Dominion Land Surveyors who have been supplied with Standard Measures—*Concluded.*

| Name. | Address. | Date of Birth. | Date of Appointment or of Commission. | Remarks. |
|---|---|---|---|---|
| Saunders, Bryce Johnston | Edmonton, Alta | Oct. 17, '60 | Nov. 16, '84 | O.L.S. |
| Scott, Walter Alexander | Galt, Ont | Aug. 8, '85 | Mar. 9, '09 | |
| Seager, Edmund | Kenora, Ont | Nov. 22, '38 | April 14, '72 | O.L.S. |
| Sewell, Henry DeQuincy | Toronto, Ont | April 18, '48 | May 16, '85 | O.L.S. |
| Seymour, Horace Llewellyn | Edmonton, Alta | June 11, '82 | Feb. 22, '06 | O.L.S. |
| Shaw, Charles Aeneas | Greenwood, B.C | Nov. 16, '53 | May 10, '80 | O.L.S., B.C.L.S. |
| Sheply, Joseph Drummond | N. Battleford, Sask | Sept. 13, '79 | Mar. 12, '06 | |
| Smith, Charles Campbell | Ottawa, Ont | Jan. 1, '73 | Feb. 22, '06 | O.L.S. |
| Smith, Donald Alpine | Claude, Ont | Sept. 22, '80 | April 21, '10 | |
| Smith, James Herbert | Edmonton, Alta | Nov. 9, '76 | Feb. 23, '05 | |
| Speight, Thomas Bailey | Toronto, Ont | Feb. 8, '59 | Nov. 16, '82 | O.L.S. |
| Starkey, Samuel M | Codys, N.B | Sept. 4, '37 | April 14, '72 | |
| Steele, Ira John | Ottawa, Ont | April 6, '81 | April 16, '08 | |
| Stewart, Elihu | Collingwood, Ont | Nov. 17, '44 | April 14, '72 | O.L.S. |
| Stewart, Lionel Douglas N | Collingwood, Ont | .......... | Jan. 27, '10 | |
| Stewart, Will Malcolm | Saskatoon, Sask | Nov. 26, '84 | June 6, '07 | |
| Stewart, Louis Beaufort | Toronto, Ont | Jan. 27, '61 | Nov. 22, '82 | O.L.S., D.T.S. |
| Stewart, George Alexander | .......... | .......... | April 14, '72 | O.L.S. |
| Stock, James Joseph | Ottawa, Ont | Aug. 16, '87 | Mar. 2, '10 | |
| Street, Paul Bishop | Toronto, Ont | Dec. 3, '81 | Mar. 29, '10 | |
| Summers, Gordon Foster | Haileybury, Ont | .......... | Oct. 20, '10 | |
| Talbot, Albert Charles | Calgary, Alta | April 5, '56 | May 13, '80 | |
| Taylor, Alexander | Portage la Prairie, Man. | Aug. 6, '75 | June 9, '04 | M.L.S. |
| Taylor, William Emerson | Owen Sound, Ont | Aug. 3, '81 | Dec. 16, '10 | |
| Teasdale, Charles Montgomery | Concord, Ont | Oct. 18, '79 | Mar. 9, '06 | |
| Thompson, William Thomas | Grenfell, Sask | Nov. 1, '53 | Nov. 19, '77 | D.T.S. |
| Tracy, Thomas Henry | Vancouver, B.C | June 25, '48 | April 14, '72 | O.L.S., B.C.L.S. |
| Tremblay, Alfred Joseph | Les Eboulements, P.Q. | .......... | Feb. 18, '90 | |
| Turnbull, Thomas | Winnipeg, Man | May 26, '57 | Mar. 29, '82 | O.L.S. |
| Tyrrell, James William | Hamilton, Ont | May 10, '63 | Feb. 16, '87 | O.L.S. |
| Vaughan, Josephus Wyatt | Vancouver, B.C | Oct. 17, '45 | June 11, '78 | B.C.L.S. |
| Vicars, John Richard Odlum | Kamloops, B.C | April 16, '55 | May 17, '86 | O.L.S., B.C.L.S. |
| Waddell, William Henry | Edmonton, Alta | Mar. 23, '83 | Mar. 25, '07 | O.L.S. |
| Waldron, John | Pine Grove, Ont | Aug. 1, '72 | April, 2, '07 | |
| Walker, Claude Melville | Guelph, Ont | Oct. 16, '84 | Mar. 11, '11 | |
| Walker, Ernest Ward | Regina, Sask | Dec. 26, '75 | Mar. 27, '07 | |
| Wallace, James Nevin | Calgary, Alta | Aug. 21, '70 | Feb. 20, '00 | O.L.S. |
| Warren, James | Walkerton, Ont | Nov. 7, '37 | April 14, '72 | |
| Watt, George Herbert | Ottawa, Ont | Feb. 5, '76 | Feb. 24, '02 | |
| Weekes, Abel Seneca | Edmonton, Alta | Feb. 17, '66 | Feb. 11, '92 | |
| Weekes, Melville Bell | Regina, Sask | Nov. 28, '74 | Feb. 18, '03 | O.L.S. |
| Wheeler, Arthur Oliver | Calgary, Alta | May 1, '60 | Nov. 21, '82 | O.L.S., B.C.L.S. |
| White-Fraser, George W. R. M. | Ottawa, Ont | ——— '61 | Feb. 21, '88 | D.T.S. |
| Wiggins, Thomas Henry | Saskatoon, Sask | Aug. 24, '63 | Feb. 18, '96 | O.L.S. |
| Wilkins, Frederick W. B | Norwood, Ont | June 27, '54 | May 18, '81 | O.L.S., D.T.S. |
| Wilkinson, William Downing | Not known | .......... | Feb. 22, '93 | |
| Williams, Guy Lorne | Enderby, B.C | Mar. 3, '79 | June 24, '08 | B.C.L.S. |
| Woods, Joseph Edward | Pincher Creek, Alta. | Oct. 13, '61 | Nov. 14, '85 | |
| Young, Walter Beatty | Winnipeg, Man | July 6, '80 | Mar. 25, '05 | M.L.S. |
| Young, William Howard | Lethbridge, Alta | June 8, '78 | May 17, '07 | |

# GENERAL REPORTS OF SURVEYORS

## 1910-1911

## APPENDIX No. 11.

## ABSTRACT OF THE REPORT OF J. R. AKINS, D.L.S.

### BASE LINE AND MISCELLANEOUS SURVEYS IN SOUTHWESTERN ALBERTA.

After four days spent in having the horses shod, getting the outfit together, engaging men and testing instruments we left Morley for the field on May 13, 1910 and reached the northeast corner of township 20 range 7 west of the fifth meridian on the 17th.

My instructions were to extend the sixth base line across ranges 7, 8 and 9 from the Elbow to Kananaskis river, so that a meridian line might be run north through the valley of the Kananaskis, to locate, and tie to the Dominion Lands system of survey, some coal claims in townships 21, 22 and 23, range 9.

Between these two rivers the country is very mountainous, being a sea of high peaks and ridges, some of an elevation of ten thousand feet. To produce the line over these by ordinary surveying operations was out of the question. Our method was to produce the line in proper azimuth and to obtain the distance by a system of triangulation.

We laid out a base line in the valley of Elbow river of one hundred and forty-seven chains, and one hundred and nineteen chains of this we used as a second base, thus having a common side for the two triangles. Corrections to the measurements were made for sag, temperature and difference of elevation of stations. In the triangulation, all the angles were read to seconds by repetition. The work was carried on as far as practicable from the camp on the Elbow and our next camp was pitched on Fisher creek at its intersection by the base line. From this point we worked westerly making flying camps to about timber-line on the sides of the mountains.

During the month of May clouds interfered considerably with the work; in many cases several trips up a mountain had to be made before the angles could be read. In June our troubles were increased by smoke from fires to the east and south of us.

Abont the end of June we reached Kananaskis river and from there we carried on operations by man-packing over the ridge. After getting the line and triangulation to the Kananaskis valley we checked our work by measuring a side of a triangle whose length had been obtained already by calculation. The distances checked to abont a link.

We finished operations in the Kananaskis valley about the end of October, with the snow one foot and a half deep on the tops of the mountains.

We returned to Morley and on October 31 started for township 24, range 6, where we worked till December 7 when we returned to Morley and disbanded.

## APPENDIX No. 12.

### ABSTRACT OF THE REPORT OF C. F. AYLSWORTH, D.L.S.

RESURVEYS IN SOUTHEASTERN SASKATCHEWAN AND MANITOBA.

Having organized my party at Winnipeg we left on May 6 for Kamsack and began work in township 31, range 31, west of the principal meridian on May 12. We resurveyed part of this township and also part of township 30 in the same range.

On June 10 we moved to township 30, range 1, west of the second meridian, where we retraced sections 1, 2, 3, 4, 5 and 6 adjoining the headquarters of the Doukhobor colony at Veregin station. This colony at the time of my visit were preparing to leave for British Columbia. Their lands and other properties were being offered for sale including a grist-mill and elevator together with a residence for help, valued at $52,000, a brick manufacturing plant and a wholesale warehouse with office and store. We also made a traverse of Whitesand river across section 36 in this township and surveyed a school site on section 4, township 30, range 2. We then returned to Kamsack to make a resurvey of sections 22 and 27 in township 29, range 32, west of the principal meridian.

Our next work was in township 28, range 5, west of the second meridian, where we retraced several sections. On August 2 we left for township 2, range 12, west of the second meridian and made a complete new survey of the township. The land in this township is good and although there was little rain during 1910 crops were very fair. The district has been retarded by lack of railway facilities but the Canadian Pacific railway has a branch now under construction westward from Estevan.

Our next work was some retracement surveys in township 20, range 21, west of the principal meridian which we completed on October 3 and then proceeded to Tyndall to make retracement surveys in townships 13, ranges 6, 7 and 8 and township 14, range 7, east of the principal meridian. These surveys kept us busy until the close of the season.

## APPENDIX No. 13.

## ABSTRACT OF THE REPORT OF P. R. A. BELANGER, D.L.S.

### MISCELLANEOUS SURVEYS IN ALBERTA AND MANITOBA AND INSPECTION OF CONTRACT SURVEYS IN MANITOBA.

I organized my party at Winnipeg on April 9, 1910, and proceeded to Sandy lake to reinspect contract No. 33 of 1907. This contract is situated in a district settled largely by Galicians who are converting a bush country, formerly considered valueless, into good farm land.

On May 4 I returned to Winnipeg and after inspecting the iron posts manufactured by the Manitoba Bridge and Iron Works and the Vulcan Iron Works for the Department, I left for Oak Point and Vestfold, a small Icelandic settlement on the west shore of Shoal lake, which I reached on May 9.

I made some retracement surveys in township 19, range 3, west of the principal meridian, and also traversed parts of the lake affected by the lines resurveyed and by the recession of the water. This lake is drying up very fast, and its topography has greatly changed since it was first surveyed. Large tracts of land shown under water by the original survey are now converted into valuable hay meadows which are proving a blessing to the settlers who depend for their living on the dairying industry.

From Vestfold. I proceeded via the north end of Shoal lake easterly to Bender hamlet, a Jewish settlement situated near the Colonization road on the northwest quarter of section 36, township 19, range 1. All the houses, numbering about nineteen, are built in a row east and west along the road allowance on the north boundary of this quarter section, on lots averaging one hundred and forty feet wide by half a mile long. This arrangement has the advantage of keeping the colony together and forms the whole village into one family. A practically inexhaustible well has been dug beside the public road for the use of the whole colony, and it is of great benefit to the public who travel across this dry piece of country.

I understand that all these settlers have homesteads in the neighbourhood of the village. One of them keeps a steam gang-plough for the use of the whole colony, and as he is a blacksmith by trade, he is in a position to repair his machine which is often wrecked on their stony land. There is also a good store, a post-office and a boarding-house in the village, so that people travelling that way are sure to find some accommodation besides good well water, which is a rather scarce commodity in that country.

From this settlement, I drove along the Colonization road southerly to Cossette, and then followed another road southwesterly to the south end of Shoal lake, where I put in several days' work retracing blocks of sections in townships 15, ranges 1 and 2.

Along the Colonization road I noticed some very good farms, principally in the neighbourhood of Cossette, but in township 15 the land is low and gravelly and better adapted for stock-raising. The settlers I met are all doing well in that line by selling cream, cattle, &c.

From township 15, range 1, I proceeded to township 21, range 4, via Oak Point where I spent a day repairing the outfit and having the horses shod, reaching my new work on June 8. Here my survey consisted in the retracement of a few lines and the traverse of lakes which are not shown on the original plans. All these lakes connect together in wet seasons by the flooding of the hay marshes which surround them, and form part of what is locally known as 'Island' lake.

From this township I drove westerly and northerly to township 22, range 6, driving for the latter part over a railway grade which lies within a short distance from the northeast corner of the township, which I had to renew. This railway grade is an extension of the Canadian Northern railway branch from Oak Point to Gypsumville. At present the gypsum mines and the winter fish trade are the chief revenue producers for this railroad.

From township 22, I came back along this same railway grade to township 21 where I branched off westerly following a road which led me to Scotch Bay via Pine View and Lily Bay, arriving at Scotch Bay on June 20. After spending a couple of days at that place traversing a small piece of lake Manitoba in township 21, range 7, I proceeded to township 22, range 8, which I reached on the 23rd. Here I spent three days retracing blocks of sections and then proceeded via the regular mail route along the east shore of lake Manitoba to Fairford settlement, where I arrived on July 1 and put in four days' work in the retracement of sections in township 30, range 9 adjoining the Indian reserve.

Fairford is an old Hudson's Bay company trading post, which up to the present time has practically remained unknown to farmers owing to its almost inaccessible position by land. The building of the Canadian Northern railway extension through this place should give it a chance to develop as there are tracts of good land suitable for mixed farming, and though the country is mostly covered with timber or scrub the fish business and the development of the gypsum industry should help to induce settlement in that direction.

From Fairford I drove back to "The Narrows" where I had left my sail-boat in the fall of 1909, and after transferring my supplies and camp equipage from the wagons to the boat, I sent my horses and wagons to Oak Point, and sailed at once to township 30, range 15, where I arrived on July 13. Here, again, I made retracement surveys which occupied ten days, and it was not until the 23rd that I could leave for Pine creek, via Waterhen river and lake Winnipegosis, which had been omitted at the time of the subdivision. I also surveyed a few miles of section lines.

Having completed the work at this point, I sailed back across lake Winnipegosis and down the first part of Waterhen river to the Indian reserve at Waterhen lake where, in order to ensure the safety of the trip down the lower part of the river, I hired an Indian to pilot the boat as far as lake Manitoba as the water was extremely low at that time of the year. I sailed across the lake to Elm creek, a small stream on the east shore in township 26, range 9, where I spent two days reinspecting two townships in Mr. Teasdale's contract of 1909 after which I returned to Oak Point. On August 23 I boarded the train at Oak Point with my party for Sprague, a station on the Canadian Northern railway southeast of Winnipeg, where I arrived on the same day. Here my work consisted in the retracement of one section in township 1, range 13, east of the principal meridian, but my work had to be trebled before a satisfactory closing could be obtained, and it was not until the 29th that I could finish the survey.

The inspection of part of Mr. Molloy's contract of 1909 kept me busy till September 8, and the next day I boarded the train at Culver for Beausejour, and from there proceeded to township 16, range 7, following a graded road which passed through many prosperous settlements.

I spent five days at this new place retracing lines in the vicinity of the Indian reserve, after which I moved camp to Hnausa, via Selkirk, reaching there on September 20.

Sixteen days were employed there surveying the east boundaries of townships 22 and 23 of range 3, which had never been properly surveyed before, and connecting the section corners on this outline with the nearest monuments on section chords in both ranges 3 and 4.

This work will prove a blessing to the settlers of that locality, a group of industrious Icelanders, who up to the present have made their living by fishing and a little farming which they increase every year. Owing to the land being heavily timbered the progress must be slow, but the land is very rich and, when it is all cultivated, this Icelandic settlement, on account of its situation near lake Winnipeg, and watered as it is by Icelandic river, will be one of the richest in the Province of Manitoba.

Inexhaustible, large, flowing wells of the purest water are found near the river at a short distance from its mouth on lake Winnipeg.

Large stores, butter factories, fish-packing plants and sawmills are found there, together with a flotilla of steamboats plying on lake Winnipeg.

From Icelandic river I moved to township 24, range 3, where I removed a witness mark wrongly placed on the road allowance, and established a new monument at the true corner after which I proceeded to township 24, range 2, west of the principal meridian where I made a similar correction. From there I returned to Oak point to procure new supplies before continuing further surveys west of lake Manitoba.

I proceeded next to townships 15 and 18, range 10, for the purpose of retracing blocks of sections in the former township which did not close in accordance with the provisions of the Manual, and to investigate in the latter township a section corner which was reported as wrongly marked. While there, I also surveyed a small piece of land in township 18, range 11 which had been omitted in the original subdivision. I then turned southerly to township 9, range 11, where I traversed a small piece of Assiniboine river which had also been left unsurveyed at the time of the subdivision. I might also mention the verification I made of the northeast corner of township 14, range 6.

After surveying one section line in township 16, range 12, east of the principal meridian, I left for Edmonton reaching there on November 11.

The surveys I made in Alberta comprise the traverse of lakes which had been omitted by contractors in different townships west of the fourth and fifth meridians, together with the survey of a few section lines across the beds of lakes in townships 45 and 46, ranges 16 and 17, which had dried up and are now converted into good hay land. I also verified and rectified the position of survey monuments in township 32, range 15, west of the fourth meridian.

These new surveys, though not extensive, occasioned much travelling and kept me busy up to December 15 when I closed operations for the season.

## APPENDIX No. 14.

### ABSTRACT OF THE REPORT OF G. H. BLANCHET, D.L.S

MISCELLANEOUS SURVEYS IN THE RAILWAY BELT, BRITISH COLUMBIA.

After several days spent in organizing the party at Kamloops, we left for our first work in township 22, range 11, west of the sixth meridian, arriving there on April 16.

This township is crossed from east to west by Shuswap lake, the south shore of which is formed approximately by the centre line of the township. South from the lake there is a narrow fringe of low-lying land not exceeding twenty chains in width. Beyond this the land rises with varying steepness to an elevation of about seven hundred feet above the lake, the summit being about half a mile south of the lake at the west side of the township and nearly two miles from the lake shore at the east side. This slope seems to be well adapted to fruit growing, the soil varying from a clay loam to a sandy loam and gravel, and though surface water is scarce water is apparently easily obtained in wells.

Continuing south from the summit of the above-mentioned slope, a descent of a couple of hundred feet is made to the level of the Canadian Pacific railway main line. This slope is drier than the northern declivity, but the valley bottom is fertile and well watered, being probably best adapted to hay, grain, root crops and small fruits.

In the southern part of the township are to be found the lower slopes of the Black Hill mountain, which become high and rugged in the southwest corner. The lower slopes are well watered and seem suitable for any form of agriculture.

Good roads render all parts of the township easily accessible and the railway provides convenient commercial connections.

On the completion of the surveys in this township, I proceeded on May 27 to township 23, range 8, west of the sixth meridian, which was reached by a gasoline launch from Sicamous.

The portion of this township considered lies between the two arms of Shuswap lake, known as the "Long Traverse" and the "Sicamous Branch," which are joined by the Cinnemousun narrows. It has the appearance of a peninsula, the rib of which starts at the narrows and reaches a maximum elevation of about 1,500 feet above the lake in the southeast quarter of section 22. From here there is a rugged spur which continues south to the lake, making the easterly side steep and rocky. The main ridge, however, swings off to the southwest and, descending and broadening, forms a rolling upland with an elevation of about 1,300 feet in the southwest corner of the township. This small plateau and the declivities and benches by which it descends to the northwest, to the level of Shuswap lake, were the only portions considered to have agricultural possibilities.

The original rocky core is not very deeply buried at any point and frequently outcrops in bluffs and escarpments, most frequently in the northern portion. A seepage from the northeasterly slopes of the Bastion mountains supplies moisture, and although there are no permanent streams, springs occur at intervals, indicating a probable underground flow.

In the descent from the upper plateau level to the lake, two benches break the steepness of the slope. The first has an elevation of from 500 to 800 feet, and varies in width from over half a mile in the western side of the township to less than a quarter of a mile in section 21. The second bench extends back from the lake shore three-quarters of a mile in the west of the township and gradually narrows till it finally runs out altogether in section 20, beyond which the shore is steep and rocky.

As might be expected, the soil is almost everywhere rocky in the upper benches, being mainly of whitish clay, except in a few places where the humus has escaped the fires, which have destroyed most of the big timber. On the lower bench, however, the soil is mostly sand and gravel.

To render the higher lands, here considered, accessible for settlement, it is probable that a high-level road would have to be opened up. This could probably be done by extending the White lake trail eastward through township 23, range 9, to this township.

On the completion of the work in township 23, range 8, I moved the outfit to Canoe Point, section 29, township 21, range 8, where Salmon Arm branches off Shuswap lake. Here there is a low-lying bench already disposed of, on which excellent results have been obtained on a small scale in fruit, vegetables and grain. Back of this flat the ground rises rather abruptly towards the Bastion mountains. Portions of sections 30 and 32 on this slope were surveyed. The soil is, for the most part, a whitish clay with rocky outcrops and scattered fragments, except on the small flats where the humus has been able to accumulate.

An examination was made of township 22, range 8, which is crossed from north to south by Shuswap lake. On the easterly side the Shuswap mountains rise abruptly from the shore, which is, for the most part, extremely rugged, except about the mouth of Eagle river, where there is a small flat already disposed of. On the west side of the lake the conditions are very similar, the Bastion mountains forming a shore line inaccessible to the agriculturist, except in several places where large streams have cut gorges through the mountains, depositing the debris in miniature deltas, which have already been disposed of. A small bench of good land was found in the portions of section 32 and the northwest quarter of section 29, west of the lake. This was surveyed.

Proceeding by gasoline launch up Mara lake, portions of sections 2 and 3, township 21, range 8, were subdivided. The land here exhibited the general characteristics already described, the Hunters range forming the easterly shore of the lake, and only the lower slopes being suitable for agriculture.

I left Shuswap lake on August 18 for the lower Columbia river to undertake several surveys between Revelstoke and Arrowhead, in township 21, range 1, west of the sixth meridian, and townships 20 and 21, range 29, west of the fifth meridian.

Columbia river runs through the northeast quarter of township 21, range 1, west of the sixth meridian, the southwest quarter of township 21, range 29, and the northwest quarter of township 20, range 29, west of the fifth meridian, and the lands surveyed formed parts of the flats and the lower slopes of the mountains bordering the river. On the easterly side of the river the higher land backing the river flats is bare and rocky, but farther back there may be lands of agricultural value, now included in timber berths. The elevation of the river flats is, for the most part, sufficient to eliminate any danger of flooding by the river, while those portions liable to flood could probably be utilized as hay lands. The flats have been heavily timbered with large cedar, which are rapidly being converted into lumber. On the west bank of the Columbia the conditions are similar to those just described, except that the width of the flat is greater and that less of the timber has been removed.

The islands are for the most part merely overgrown sand-bars, flooded at high water. Water is abundant and of good quality throughout this portion of the Columbia valley.

On the completion of the surveys in these townships I moved to Revelstoke to survey timber berth No. 539, lying on the westerly slope of Mt. Mackenzie.

Up to this time the weather had been warm and remarkably fine, but the fall rains now commenced and continued with few interruptions until early in November.

when the rain changed to wet snow. This weather caused much interruption to the work during the latter part of the season.

I next proceeded with surveys in township 23, range 2, west of the sixth meridian. Owing to the advanced season I considered it advisable to undertake the work on the hills on the west side of the river first. This work embraced the lower foot-hills of Mt. McArthur, which, though in places rough, contains a considerable quantity of agricultural land lying between the rock bluffs. Some of these valleys are old beaver meadows which would require draining.

The large timber has been burnt off, except on the upper slopes of the mountain, and in section 3, where a heavy growth of cedar, tamarack, fir and pine still remains.

The Provincial Government is building a road south through this part of the township, which is to form part of the proposed Revelstoke-Arrowhead road, and which will promote development in this district. There are many prospective settlers anxiously awaiting an opportunity to take up homesteads here, as the proximity of Revelstoke renders this a very desirable locality.

On the east side of Columbia river the conditions are somewhat different. Instead of the foot-hills, as on the west side, we have a series of three almost level benches, dropping sharply from one level to the next. The lowest of these benches includes most of section 1 and portions of sections 2, 11 and 12. It is much cut up by sloughs and is covered with cottonwood, willow and alder and in some parts cedar. It is probably best adapted for hay lands, and hay at the local price of from $20 to $35 a ton makes a valuable asset. It could also produce vegetables and grain on the higher ground.

The second bench, including most of section 14 and the southwest quarter of section 13, is probably best adapted for garden produce, hay and grain. The higher ground and the lower slopes of Mt. MacKenzie seem suitable for any form of agriculture, good fruit being raised here.

## APPENDIX No. 15.

### ABSTRACT OF THE REPORT OF M. P. BRIDGLAND, D.L.S.

TRIANGULATION SURVEYS IN THE RAILWAY BELT, BRITISH COLUMBIA, AND MISCELLANEOUS SURVEYS IN ALBERTA AND SASKATCHEWAN.

I left Calgary on May 31 for Golden and after a few days arranging for my party and outfit we proceeded to Revelstoke, and began field operations on June 8.

The first mountain to be ascended was mount Mackenzie, near Revelstoke. A camp was placed at the base of the mountain where the Canadian Pacific railway crosses Illecillewaet river, about two miles east of the town. The slopes here are very steep, but as the timber has been burned off and there is not much undergrowth, they offer an easy means of ascent. Much snow was encountered on the upper slopes. On reaching the summit it was too hazy to obtain any satisfactory view, but a cairn was erected in the position of the station occupied by Mr. A. O. Wheeler in his photographic survey of the Selkirk range, 1901-02. No permanent marks were made.

On our return to camp, one day was lost owing to wet weather, and then the party started for Carnes creek at the north limit of the railway belt. Mr. Carson's secondary cairns erected the previous year on Roseberry mountain and Carnes mountain were located, and a high peak to the northeast of them was climbed and selected for a station. Unfortunately, owing to the depth of snow on the summit, it was found impossible to erect a suitable cairn. This was done later during a prolonged spell of smoky weather. This mountain is about 9,800 feet above sea-level and lies to the east of the north fork of Carnes creek.

It is rather difficult to reach, but is the only peak in the vicinity suitable for a station. The view from here is magnificent, and typical of the Selkirk range, consisting of deep, narrow valleys, heavily timbered, and glacier-crowned peaks rising proudly from the dark green slopes below. Snow fields and glaciers are visible in every direction, and to the northeast that unclimbed monarch of the Selkirks, mount Sir Sandford, rises high above all others. This station was called signal XXXV.

Our next trip was to establish a signal on mount Copeland, a prominent peak up Jordan river and about fifteen miles northwest of Revelstoke. There is an old trail leading up this stream, but it had not been used for years and was in very bad condition, necessitating much cutting. The valley is from a quarter to half a mile in width, with very steep, rocky slopes on both sides. There is much excellent cedar and hemlock in the valley and on some of the lower slopes, and also a most luxuriant growth of fern and devil's club. We succeeded in getting horses about nine miles up the stream and were then compelled to send them back and proceed on foot, owing to the lack of pasture and the poor condition of the trails. From here we followed the Jordan, which turns north at this point, for about four miles. Here the old trail turns west up a narrow valley leading to some old mining claims. This trail we followed for about three miles through dense alder slides, and finally pitched camp about 500 feet above the valley on the north slopes of mount Copeland (9,700 feet), which we climbed the day following. A hole was drilled in the rock at the centre of the base of the cairn to receive the brass bolt usually used for marking stations, and a hole drilled for a reference bolt seven feet south. The cairn is five feet seven inches in diameter at the base and seven feet high, and was called signal XXXVII. This trip occupied in all nine days.

On returning to Revelstoke angles were read at the northeast corner of section 33, township 23, range 2, west of the sixth meridian, to connect the corner with mounts Mackenzie, Cartier, Begbie and Copeland. A trip was then made to the long tangent on the Arrowhead branch of the Canadian Pacific railway to find a suitable base for connecting mounts Mackenzie, Cartier and Begbie with the Dominion Lands surveys.

On July 3, a start was made for mount Begbie to the west of Revelstoke. Crossing Columbia river by the bridge at this point, we travelled south about four miles by means of a settler's trail. From here the horses were sent back and we proceeded on foot about three miles farther south to the base of mount Begbie. Camp was pitched at night on the side of the mountain about 2,000 feet above the Columbia valley. Much to our delight, the following day was fine and beautifully clear. The mountain offered no difficulty and we were on the summit by nine o'clock. A cairn was erected, five feet in diameter at the base and eight feet seven inches high. In the rock at the centre of the cairn a hole was drilled to receive the brass bolt and four holes, each distant six feet from the central hole and bearing north, east, south and west respectively, were drilled for reference bolts. This cairn was designated as signal XXXVIII. The trip to this mountain and return occupied only three days.

On returning from mount Begbie, preparations were at once made to visit the Incomappleux valley. Horses and outfit were shipped by train to Arrowhead and thence by boat to Beaton, a small village at the head of the Arrow lakes. From here an excellent wagon road leads up the river to the almost deserted village of Camborne, about six miles distant. On the way the road passes through a fine canyon about a mile in length.

Ten years ago Camborne was one of the busiest mining camps in British Columbia, but now there are only three or four families remaining. Four mills have been built, but they are all lying idle and one, at least, is in ruins. The country is all divided into claims, but no work, other than assessment work, is being done. The ore is chiefly quartz-bearing free gold, and some very rich samples were shown to us by people living there.

The valley above Camborne consists of a low flat about half a mile wide with steep mountain slopes on both sides.

The bottom-land appears very fertile and would yield good crops if cultivated. There is much excellent cedar and hemlock in the bottom of the valley and on the lower slopes.

On leaving Beaton, camp was taken to the mouth of Menhinnic creek, about one mile above Camborne. At this point there is a bridge across Incomappleux river, making it a very convenient base of operations for work on either side. On the west side of the river, a trail starts up Menhinnic creek and then turns across the mountain, leading to several claims high up on the slopes, the highest being the 'Burniere' near the edge of timber-line. This trail had been recently repaired and was in good condition. A good wagon road also leads up the west side of the river for several miles. About four miles above camp another trail leads up Sable creek to the Trilby basin. This is also a mining trail, but has not been used for some years and is in very bad condition. On the east side of the river there is a good trail for about twelve miles. There are also several branch trails, one at Camborne leads up Poole creek to 'The Silver Dollar' and other properties, about five miles farther up another trail leads up Lexington creek and a little farther on still another leads up the face of the mountain to a claim known as 'The Mammoth.' The main trail turns up Boyd creek, about twelve miles above Camborne.

Some difficulty was experienced in finding a suitable station in this locality as signal XXVII, which it was necessary to see from this point, was placed on a shoulder of North Albert peak. Eventually a peak about 8,000 feet above sea-level, a little to the northwest of Camborne, was selected. A cairn five feet in diameter at the base and eight feet seven inches high was erected. This was designated as signal XXXII. Two secondary cairns were also erected, one at the head of Trilby basin and another on Kelly peak, a high peak on the east side of Incomappleux river and a short distance above Kelly creek.

This trip occupied in all sixteen days. The weather was very warm and smoky, but it was singularly fortunate that the smoke cleared off every day we climbed.

Leaving Camborne, we next moved to Comaplix on the north shore of Arrow lake. This is a busy little lumbering town, the headquarters of one of the mills of the Bowman Lumber company. The smoke from a large fire across the lake was so dense that it was impossible to see any distance. Fortunately some heavy rains settled the smoke and we started for mount Sproat. Camp was taken by boat to a point about three miles west of Comaplix and thence up an old trail to a point about two thousand feet above the lake. Next day the summit was reached after a long and tedious climb. Owing to storms while on top it was impossible to do anything except build a cairn. This cairn was five feet six inches in diameter at the base, eight feet six inches high and was numbered signal XXXIII. During the ascent of this mountain we encountered on the upper slopes an old grizzly and two cubs. Next morning we returned to Comaplix, took the boat to Arrowhead and went by train to Revelstoke, reaching there on the evening of July 26.

On July 28, as it was very smoky with no indication of rain, we decided to revisit signal XXXV and erect the signal we were unable to build before. The signal was five feet in diameter at the base and eight feet two inches high. This trip occupied six days, during all of which time it was too smoky or cloudy to make any observations.

On our return to Revelstoke, we were again delayed some days by unfavourable weather. We then set out to place a signal on mount Cartier to take the place of the one formerly erected on mount Mackenzie, which had proved to be unsatisfactory. Horses were taken to the end of the road about five miles south of Revelstoke, and then the party proceeded on foot. The brush proved very bad and the distance greater than we had expected, so it was not until the afternoon of the following day that we reached timber-line below the peak. On the third day mount Cartier was ascended and angles read where possible. Owing to smoke and local thunder-storms no satisfactory results were obtained.

This station was called signal XXXIV. It was marked by a brass bolt cemented in a hole drilled in the solid rock. The bolt was stamped with the number of the triangulation station, followed by a triangle having its apex at the centre of the head of the bolt. For reference points two iron bolts were cemented in holes drilled in the rock six feet north and south respectively of the geodetic point. Surrounding the permanent mark, a conical stone cairn was built, five feet in diameter at the base, one foot six inches in diameter at the top, and eight feet high. The cairn was placed in the position of the photographic station occupied by Mr. A. O. Wheeler in his topographical survey of the Selkirk range, 1901-1902.

The return trip was made on the fourth day by way of what is known as 'the green slide.' This is a long open slope swept clear by frequent avalanches, and proved a very easy means of descent to the railway. From there we walked back to Revelstoke, a distance of about nine miles.

We next moved to Three Valley, a small lumbering town fourteen miles west of Revelstoke, to establish a station on Griffin mountain, leaving the pack-train at Revelstoke in charge of one of the men. Three days were lost through smoke and wet weather. On August 16 we started for the peak, commencing the ascent at a point on the railroad about a mile and a half west of Three Valley. Our path led up steep slopes which had been burned over many years ago and were nearly free from underbrush. Blueberries were found in great abundance. On reaching the summit of the ridge, we turned westward along the ridge until the highest point was reached.

Here a disappointment awaited us, for we found that a slightly higher peak, some distance south and on the same ridge, cut out everything in that direction. Accordingly we turned back and followed the ridge to the other peak, which we reached about one o'clock, after a climb of nine hours. Further delay followed on account of clouds, and it was nearly six o'clock before we started for camp. Fortunately it was a fine moonlight night and we reached camp safely about half past nine.

This mountain (signal XXXIX) although low, is excellently situated for a station. It was marked by a hole drilled in the solid rock. Over this hole a cairn was erected five feet in diameter at the base, two feet in diameter at the top, and nine feet two inches high.

Craigellachie was then visited to ascertain the truth of certain rumours regarding a trail up the north fork of Eagle river and also of one up Queest mountain. We found that there was an old trail for about twenty miles up the north fork of the Eagle, but we could not find any up Queest mountain. The trail up Eagle river is rough and will require considerable chopping, but it will be very useful in establishing a station near the north limit of the railway belt north of that point. It was originally built by lumber companies in order to get some of their limits surveyed. As the weather was still unfavourable and feed scarce, it was decided not to bring the horses, but to move to Salmon Arm and make use of the bad weather to locate a base line.

On August 20 I went to Revelstoke and made arrangements for shipping horses and outfit to Salmon Arm. In the evening I returned to Craigellachie, and the following day moved to Salmon Arm. The remainder of the outfit did not arrive until August 23.

On the 24th a start was made for the Hunters range on the east side of Mara lake. Throughout this district good wagon roads have been built in all the principal valleys. We followed the Enderby road for about nine miles and then turned north to Mara. Crossing Shuswap river by means of the bridge at this point, we camped at Mr. Blurton's, near whose place an old Indian trail ascends to the summit of the range. As this trail was very nearly obliterated, I decided to get Mr. Blurton to accompany me for a few days.

The following morning we started for the summit of the range. Until an elevation of 4,500 feet was reached the trail led through green timber, chiefly small fir, poplar and willow. It then entered a tract of old brule where it was almost impossible to follow it, as it wound in and out among burned logs and fallen trees. After travelling through this for about three hours we reached the summit of the ridge. This summit consists of rolling benches with large open meadows and clumps of scattered spruce and balsam. Country of a similar nature extends from here to Griffin mountain above Three Valley, a distance of about twenty-five miles. Camp was pitched that night in a beautiful open meadow about three miles from the point where we first reached the ridge. Next day we travelled about ten miles farther north to the base of the highest peak on the range, about 7,300 feet above sea-level.

In the meantime the smoke had become so dense that it was impossible to see anything half a mile away. The peak was ascended and a cairn erected, but we were unable to decide whether or not it was suitable for a station. When the weather cleared some days later it was found necessary to place the cairn on a ridge about one mile south and about one hundred feet lower.

The station was marked by a hole drilled in the solid rock to receive the permanent brass bolt. With this hole as a centre the cairn was built, having a diameter of five feet six inches at the base and a height of nine feet six inches. The cairn is situated on the solid rock ridge affording an excellent location for permanent marks. This station was designated as signal XLII.

On September 3 we left Mara and moved down to Enderby, where we remained over Sunday. On Monday we started for Mabel lake, following a good wagon road which leads up the Shuswap valley to the lake, a distance of about twenty- four miles. There is considerable good land in the valley, but much of it is held in timber limits, which are not likely to be thrown open for settlement until the timber is taken off.

In order to reach mount Mabel we borrowed a boat from the A. R. Rogers Lumber company, and took a light camp to the mouth of Cottonwood creek. Here we found an old Indian trail leading to timber-line, and by means of this trail the ascent was made. There is some good cedar, hemlock and fir on the mountain-side, but the slopes are so steep that it would be very difficulty to get it out.

As time was short and loose rock was very scarce, a cairn was not erected. A hole was drilled in the solid rock to receive a permanent bolt and the butt of a tree eighteen inches in diameter and nine feet high was carefully centred and plumbed over the hole. This was securely braced and a piece of white cotton tacked around the upper end. This was designated as signal XLI.

Two days were spent looking up the position of some of the Dominion Lands survey posts in the vicinity and a secondary signal was also erected on Trinity hills, about half way between Mabel lake and Enderby, on the south side of the valley. This trip occupied eight days, during all of which time the weather was cloudy and showery.

On returning to Enderby, a secondary station was placed on a low rocky hill near the northeast corner of section 22, township 19, range 9, west of the sixth meridian. The party then moved to Salmon Arm, where much of the remaining time was devoted to work on the base line.

During a few days of fine weather, a trip was made to mount Ida. Considerable difficulty was experienced in finding a suitable station as the top of the mountain consisted of a rolling flat, heavily timbered. This made it necessary to visit practically every ridge on the summit. A sharp knob on the eastern side of the mountain was finally selected as a suitable point. This is not the highest part of the mountain, but it offers a good view in most directions and is the most favourable point for connecting with the ends of the proposed base in the valley.

Advantage was also taken of two or three fine days to visit Granite mountain and see if it would be possible to obtain a station thereon, from which the ends of the proposed base could be seen and also the peaks necessary for further expansion. It was found that the summit of this mountain consisted of a rounded rocky ridge heavily timbered with second-growth jackpine. A suitable point was selected on a shoulder about twenty feet below the summit and a temporary signal erected. Lines of sight were also cleared to existing signals and to some of the other peaks likely to be useful for stations.

During the last month of the season, much of the weather was too cloudy or smoky for work on the summits, and much of the time was spent trying to secure a suitable location for a base line. For this purpose a line a little over five miles in length was located, commencing on the east side of Salmon Arm of Shuswap lake, about one mile northeast of the town. From here it runs in a southwesterly direction, passing along the shore of the lake and through the Salmon Arm Indian reserve. This line was cleared out so that the ends were intervisible, but no attempt was made to prepare it for actual measurement.

On September 21, instructions were received to close work in the mountains as soon as possible, in order to attend to some miscellaneous surveys in Alberta and Saskatchewan. Accordingly on October 11 arrangements were made for shipping the horses and outfit back to Golden. Here the outfit was stored and the horses sent out to Mr. McKeeman's ranch, about thirty miles south of Golden for the winter.

During the season the work was greatly retarded by rain and smoke. During the interval from June 1 till October 10 it had rained on thirty-nine days and was very smoky and hazy on twenty-nine other days, a total of sixty-eight days out of one hundred and thirty-two. This does not include days on which the clouds were hanging low on the peaks, a condition almost equally unfavourable for work.

The district around Salmon Arm and the Shuswap valley is in a very prosperous condition. Long ago, all the available land in the valleys was taken up for farming. Recently much attention has been given to fruit growing, and this has resulted in much land on the mountain slopes, formerly considered worthless, being taken up by settlers. The limits of the useful land are still being extended and it is impossible to say where cultivation will eventually cease. During the season of 1910, there was a very heavy crop of apples, pears, plums and small fruits, and nearly all the settlers engaged in fruit growing were enthusiastic about their success.

*Miscellaneous Surveys.*

On October 15, in accordance with your instructions of September 25, a small survey was commenced in the northeast quarter of section 18, township 24, range 1, west of the fifth meridian. This survey was completed on October 19.

Then, accompanied by one man, I went to Swift Current. Two correction surveys were made in this vicinity, one in section 2, township 18, range 14, and the other in section 9, township 12, range 12, both west of the third meridian.

On completing this work, I moved to Moosejaw. Here a resurvey was made of some of the lines in township 15, range 26, west of the second meridian, and some duplicate monuments destroyed.

On November 1, I moved to Moosomin where a survey was made in township 13, range 32, west of the principal meridian to ascertain which of some duplicate monuments were correct.

I next proceeded to Brandon, and thence to Forward, stopping on the way at Redvers to make a small correction survey in section 6, township 8, range 31, west of the principal meridian. At Forward two surveys were made, one a traverse of a lake in section 31, township 7, range 19, west of the second meridian, and the other a traverse of part of a lake lying in section 6, township 5, range 19, and section 1, township 5, range 20, west of the second meridian.

On November 13, I arrived at Moosejaw and received there instructions to make a survey of a lake in section 15, township 9, range 23, west of the second meridian. Accordingly I returned to Milestone and drove out to the above section. I completed this survey and returned to Milestone on the evening of November 16.

Leaving Milestone the same evening, I reached Maple Creek the following morning and made arrangements to drive out to section 21 township 7, range 29, west of the third meridian, where a survey was to be made of the old Northwest Mounted Police burial ground at the old site of Fort Walsh. This survey was finished and on November 20 we returned to Maple Creek. Transportation was furnished for this survey and every possible assistance rendered by the Mounted Police.

The following day we started along the Crowsnest line of the Canadian Pacific railway for Macleod. Three surveys were made along the line; one was a correction survey near Purple Springs on the east boundary of section 17, township 10, range 14, and the second was a retracement survey on the correction line between townships 10 and 11, range 19, both west of the fourth meridian. The third was a traverse of Belly river in sections 13 and 24, township 9 range 23, west of the fourth meridian. The north bank of the river through these sections was traversed, but owing to the river being partly frozen and full of floating ice, it was found impossible to cross to the other side.

On December 1 and 2, a traverse was made of a lake lying in section 4, township 21, range 27, west of the fourth meridian, and then I returned to Calgary where a traverse was to be made of Bow river through township 24, range 2, west of the fifth meridian. This was completed on December 9.

I then went up to Didsbury and made a small correction survey near there, on the north boundary of section 11, township 31, range 1, west of the fifth meridian.

On returning to Calgary some additional work was done in the northeast quarter of section 18, township 24, range 2, west of the fifth meridian, and on December 15 I closed work for the season.

## APPENDIX No. 16.

### REPORT OF E. L. BURGESS, D.L.S.

MISCELLANEOUS SURVEYS.

OTTAWA, March 15, 1911.

E. DEVILLE, Esq., LL.D.,
Surveyor General
Ottawa.

SIR,—I have the honour in accordance with my instructions to submit the following report on the miscellaneous surveys which I made during the past year.

On Sept. 3, 1910. I received instructions to survey the ordnance lands lying in lots 39 and 40 of the first concession, Ottawa front, township of Nepean, now within the limits of the city of Ottawa.

The survey was proceeded with immediately. After locating the boundaries of these lands I produced Bell street, Division street, LeBreton street and Rochester street through them to Carling avenue and submitted a plan showing these streets as well as the topography and the improvements on the land. I was then instructed to prepare a method for subdividing the land into city lots. This was done and the lots subsequently marked on the ground.

At the completion of the survey on Nov. 30, I received a message from J. P. Dunne, Esq., of the Ordnance Lands Branch, stating that the Deputy Minister of the Interior had ordered the work to be stopped as the Ottawa Improvement Commission was negotiating with the Department for the property in question. As no decision has been arrived at so far as I am aware as to the disposal of the property no further action has been taken in connection with the survey.

On Jan. 14, 1911, I received instructions to locate the contour line from the spillway of the dam then being erected on Sturgeon river by the Municipality of Fort Saskatchewan in section 22, township 55, range 22, west of the fourth meridian and to traverse Sturgeon river from its mouth across sections 21 and 22 connecting with the traverse the dam and power works and to survey the boundaries of section 22. The chief object of the survey was to determine whether any lands other than those owned by the municipality would be flooded by the dam. It was found that a considerable area of land in sections 27 and 28 which I believe are not owned by the municipality would be so flooded. Sturgeon river was, therefore, surveyed across these sections and the extent of the area required for flooding purposes determined.

I was engaged in the field on this work from January 20 to February 6. My party consisted of two labourers.

I have the honour to be, Sir.
Your obedient servant,
E. L. BURGESS, D.L.S.

## APPENDIX No. 17.

### REPORT OF ALAN J. CAMPBELL, D.L.S.

EXAMINATION OF LANDS IN THE RAILWAY BELT, BRITISH COLUMBIA.

CALGARY, ALBERTA, February 24, 1911.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I beg to submit herewith my report regarding the operations of my parties engaged in the examination of undisposed of lands in the New Westminster district of the railway belt of British Columbia.

In accordance with your instructions, received through Mr. A. O. Wheeler, D.L.S., I took charge of the examination of lands in the New Westminster district. Two parties were placed in the field, one in charge of G. A. Bennett, D.L.S., worked in the Chehalis and Harrison lake country and northward along the Fraser valley, while the other in my charge worked in the vicinity of Stave, Lillooet and Pitt lakes and westward. The report of Mr. Bennett, giving details of his operations, is submitted herewith.

I left Calgary on May 12 and proceeded to Vancouver, where I procured my outfit. It was thought advisable, as there were so many lakes lying in the country to be examined, to provide the parties with canoes for the purpose of transporting the camp outfit, and for use in working around lakes. Two Peterborough canoes were purchased for each party and were found of great service.

The examination of lands was commenced on May 19 at Nicomen and the lands in the vicinity of that place and of Dewdney, including the valley of Suicide creek, were gone over.

On May 28, Mr. Bennett arrived and I immediately proceeded to Vancouver to procure for him the necessary outfit and supplies and also to hire men. In the meantime he was in charge of my party and was carrying the work forward. On June 2 Mr. Bennett took charge of his party and started on the examination of lands at Nicomen, working from there eastward.

By June 1 the lands in the vicinity of Nicomen and Dewdney were completed and the party proceeded with the work of examining the lands in the vicinity of Durieu or Hatzic Prairie. This was completed by the 14th and a move was made to the vicinity of Stave lake. Between June 15 and July 9 the lands around the south end of Stave lake and those lying in the vicinity of Stave river were examined, the latter being reached by flying camps. There being no survey posts on the west side of Stave lake and being unable to locate more than a very few of those on the east, it was necessary to make a traverse of the lake so as to be able to describe the lands adjoining the lake by sections and quarter sections. Accordingly a traverse was run along the west side of the lake and up North Stave river and for some distance up Cypress and Clearwater creeks. The lands in the vicinity were also examined and the work around Stave lake was finished on July 28.

I had intended to move the camp across the ridge between Stave and Lillooet lakes, but on exploration found that it would be just as expeditious, if not more so, to reach the Lillooet lakes by moving down to the Fraser and going in from Haney. Accordingly we moved down to Stave falls by canoe, and, by the kindness of the superintendent at the power works there, were allowed the use of a team to transport the camp to Ruskin. From Ruskin we moved to Haney via Fraser river, and from Haney by wagon to Lillooet river.

The period from August 2 to 11 was spent looking over lands in the vicinity of Lillooet river and camp was then moved to Lillooet lake. The river being unnavigable, it was necessary to pack the camp outfit on our backs.

During this period I visited Mr. Bennett's party to see how he was progressing and to make arrangements for future work.

There being no survey posts in the neighbourhood of Lillooet lake, it was necessary to make some surveys. This was done by traverse and by carrying a system of triangulation up the lake, the lands being examined by lines run from the traverse points. The time between August 12 and September 7 was occupied in this work and in the exploration of Gold creek valley.

The lands on the southerly slopes between Lillooet river and the North Lillooet and across to Pitt meadows were then examined. This work was finished on September 30, and a move was then made to the Pitt lake country and the examination carried on in that region and in the vicinity of Pitt river, which was completed on October 28. The period from October 29 to November 8 was spent in examining the lands to the east of Coquitlam river, and from November 9 to November 15, those on the west side of the river.

On September 28 rain started and fell nearly steadily until October 8; from then the weather was very unsettled and it rained at frequent intervals, making the work on which we were engaged very disagreeable. On November 16 the party moved to Westminster Junction and the men were paid off. Mr. Bennett's party came in on the 17th and was also paid off.

Mr. Bennett and I spent a day at Vancouver collecting data as to lands disposed of and we then started for Calgary arriving there on November 20.

The following methods and instruments were used in conducting the examination. If the lands lay within surveyed territory, the survey lines were traced and auxiliary lines run to gather sufficient information to make a complete report of the lands examined. In unsurveyed territory triangulations, traverses and approximate production of the township subdivision lines were made so as to collect the necessary information regarding the lands examined.

For triangulation work, transit instruments were used, and for traverses a transit surveying compass, a sixty-six foot chain and a stadia rod.

In the land examination direction was kept by military pocket compasses and distance measured by chain, stadia hand-levels and by pacing with the assistance of a tally register. Elevations above sea-level were obtained by aneroid barometers which were carried by the examiner. The travelling barometers were checked for fluctuations due to changes in the atmospheric pressure by the readings of a stationary barometer at camp, these readings being taken every hour. The elevations above sea-level were obtaind from elevations along the Canadian Pacific railway by James White, Geographer. The stationary barometer readings were checked with these elevations wherever possible.

I have the honour to be, Sir,

Your obedient servant,

ALAN J. CAMPBELL, D.L.S.

REPORT OF G. A. BENNETT, D.L.S., ON OPERATIONS IN EXAMINATION OF LANDS IN THE NEW WESTMINSTER DISTRICT.

CALGARY, ALTA.
February 21, 1911.

ALAN J. CAMPBELL, Esq., D.L.S.,
CALGARY, ALTA.

SIR,—I have the honour to submit the following report on my season's work of examining lands in the New Westminster district of the railway belt.

On May 23, in accordance with a letter of instructions from the Surveyor General dated May 18, I started for Nicomen, British Columbia, where I was instructed to meet you. I arrived at Nicomen on the 28th, and finding that you had moved to Dewdney, proceeded there the same day and joined your party. On June 2, with arrangements completed for putting my party in the field, I returned to Nicomen, met the three men you had hired in Vancouver and prepared to make location surveys for the examination of township 24, east of the coast meridian.

Using Nicomen slough and later Harrison bay as a base, the country was examined eastward to the mouth of Chehalis river and finished by June 25. Finding it impossible to use the canoes on Chehalis river the party packed the camp equipage up the Chehalis valley, and completed the surveys and classification of that district on July 29. Using the canoes, Morris lake was then visited and the country adjacent to it was examined, including the lands in the vicinity of Weaver lake. Completing this work on August 3, the party moved to Harrison lake and began the examination of lands on the western side of the lake. These lands, including the islands in the lake were classified by the 23rd and then the party crossed the lake and, beginning with Silver creek valley continued southward the examination of the lands accessible from the eastern shore of Harrison lake. Completing the examination of all lands adjacent to Harrison lake and Harrison river by September 19, the party returned to Fraser river and resumed the work of examining eastward on the north side of the Fraser valley.

In order that the party might safely and expeditiously take the canoes up the riffles of Fraser river an Indian canoeman was engaged. However, because of the heavy continuous rains, which fell during the first two weeks of October, the work of examination was delayed and the river navigation made difficult so that the party did not complete the work to Yale until October 18. To travel farther up the river with the canoes was now impracticable, the high water making the rapids in the canyon above so dangerous that no boat could possibly survive.

On account of the difficulties of transportation in this region, the party now crossed Fraser river and examined the portion of township 6, range 26 and township 7, range 25 east of the river. Therefore it will be unnecessary for another party to come farther up Fraser river than Hope when examining the lands south of the river.

Completing the work in the neighbourhood of Yale by October 25, the camp equipage was transported to Spuzzum by freight. From here surveys were made connecting with those from Yale and the lands in the neighbourhood examined including the Spuzzum creek valley and the lands east across Fraser river consisting of fractional range 26 and township 8, range 25. On October 31 the camp equipage was shipped via Canadian Pacific railway to China Bar and from here lands were examined up to the north limit of the Coast division including the Scuzzy river valley and lower Anderson river valley.

Winter had now begun to set in. From October 1, when the rainy season began there had been almost continual rain which now changed to sleet and snow, and covered the uplands to a depth of from six to ten inches. These weather conditions made work such as the party were engaged on very disagreeable, as much of the time had to be spent in flying camps up in the mountains.

The examination of the country to the west of Fraser river in the Coast division was now completed, as well as of lands east of Fraser river, north of township 5, which could be conveniently reached without the assistance of packhorses.

On November 10 the party started for Westminster Junction travelling by railway to Yale, then by canoe down Fraser river to Pitt river where the canoes were stored, and reaching Westminster Junction on the 17th the party were paid off.

After spending a day in the Lands Office at New Westminster gathering data about lands disposed of, I started for Calgary, reaching there November 20.

I have the honour to be, Sir,

Your obedient servant,

G. A. BENNETT, D.L.S.

## APPENDIX No. 18.

## ABSTRACT OF THE REPORT OF P. A. CARSON, D.L.S.

### MISCELLANEOUS SURVEYS IN SASKATCHEWAN.

The miscellaneous surveys on which I was engaged throughout the season were very varied in their nature. They consisted in locating, and correcting where possible, errors in original surveys; reconciling seeming discrepancies in the returns of old surveys; restoring and reestablishing obliterated and lost monuments; determining the areas of small lakes evidently overlooked in the original survey; traversing lakes or rivers whose beds or channels have sensibly altered since the original survey; surveying the beds of a number of prairie lakes which have dried up and conceded many acres of valuable hay and farming land; investigating all manner of communications received by the Department from settlers with reference to surveys. When such matters are brought to the notice of the Department, it is necessary in many cases to investigate the true condition of affairs on the ground, and it has been found that time and money are saved by sending, instead of a whole survey party, merely a surveyor and assistant, who can easily make the necessary investigations and in most instances perform any small surveys required.

The year 1910 was a remarkably dry year, due to the light snowfall of the preceding winter and the drought of the spring and summer. Lakes and sloughs, which during previous years were full of water, were, in 1910, perfectly dry, and produced great quantities of hay. In some cases the dry beds seemed suitable for agriculture and many applications were received for these lands. The question was to decide whether the dryness was a permanent condition or only due to the abnormal drought. The real old timers in some of the districts where this condition of affairs existed affirmed that the wet and dry seasons go in cycles, that they had seen the same dry state before, some fifteen or twenty years ago, and that, if the winter of 1910-11 brought an abundance of snow, these lakes would fill up again. Others claimed that the climate of western Canada was changing, due to the tilling of the soil, that the amount of rainfall is decreasing each year, that the ploughing and growing of crops on the land surrounding the lakes prevented the moisture from seeping to the low levels, and that cutting the hay from the beds allowed the water to dry off more quickly.

From my personal observations I have formed a rather qualified opinion on this subject. In some districts, particularly where the land is fairly level and open, many shallow lakes are at present dry, and I believe will remain so. On the plan of township 37, range 25, west of the third meridian, are shown eight lakes. These must have contained water at the date of survey, July, 1904. In October, 1910, there was not a drop of water in the township, except in lake No. 8, where only a muddy pond of ten acres remained. Some portions of the old beds have been broken and tilled, others are producing hay. In the bed of lake No. 1 which covered nearly a thousand acres in sections 24 and 25, I saw a field of flax yielding between fifteen and twenty bushels to the acre. Similar conditions exist in several neighbouring townships. I believe that the majority of these lakes will remain dry, and even those which contain water at wet seasons will produce hay in the late summer, and should not be excluded from the quarter sections as being useless.

There are, however, a number of lakes which, although at present dry, will probably revert to their normal condition during wet years, for example, Grass lake, in townships 37, ranges 23 and 24, west of the third meridian. This lake is four miles long and a mile wide. The banks are from ten to thirty feet high, and the surrounding country is rolling prairie. Although some of the neighbouring land has been broken and tilled, and enormous quantities of coarse hay have been cut from the dry bed, I see no reason why Grass lake will not again contain water. For this reason and as the soil of the bed is of a muck-like nature, the lands of Grass lake will be useful only for haying purposes. Muddy lake in townships 38 and 39, range 22, west of the third meridian is a somewhat similar case, but in this, as in most alkaline lakes, a deposit of alkaline mud lessens the value of the land for hay. The waters of Killsquaw lake in townships 39 and 40, range 22, west of the third meridian have receded greatly since the subdivision survey in 1903. Many acres formerly covered by this lake are now arable, many more are hay producing, while unfortunately in some quarter sections foxtail, or wild barley has grown so luxuriantly that any useful growth is smothered.

These are but a few of the numerous cases of a similar nature each of which must be investigated individually to be dealt with at all.

In addition to the miscellaneous surveys, observations were taken at the different localities for magnetic declination, dip and total force, these observations not materially retarding the regular work. One hundred and sixty observations for magnetic declination were obtained, with a Bausch and Lomb trough compass attached to the standards of a Watts transit. The index correction of the compass was determined at the Agincourt magnetic observatory, both at the beginning and the end of the season.

The observations for dip and total force were made with a Dover dip circle, according to Lloyd's method. Two complete observations for each were taken at twenty-three stations. The constants of the dip circle were determined at Agincourt, both at the beginning and the end of the season.

Observations were also taken for the diurnal variation of magnetic declination on several days during the summer. The diurnal variation was also observed every day during the month of November at Rosthern, Sask., in township 42, range 3, west of the third meridian, simultaneously with another observer stationed at Athabaska Landing, Alberta. My assistant observed for diurnal variation and as well for dip and total force.

## APPENDIX No. 19.

### ABSTRACT OF THE REPORT OF WM. CHRISTIE, D.L.S.

SURVEY OF PARTS OF THE EIGHTEENTH AND TWENTIETH BASE LINES WEST OF THE FOURTH MERIDIAN.

During the winter I arranged to have my season's supplies forwarded to Cold lake, and on May 9 I left Prince Albert for the survey by way of Lloydminster. With my party I reached Cold lake on May 20, and proceeded thence by the wagon road around the west shore of Cold lake and Primrose lake to the intersection of the meridian and the eighteenth base. We commenced work on May 31, leaving our wagons behind and moving all the season by pack-train. The work was pushed vigorously ahead and on August 17, we reached range 13, to which point the base had been previously established.

We then started back over our own trail and reached the fourth meridian August 26. We then followed the trail made by Mr. J. N. Wallace when surveying the fourth meridian and arrived at the intersection of the twentieth base, September 5. We surveyed this base across nine ranges, and, on October 31, our supply of oats being exhausted and forage being poor, we closed operations for the season and arrived back in Lloydminster, November 28.

The country along the first six ranges of the eighteenth base consists of sandy ridges covered chiefly with jackpine together with some poplar and small spruce, alternating with large muskegs and tamarack swamps. There are practically no hay lands, the only grass found being around some of the lakes and along a few creeks. The soil on the ridges is mostly light and sandy. Most of the swamps can be easily drained and converted into good agricultural lands.

Across ranges 7, 8 and part of 9, the country is more rolling but contains many swamps. The soil is better and is covered with poplar, spruce, jackpine and brule. A stream, one hundred and twenty feet wide and three feet deep, crosses the line in section 35, range 8. Its valley is from one-half to three-quarters of a mile wide and seventy-five to one hundred and thirty feet deep. Some good clumps of spruce and poplar occur on the slopes of the valley. Several small creeks flow into this stream in the vicinity of the base line. Along most of these and also along the main stream good grass is to be found.

Across the remainder of range 9 and range 10, the country is high, rolling, and heavily timbered with poplar up to sixteen inches, spruce up to twenty-four inches and some birch and jackpine. The soil is good, consisting of black loam to a depth of six to ten inches on a subsoil of clay. Touchwood lake, which lies in townships 66 and 67, ranges 9 and 10, drains into Beaver river and Heart lake in townships 70, ranges 10 and 11, and ultimately to the Athabaska. Both lakes abound in whitefish.

The line in ranges 11 and 12 crosses rolling country, but the hills are lower than in the more easterly ranges, and there is considerably more swamp and muskeg. The timber is mostly poplar, spruce and birch up to eight inches. A wagon road from lac la Biche to Heart lake crosses in range 11, and on the west shore of Heart lake there is a small settlement of Indians and half-breeds. They grow potatoes and vegetables successfully and have a number of horses. The land in this vicinity is very lightly wooded and can be easily cleared.

The country crossed by the twentieth base line is of much the same character across the nine ranges. The general slope is to the north and the surface is rolling, consisting of ridges covered with spruce, jackpine, poplar and a little birch, alternating with spruce and tamarack swamps. The timber seldom exceeds eight inches and nowhere is it of commercial value ; but there is everywhere sufficient for the needs of settlers. All the swamps can be easily drained and will make good agricultural lands. Little hay was found.

Buffalo river flows east across the line in range 1; there is a little grass along its banks. Winefred river crosses in range 3, flowing northeast from Winefred lake in townships 75 and 76, ranges 4 and 5. The banks of the stream are low and swampy. Winefred lake is said to abound with whitefish. There are a few Indians at the lake who grow a few potatoes that appear to do well.

The pack-trail from Heart lake to McMurray crosses the line in range 3.

A lake, about eleven miles long and averaging one and one-half miles wide, lies close to the line in townships 76, ranges 5, 6 and 7. Whitefish and jackfish are plentiful in this lake. The outlet is at the west end by a creek which flows to Pembina river, about six miles to the north. There is a number of old houses at the west end, but only one Indian, with his family, now lives there.

A small lake just north of the line in range 7 is surrounded by a narrow strip of good hay meadow.

## APPENDIX No. 20.

### ABSTRACT OF THE REPORT OF A. L. CUMMING, D.L.S.

SURVEYS AROUND BRULE LAKE, SOUTHWESTERN ALBERTA.

Leaving Edmonton on May 6, we went by the Grand Trunk Pacific railway to Wolf Creek, and from there by trail to the fourteenth base line, north of Brule lake. We crossed McLeod river at Wolf Creek and Athabaska river at Prairie Creek, both rivers being at high water.

After building two caches, one at Prairie Creek and another near our work, we commenced on June 1, the subdivision of township 52, range 26, west of the fifth meridian.

Subdivision work was also performed in townships 49, 50 and 51, range 25, and township 51, range 26, after which Athabaska river was traversed from township 50, range 27, west of the fifth meridian to township 47, range 1, west of the sixth meridian.

The part of the Athabaska traversed lies wholly within the Jasper Forest Park reserve. Township 47, range 1, west of the sixth meridian, is reached by the freight road along the Grand Trunk Pacific railway.

It is a first-class wagon road and heavy loads can be hauled over it. The Athabaska ferry crosses the river approximately in section 14, township 48, range 28, west of the fifth meridian, and from there the road follows the left bank of the river. The soil along the river is mostly a sandy loam with sand subsoil, but in places is rocky, the rock being a hard bluish limestone. The banks are not very high and are covered mostly with good spruce running from fifteen to twenty inches in diameter. Athabaska river is a large swift- running stream, varying in width from one hundred yards to almost a mile, where it expands into Jasper and Brule lakes. The river was not frozen over at the time of traverse in December, because the current is swift and the Chinook winds play havoc with the ice that forms. The ice was sufficiently formed along the banks to permit us to do most of the traverse on the river, and we were compelled to work on the shore only where points jutting out allowed no ice to form. The first expansion of the river going down stream is Jasper lake, which is about one mile wide and six miles long. A very large lake about five miles long runs almost parallel to Jasper lake on the right bank, being separated by only a narrow ridge of land. At the outlet of Jasper lake going down stream there is a beautiful archipelago containing islands of all sizes which are covered with good green spruce, and at high water the larger islands appear as a number of smaller ones, while a great number of gravel bars are to be seen at low water. The river runs through a very pretty valley varying from one to four miles in width. Again there are places where this valley is broken by the foot-hills rising at the edge of the river, and consequently narrowing the river very much at these points. Water-power might be developed by damming the river at those points, but very little could be done without seriously interfering with the Grand Trunk Pacific grade which is very close to high-water mark. The scenery in the park is magnificent, the snow-capped peaks of the Rocky mountains forming a striking contrast to the peaceful green valley of the Athabaska. Bullrush mountains and roche Suette on the left bank, and the Folding mountains, roche Miette and roche Jacques on the right bank within three miles of each other, appear to tower over the river.

Finishing the traverse on December 28, the party returned to Edmonton, arriving there on Jaunary 3, 1911.

## APPENDIX No. 21.

### ABSTRACT OF THE REPORT OF W. J. DEANS, D.L.S.

SURVEYS IN THE RAILWAY BELT OF BRITISH COLUMBIA

I arrived at Notch Hill on May 3, 1910, whence I proceeded to township 22, range 10, west of the sixth meridian.

My first work consisted of the surveying of part of this township into half legal subdivisions. These lands extend to the shore of Blind bay on Shuswap lake and vary in height from a few feet to 1,300 feet above the lake. Most of the land in the area subdivided is classed as bench land though in some places there are quite large level tracts, and in other places the land is broken by ridges and ravines. The soil generally on the flat land is clay, while on the broken land it is a clay mixed with sand and gravel. The whole surface, except where burnt over by fire, is covered with a thick growth of small poplar, birch and willow, with occasional clumps of fir which have been left by the lumbermen owing to the difficulties of getting the logs out. There are four small lakes containing good water. As all or most of the land surveyed by me was in a timber berth, there are numerous lumber roads and trails throughout the whole tract. There is, also, a good road from Notch Hill station, running through the township. These roads and trails make travelling easy and the market for produce can at all seasons be reached without difficulty. I am told by the settlers that the heavy clay land will not produce satisfactory crops until it has been sown with white clover; this seems to restore to the soil all the elements necessary for successful production. I saw a few small apple orchards, which had been planted on this clay soil prepared first by sowing clover, and, although the trees had only been set out two years, they were in a very healthy condition and gave promise of development into a producing orchard. I saw a five-acre apple orchard at Notch Hill station, the trees of which consisted of well-known winter varieties, and had been set out two years. The owner bought the land at fifty dollars an acre. He was well pleased with his venture, and felt sure that the climate and soil were well suited to apple production. This land is similar to the lands I subdivided, and I have no doubt that most of the land surveyed in this township is well adapted to the cultivation of apples, cherries and berries.

These lands are also well adapted to the production of garden vegetables. I saw many small gardens, and although the land did not seem to be in a high state of cultivation, yet the vegetables would be hard to excel.

Timothy yields well on the lower levels, and heavy crops of oats are grown.

The rainfall during May, June and part of July was sufficient for agricultural purposes, and although we had frosts in May and June, yet they were not severe enough to do any damage to grain or vegetables.

There are many ideal camping places in this township along the shores of Shuswap lake. A beach of sand and gravel extends fifty feet back from the water, and from there the land rises in a gradual slope. The ground is carpeted with a thick growth of grass and creeping vines and is wooded with large fir and cedar. Bears and deer are to be found in the forest, while the lake abounds in fish. Plenty of pure water is to be found in the numerous mountain streams. My last work in the township, which was finished on July 12, was near White lake. The land near the lake is covered with a heavy growth of fir and cedar, some of them thirty-six inches in diameter. Fire has done some damage around the lake and the fallen timber makes it difficult to travel.

On July 13, I hired a gasoline launch and moved the outfit to township 24, range 8, west of the sixth meridian. This township is situated on the shores of Seymour Arm, a part of Shuswap lake. On July 15, I started to run the north boundaries of sections 3, 2 and 1, which form part of a reservation to the south. This line extends from the lake shore up the side of a steep mountain and attains a height of 2,200 feet above the lake. Then there is a flat of some twenty chains and then the line descends to the west shore of Anstey Arm. The surface of the mountain on the west side near the lake is covered with fir, poplar and cedar from ten to twelve inches in diameter, while farther up the mountain the trees are small and scattered, with clumps of poplar and hemlock scrub. On the top of the mountain, the timber consists of fir, hemlock, and birch, from eight to ten inches in diameter, with hemlock scrub. On the east slope of the mountain the timber is generally small, except in a few places where the fir and hemlock attain a diameter of from twelve to sixteen inches.

The soil along the north boundary of this reservation consists of sand and stones, with patches of rock. There are a few places where the soil is clay, but the area is very small. I do not consider the lands adjoining the north boundary of this reservation on either side of any value for agricultural purposes.

On July 19, we moved the outfit up Seymour Arm to the north boundary of section 15. My work here consisted in subdividing a strip of land lying between the north boundaries of sections 15 and 35 and extending back from the lake shore for a distance of about a mile and a half. The shore of the lake had been traversed and monuments erected at section corners. Generally speaking, the whole of this tract rises very abruptly from the lake to a height of 400 feet, then in short benches until a height of from 1,200 to 1,600 feet is attained at a distance of a mile from the lake shore. There is a large portion of this tract which in my opinion is suitable for the cultivation of apples, cherries and berries. Wild berries grow in great abundance, attain a great size and have a splendid flavour. The soil in this part is mostly clay, gravel and sand, with large patches of bare rock in many places. The surface near the lake is covered with fir, poplar, birch and cedar, from six to twenty-four inches in diameter. Most of the large fir which we cut down were rotten at the heart, while the cedar were only shells. The surface a mile back from the lake is largely covered with a thick growth of small hemlock with occasional clumps of fir. The soil where these small hemlock grow consists of loose rock, covered with moss and an inch or two of soil. I did not subdivide the east half of section 23 nor the west half of section 25, township 24, range 8. I do not think that these lands are of any use for agricultural purposes. The soil is largely composed of loose rock and moss on which there is a thick growth of small hemlock scrub.

I completed the subdivision of that portion of township 24, range 8, lying along Seymour Arm, and on August 23, moved the outfit by gasoline launch to Anstey Arm, camping on section 12. I subdivided the northeast quarter of section 12 and the east half of section 13, thus completing all the subdivisions which I had to make in township 24, range 8. The land in sections 12 and 13 slopes gradually up from the lake to a height of 400 to 800 feet. The surface is covered with a thick growth of poplar, fir and cedar, from three to six inches in diameter; there are numerous ravines in section 12, which cut the land up badly and the soil is clay with gravel and loose rock covered with moss along the north side of the section.

The east half of section 13 contains some good land which slopes towards Anstey Arm; the soil is clay and sand with gravel and patches of rock in places, and the surface is covered with a thick growth of small spruce and birch, with thick underbrush. To clear this land would entail a good deal of hard work, but it would amply repay the settler when under cultivation. I subdivided section 18 and part of 19 in township 24, range 7. These sections slope sharply towards Anstey Arm and are covered with a thick growth of bush, with scattered fir, cedar, poplar and birch, eight to ten inches in diameter. The soil is clay and gravel with patches of rock.

On September 9, I moved the outfit with two small rowboats across Anstey Arm to section 8. My work in this locality was to subdivide the land lying along the shore of the arm between the north boundary of section 7, and the south boundaries of sections 5 and 6. I completed the subdivision of this tract on September 21, and moved camp to section 35, township 24, range 7. The work in the township was finished on October 15. Most of the land which I subdivided along Seymour and Anstey Arms is well adapted to apple and berry production. The soil is suitable, the rainfall sufficient, and I think there are no severe summer frosts. The land is accessible by boat, the greater part of the year. Sicamous Junction, a station on the Canadian Pacific railway, is within eighteen miles, and from this point a number of steamboats and gasoline launches make trips to different parts of the lake. Farm produce and vegetables are very high in price, the local demand at all times being much in excess of the supply.

On October 15, I moved into Sicamous on my way to the Columbia river valley. I arrived in Golden on October 16, whence I moved the outfit by team to section 3, township 26, range 21, west of the fifth meridian.

Golden, situated on the main line of the Canadian Pacific railway near the junction of the Kicking Horse and Columbia rivers, contains about 800 inhabitants. It is an important railway point, and it is also the headquarters of a large lumbering company. There are a number of churches in Golden and also a good school. The town is lighted by electricity and has an efficient fire brigade. The lands in the vicinity are fertile and when settled and cultivated Golden will become a thriving centre. There is a steamboat which sails from Golden to the head waters of the Columbia river and does a large trade in passengers and freight. There is also a good wagon road, running south in the Columbia river valley to Fort Steele. The Kootenay Central railway have a portion of their road constructed.

My work in the Columbia river valley was to survey three timber berths and subdivide agricultural lands in townships 25 and 26, range 21, west of the fifth meridian. I had a great deal of trouble and hard work to get my outfit up to the northeast corner of section 4, as this point is about 800 feet above the Kootenay road. I surveyed timber berth No. 542 from this camp and ran all lines within a reasonable distance. On November 17 I divided my outfit, leaving half camped on section 26, township 25, range 21, while the other half went up to survey timber berth No. 541 and camped near the east boundary of section 36, and as this land is fairly good for agricultural purposes I laid it out in legal subdivisions. The timber will probably be cut off inside of two years, when the land will be available for settlement. The Columbia River Lumber company have about sixty men working on timber limit No. 421 and expect to cut not less than 3,000,000 feet. The same company have also a camp on section 10, township 26, range 21, and expect to cut 2,000,000 feet. On both these limits they are cutting some fine timber, principally fir and spruce. These camps furnish employment for a large number of men in winter. Few of the settlers appear to take advantage of this opportunity to get employment, as nearly all the men are from outside points, and when the camps break up in the spring, they seek new fields of employment. I did not subdivide the northwest quarter of section 26, as this land is subject to flood and is at the present time largely covered with water, the only portion dry being a small fringe along the banks of Columbia river. I had considerable difficulty in surveying timber berth No. 543 on account of the river not being frozen very hard it being necessary for us to cross and recross it a number of times. This timber berth lies on the west side of Columbia river and consists of fractional southwest quarter of section 26, township 25, range 21. The berth is level, except at the southwest corner, where it rises to a height of about 300 feet. The soil is clay and sand, and will produce hay, grain, vegetables and fruit. There is an extensive strip of flat land on both sides of Columbia river, but owing to the river overflowing its banks, this land is covered with water the greater part of the year, and, therefore, not of much value even for grazing purposes. To make this land available for settlement involves engineering difficulties, the solution of which is of the greatest importance to the settlers. Owing to the depth of snow on the benches and the stormy weather, I was unable to complete all of the work in townships 25 and 26, range 21, for which I had instructions.

Before discontinuing the work I ran the north and east boundaries of section 30, township 26, range 21.

The settlement in the Columbia river valley is confined to a narrow strip along the Kootenay road, so that between the settled lands and the mountains there is quite an extensive bench of agricultural land. These bench lands are from 100 to 1,000 feet above Columbia river and contain many small tracts of level land. The soil is clay, sand and gravel, with patches of rock, and the surface is covered with fir, spruce, poplar and birch. In most places the merchantable timber has been cut off, yet in many places there are quite large clumps of fir twelve to eighteen inches in diameter which were too scattered for lumbermen to log economically. There are numerous trails and roads through these lands, made by the lumbermen, and in some places the land could be cleared with little labour.

This part of British Columbia has many inducements to offer the settler. The summers are delightful, being warm in the daytime and cool at night, while the winters are mild. Good prices can be obtained for all kinds of farm produce. The soil is fertile, and there is plenty of timber for building purposes and fuel. An abundant supply of pure water suitable for all domestic purposes can be easily obtained. Roads are good, while schools and churches are within reach of all. Plenty of wild game is found in the forest and fish in the rivers and streams.

The weather for the greater part of the season was favourable for field work. We had two weeks of rainy weather in October, and some rainy and stormy weather in November and December.

I discontinued the work on December 15, and on the same day moved into Golden, paid the men off, and on December 19 arrived back in Brandon.

## APPENDIX No. 22.

### ABSTRACT OF THE REPORT OF W. A. DUCKER, D.L.S.

SURVEY OF THE OUTLINES OF THE PORCUPINE FOREST RESERVE.

My first work was the survey of the east boundary of township 40, range 28, west of the principal meridian, starting from my base line of last winter. I then ran the east boundaries of townships 40 and 39, range 29, and having produced the east boundary of township 38, range 29, from the northeast corner of section 24 to the correction line, I ran the jog and fixed the corners on the correction line in accordance with the instructions of the Manual of Survey.

From this point I had to cut a road to Caverly's mills in township 38, range 28, a distance of about five miles, and from this mill there is a good winter trail to Bowsman from which point our supplies were secured.

I then ran the east boundaries of townships 40 and 39, range 30, from my base line of last year, running the jog and fixing the posts on the correction line in accordance with the instructions of the Manual. This latter meridian is the boundary between Manitoba and Saskatchewan.

I next ran the north side of the tenth correction line across ranges 30, 31 and fractional range 32 to the second meridian giving all quarter sections their theoretic width of forty chains and sixteen links.

At this time the snow was rapidly disappearing, and I took the party into Bowsman, which was reached on April 3, and to Winnipeg the following day, where the party was disbanded.

The general character of this forest reserve was pretty fully described in my report of last winter's operations. Most of the old timber was fire-killed some years ago and now lies in a tangle. The fires did not run through the swamps and the muskegs but nearly all the humus soil on the ridges was destroyed and most of the sandy clay subsoil is pretty stony. The greater portion of the surface is covered with a thick growth of young timber, largely jackpine, though in the southern portion of the reserve there is more spruce and other timber which would be of value than in the central portion where I worked last year.

The snowfall of the past winter was exceptionally heavy, being thirty inches to three feet deep on the level, and with the windfall and undergrowth made any rapid progress impossible.

There are many fine lakes of considerable size throughout this reserve and in most of them the water is of a good quality and fish of various kinds are said to be plentiful. It is also a great summer range and breeding ground for moose, the barked trees on which they polish their horns being visible in all directions, but in winter time they move to the lower ground, and I think that only two were seen in the reserve by my party during the progress of the work.

The past two winters have been poor years for rabbits, and in consequence fur is very scarce and tracks of fur-bearing animals were very rarely seen.

There are some beaver in the reserve and a colony have a dam and a large house on section 6, township 39, range 30. A number of muskrat houses were also seen, though these animals are becoming very scarce owing to the high price of the fur for the past few years.

Owing to the large amount of fallen and decayed timber and the inflammable nature of the young growing conifers, great care will be necessary for several years to keep fire out of this reserve.

One fire crossed the south boundary last spring near Jackfish creek in range 32 at the time when the poplar were in bud, but apparently did not do much damage as it was a surface fire running in the dead leaves and grass; I do not think it ran far, but it killed the young poplar as far as it went.

# APPENDIX No. 23.

## REPORT OF CARL ENGLER, D.L.S.

### MISCELLANEOUS SURVEYS IN NORTHERN ALBERTA.

OTTAWA, Jan. 24, 1911

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I have the honour to submit the following general report on the survey of the northern boundary of the Province of Alberta across Slave river.

On May 5, 1910, I left Ottawa arriving at Edmonton on May 10 where I was joined by my assistant Mr. J. A. Cote. We set out next morning for Athabaska Landing arriving there on May 13 in the evening.

The flotilla of scows employed by the Hudson's Bay company was to leave Athabaska Landing en route for the north on May 15, but owing to delays in procuring men to manage the scows and to a reluctance on the part of those in charge to leave when the water was low, the departure did not take place till the evening of May 21. We were finally compelled to start with fewer men than usual and in low water, conditions which delayed the progress of the expedition wherever rapids existed in the river. On account of the low water many spots were dangerous which under high water could be run with comparative safety, and owing to the scarcity of men it was necessary to tie up half the scows above such bad spots while the crew "doubled up" on the remaining boats, ran them down to where the river was safe and then came back for the rest.

These delays were slight however compared to those of portages. The first portage is at Grand rapids, the most formidable obstacle to navigation on the river, which was reached May 28 about noon. The river here is divided into two channels by an island. In going down stream boats usually land their cargoes at the upper end of this island, haul the cargoes to the lower end by means of hand-cars running on a rude tramway, run the baots down empty through the eastern channel (the smaller one) and reload them at the foot of the island. As the water was very low when we arrived it was necessary to run the boats for the last two or three miles above the rapids with half loads, each boat making two trips. It was not until the afternoon of June 3 that we were ready to embark below and proceed on our journey.

The river from Grand rapids to McMurray has many rapids. In fact to one inexperienced it seems to be all rapids. The total distance is said to be ninety miles, and I have been told that it can be run in high water in ten hours. When the water is low the "big cascades" necessitate the lightening of boats by making a short portage of about half their loads. On our trip this involved a delay of about a day. We arrived at McMurray on the evening of June 8.

Here we had another delay of about a week waiting for the steamer *Grahme*. The trip by the *Grahme* promised less delay, but when we got to Chipewyan we were compelled to wait three days for calmer weather, it being considered unsafe for the boat to go out in the lake when it was at all rough. After a further delay of about a day on Slave river in a vain attempt to right the Hudson's Bay company's stranded steamer *Primrose* we arrived at Smith landing June 22.

I have dwelt in detail on the time consumed in this trip (thirty-eight days from the time boats were to leave Athabaska Landing) so that another surveyor going into the country may know what to expect. The Hudson's Bay company are in the country primarily to trade in furs, their transportation business for the public being an incidental. They plan to make a certain number of trips in a season and insist rather on doing things with care and safety than on an exact time schedule. Consequently most of the other fur traders and others going into the country do so by getting a scow of their own and employing a skilled pilot and crew. I have been informed by men who have gone into the country in this manner that they have made the trip to McKay which is about thirty-five miles below McMurray in three days and to Fort Resolution in eight days. In the latter case a steamer was used below Fort Smith. While I do not doubt the exceptional character of these rates of travel there is no doubt that a great saving of time is effected.

Upon arriving at Smith landing I received a letter left for me by the Honourable Frank Oliver, Minister of the Interior, asking me to undertake the survey of the settlement should time permit. I therefore spent about two weeks at this work and then went to Fort Smith, a distance of sixteen miles, and began a series of zenith telescope observations to determine the latitude, after which an offset southerly to the boundary of Alberta (the sixtieth parallel) and an east and west line across Slave river completed the work. On either side of the river a monument was placed to mark the boundary.

Whenever possible during the progress of the work at Fort Smith hourly readings of the declination of the magnetic needle were taken. In addition to this at every stopping place on the trip from Athabaska Landing observations were taken for magnetic declination, dip and total force as well as observations for time with a view of obtaining approximate longitudes.

The return trip was begun August 2 when we crossed to Smith landing whence the steamer *Grahme* departed August 5, arriving at McMurray, August 9. The most difficult part of the trip from McMurray to Athabaska Landing took from August 12 to September 4. Six scows laden with furs of the Hudson's Bay company and other traders, the personal effects of the passengers, and food and cooking utensils for all, were hauled up stream against the swift current at a rate varying from four to twenty-five miles per day by a crew of about eight men to each boat. Portages were made at "big cascades" and at Grand rapids. Almonst everyone who comes into the country goes out of it by this transport, at least so it seemed this season, as there were about sixty passengers. To anyone coming out independently I should think a large Peterborough canoe would have a great advantage it being so light that the trackers could make better progress.

A word as to the natural resources of the country may not be out of place. As regards timber, broadly speaking the whole river-valley is well wooded, all low river-flats and islands bearing good spruce for commercial purposes. At McMurray I measured a spruce ten feet four inches in circumference, and at many stopping places saw trees thirty inches in diameter. Many of the higher flats are covered with poplar of quite uniform size and as large as two feet in diameter. What lies outside of the river-valley I cannot say. Enormous cliffs of tar sand are seen from McMurray to McKay. The quantities of this sand are so great and some of it bears such a large proportion of tar that one would naturally expect to find pure tar or coal, gas, or oil in the vicinity. While several borings have been made for oil none are deep enough to be conclusive in their evidence. At Grand rapids a seam of coal shale was burning when we passed, and at Pelican river from a boring originally made for oil a gas flame from fifteen to twenty-five feet high shot up, the force of the natural gas making a noise like the roar of a waterfall, which could be heard several miles.

As to the agricultural possibilities of the country I should speak with caution as I was there in the warm season only. I was surprised at the rapidity and perfection of the growth of the garden produce, such as potatoes, radishes, lettuce, carrots and onions. At Fort Smith on the last day of July oats were headed out with a slight suggestion of the yellow of ripening, and barley was almost ripe; in fact the barley was so far advanced that if cut it would probably ripen in the shock. Potatoes were out in bloom. Unless this season is an exceptional one, I should say that it would be possible with a good market to carry on mixed farming, though I do not consider it advisable to attempt it while land with better climatic conditions is available. At Calling river on September 2 I saw a small field of wheat which was well ripened and as nearly as I could tell had not been damaged by frost. The owner said he had grown wheat successfully for several years. This is the farthest north that I saw wheat growing.

I have the honour to be, Sir,

Your obedient servant,

CARL ENGLER, D.L.S.

## APPENDIX No. 24.

### ABSTRACT OF THE REPORT OF L. E. FONTAINE, D.L.S

MISCELLANEOUS SURVEYS AND INSPECTION OF SURVEYS MADE UNDER CONTRACT IN THE EDMONTON DISTRICT.

On February 7, 1910, I reached Ottawa and having received my final instructions I left after a day's delay for Saskatoon to inspect the new stock of iron posts supplied to the Department to be used by surveyors in marking section and quarter section corners.

I then proceeded to Edmonton, where I arrived on February 17. Having completed my organization I left on March 1 for Entwistle to perform some miscellaneous surveys in township 55, range 7 and township 54, range 8, west of the fifth meridian.

Having completed this work on April 20, we proceeded westerly and from Chip lake as a base inspected the surveys performed under contract No. 10 of 1909, and made a retracement of part of township 54, range 12, west of the fifth meridian.

On May 26, I returned to Entwistle, and for the remainder of the season was engaged upon the following surveys in the order named : the examination of the addition to contract No. 18 of 1908, contract No. 25 of 1908, contracts Nos. 16, 23, 9, 22 and 25 of 1909, the reexamination of contract No. 12 of 1908 and some check measurements and necessary traverses in this last contract.

The principal drawbacks of the season were the poor roads in some localities and the absence of fords on the streams. However, the country is rapidly becoming accessible on account of the extensive railway construction being carried on and settlement is progressing satisfactorily.

Separate reports have been submitted on the condition of the surveys in each contract inspected.

## APPENDIX No. 25.

### ABSTRACT OF THE REPORT OF J. FRANCIS, D.L.S.

#### SURVEYS IN SOUTHWESTERN ALBERTA.

I left Edmonton on May 10 and reached "The Leavings" on McLeod river on the 14th. I remained there till the 20th, as I was compelled to send back to "big eddy" for supplies, feed for the horses being very scarce. I reached township 48, range 24, west of the fifth meridian on May 27.

On section 31 of this township the west fork of the McLeod divides into two streams of about equal volume, both coming from the rocky hills, one from the south, and the other from the southwest.

Both branches were explored for the surveyed coal claims which were found on the south fork about five miles from the confluence. No coal, however, was seen on the surface in this district. The valleys contain some timber fit for ties and sawlogs. The hills have been burnt over, but are now reforesting with pine and spruce. On June 15 we proceeded to our next work which was situated in the west half of township 49, range 23. This tract is traversed from north to south by McLeod river, the valley of which with its slopes contains some fairly large timber, consisting of pine and spruce, fit for sawlogs and railroad ties. One seam of coal was noticed on the northwest quarter of section 17, and a claim to this had been roughly marked on the ground.

Our next move was to townships 45, ranges 20 and 21. We went by a pack-trail made by A. H. Hawkins, D.L.S., up McLeod river, over some burnt hills, crossing the head waters of the Pembina and down a branch of Southesk river.

Our work in this district was crossed from east to west by Southesk river, which receives several tributaries, mostly from the south side. A range of high hills, rising about 1,400 feet above the river, commences in section 10, township 45, range 21, and extends northwesterly through this township and into the next range. The south slope of this range of hills is covered with a thick growth of pine and spruce, generally small, but having trees large enough to furnish a considerable number of railroad ties. The north slope is not so well timbered, having more spruce and balsam than pine. On sections 13 and 14, there are some open places, being mostly hillside muskegs, wet and of no use agriculturally. Numerous prospects or coal exposures were noticed along the banks of Southesk river. These coal seams were not thick, being generally in an almost vertical position, and were apparently broken from the parent bed. Development work would be required to ascertain if these seams contained sufficient quantities of coal to warrant the expense of roads. The valley of the Southesk through range 21 is only from five to ten chains wide, with successive benches extending on each side, finally merging into the high hilltops. The current of the river is swift and there are many rapids. The river is about sixty feet wide with a normal depth of eighteen inches, and in some places passes through canyons where water-power could be easily developed. During the months of August and September several snowstorms were encountered in this district, which I think is something unusual for this region.

We ran short of provisions after surveying twelve miles in township 44, range 21, as it had now become difficult to get them brought in on account of bad trails, and on October 2 we left this district for Prairie Creek, where we arrived on October 6. I procured supplies enough from the railroad contractors and roadside stores to survey part of township 50, range 25. This portion consists of burnt hills and intervening valleys, both having a general slope northwesterly to the valley of Prairie creek. The forest fires which have passed over this part seem to have rendered the soil almost useless even for the production of grass or the speedy reforesting of the surface. On Cold creek, a tributary of Prairie creek, coal was observed, claims having been already surveyed. The different tracts surveyed this year are of very little use for agricultural purposes, the altitude being too great to mature any grain crops. Vegetables, however, could no doubt be grown in many of the valleys. As these tracts were all more or less timbered, having few open places, there was no hay, and very little pasture. No part could be recommended for ranching or settlement. The timber growing on these lands will furnish ties, culvert and bridge timber for railroads into the coal fields, and an inexhaustible supply of mining props for the mines. With the exception of township 50, range 25, the country surveyed, wherever overrun by fire in the past, is now covered with a thick growth of young pine growing up through the underlying windfall. This should be preserved as far as possible so as to insure rainfall and moisture.

On finishing our work at Prairie Creek on October 26, we started on our return journey to Edmonton, where we arrived on November 1.

## APPENDIX No. 26.

### ABSTRACT OF THE REPORT OF A. H. HAWKINS, D.L.S.

SURVEY OF PART OF THE TWENTY-FIRST BASE LINE, WEST OF THE FIFTH MERIDIAN AND MISCELLANEOUS SURVEYS IN ALBERTA AND SASKATCHEWAN.

After a few days spent in organizing the party, I left Edmonton in March and proceeded by way of Athabaska Landing and the north shores of Athabaska and Little Slave rivers and Lesser Slave lake to Grouard, and thence by wagon road to our starting-point, the northeast corner of township 80, range 19. The best way to enter this country, however, is to wait until navigation opens and then Grouard may be reached by boat from Athabaska Landing. From Grouard fairly good roads lead west and north through the best districts. Along the road followed from Grouard to the base line, squatters or homesteaders are settled on almost every patch of open land. The tilled fields, haystacks, cattle, horses, chickens and hogs all in good condition, bear evidence of the productiveness of the land in this district.

The production of the base line eastward was commenced on April 25 and completed to the fifth meridian by the end of August; only two or three days were lost on account of rain throughout the season.

The alluvial soil throughout the district is a clay or sandy loam with a subsoil varying from clay to sand and gravel and appears very fertile. At Whitefish Lake and Wabiskaw there are excellent gardens, and the whole district is covered with a rank growth of grass and underbrush. The timber is light and can be cleared away with little difficulty.

The surface is timbered with poplar, spruce, balm of Gilead and balsam on the ridges and with spruce, tamarack, balm of Gilead and black alder in the low lands. The timber has no commercial value, but will supply the needs of settlers for many years for buildings, fences and fuel.

It is reported that a bush of spruce timber, about five miles by four, exists about six miles north of the line. The timber here is said to be from six to thirty inches in diameter tall and clean.

From range 19 to range 9 about sixty per cent of the land is fit for agricultural purposes, east of range 9, where it is more level and where swamps and muskegs occur between forty and fifty per cent is fit for settlement. However, a large proportion of the muskegs and marshes can be easily drained.

Hay is abundant throughout the district. It is difficult to specify the hay lands where they are so numerous, but particular mention might be made of Atekamic river along whose banks thousands of tons of hay could be put up from the excellent tracts between the base line and Atekamic lake. The same is true of the lands along Pastecho river and Atekamic lake, and a large marshy lake in sections 31 and 32, township 80, range 16.

Fresh water is abundant: the North and South Heart rivers with their tributaries supply ranges 18 and 12: Atekamic lake and river supply ranges 12 to 8, while ranges east of this are supplied by Nepesekopon and Pastecho rivers. Serious flooding is not likely to occur along any of these streams except perhaps Pastecho river whose valley is very wide.

Numerous rapids are reported to exist seven or eight miles down Atekamic river from which it may be possible to develop power.

The climate is about the same as that of Edmonton. The nights are cool and summer frosts are frequent, but usually so light that vegetation is not injured. No doubt with the advance of settlement these frosts will no longer occur. During the spring and summer months there are long hours of sunshine, and vegetation matures rapidly. The snowfall is moderate and rain is not excessive.

No lignite nor coal was noticed, but petroleum is reported to have been found on Pelican river to the east and on Loon river to the north.

Moose and caribou are said to be numerous; bears are plentiful and water-fowl of all kinds are to be seen on the lakes, open marshes and rivers. Spruce and willow-partridges, and fool-hens are numerous. A few rabbits were noticed. Lynx, foxes and wolves were very scarce, but muskrats were plentiful. The beaver, apparently, is extinct, though signs of its past activity, such as old cuttings and dams are to be seen on every hand; not once during the season did we see a fresh indication of the animal's work. Pike and jackfish are to be found in the large streams, and these, with the abundance of whitefish in the lakes, provide food for the Indians and their dogs.

Two settlements were passed during the trip, viz: Whitefish Lake and Wabiskaw. Whitefish Lake settlement is situated on the east shore of Atekamisis lake. Here are trading posts of Messrs. Revillon Bros.and the Hudson's Bay company, and an Anglican mission school and church. A very fair wagon road leads to Grouard which can be reached in two days.

Wabiskaw is situated on the southerly end of the most northerly of the Wabiskaw lakes. Here also are stores and trading posts of Messrs. Revillon Bros. and the Hudson's Bay company and an Anglican mission school and church. Three or four miles south is a Roman Catholic mission school and church. Wabiskaw is in a rather isolated location; in summer it is most easily reached by water from Pelican rapids on the Athabaska, but there are several portages. In winter a sleigh trail leads across the Pelican mountains from a point on the Athabaska about forty miles northwest of Athabaska Landing.

Upon our return to Edmonton, I reengaged the party, and in a few days proceeded to township 52, range 1, west of the fifth meridian to traverse a lake in section 30. There are several fine sandy beaches around the lake, and the land on the south-east has been subdivided into lots. It is a very beautiful place for a summer resort.

For the remainder of the season we were occupied on the following miscellaneous surveys: traverses in township 47, range 1, west of fifth meridian, township 53, range 25 and township 58, range 11, west of the fourth meridian; investigation of survey monuments in township 48, range 22, and in township 45, range 4, west of the fourth meridian, and in township 53, range 25, west of the third meridian; retracement in township 51, range 27, west of the fourth meridian, and in townships 29, ranges 31 and 32, west of the principal meridian.

## APPENDIX No. 27.

### ABSTRACT OF THE REPORT OF E. W. HUBBELL, D.L.S.

RESURVEYS AND INSPECTION OF CONTRACTS IN MANITOBA AND SASKATCHEWAN.

My first work was traversing a small lake in township 42, range 10, west of the second meridian. From there we cut a trail to township 42, range 9, and began the inspection of contract No. 13 of 1909, completing this work on April 28.

The soil throughout this contract is in general black loam with clay subsoil, suitable for the production of wheat, oats and vegetables. The surface is level and is covered with willow and second-growth poplar, with considerable windfall, but we did not notice any tracts of large timber. There are numerous muskegs and swamps interspersed throughout these townships in which plenty of good water is found; there are also a number of fine creeks. Red Deer river flows easterly across the northern part of township 48, range 7, and a wagon trail has been cut out to this river for nine miles by the lumbermen at Prairie River. We did not perceive any indications of lignite, coal or minerals

Game is apparently not plentiful as we saw only a few moose. The Canadian Northern railway is about eight miles to the north and situated thereon is Prairie River, a small lumbering village and the nearest express and post-office.

Along our trail from Nut lake to these townships, there are numerous open spaces which seemed to me very desirable for homesteading, every requirement of the settler being obtainable.

From there we proceeded to contract No. 17 of 1909, which comprises townships 44, ranges 2, 3, 4 and 5 and a portion of township 43, range 5, west of the second meridian. We had to cut a trail nearly all the way, but took advantage of the open muskegs which on May 3 were still frozen sufficiently strong to carry wagons. We passed through level country, rolling in places, and thickly covered with poplar and spruce varying in size from six to forty inches in diameter, with willow, hazel, alder, dense underbrush and immense tracts of large windfall. A great portion of this timber is well adapted for lumbering purposes, but until this has been cut the country is of little value for settlement. The soil throughout the townships of this contract is in general sandy clay and black loam with clay subsoil. A large portion would be suitable for the production of wheat, barley, oats, flax and vegetables. There are many small swamps and muskegs interspersed, from which there is always an ample supply of fairly good water.

In addition to Red Deer river, averaging about three chains in width which passes through several of these townships, there are many fine creeks, besides Etomami river, which is nearly as large as the Red Deer. Both these rivers are utilized by the various lumbering industries in this district to convey millions of logs to their sawmills, situated along the Canadian Northern railway. We saw no indications of coal, lignite veins or minerals. Owing to the low water the sawmills had to discontinue work early in the spring, an unusual occurrence for this section of the country. On May 9 we moved into Greenbush, a small lumbering town on the Canadian Northern railway.

There are no trails in this vicinity owing to the continuous muskegs along the railway track, and on this account we had to move our outfit thirteen miles by rail from Greenbush to Hudson Bay Junction, a small town of about 200 inhabitants. From there we went to further inspect contract No. 17, completing this work on May

19. We then moved into township 45, range 3, a portion of contract No. 4 of 1910, which we examined.

This township is thickly covered with poplar, spruce, tamarack and willow, with many muskegs interspersed. A branch line of the Canadian Northern railway passes through this township, starting from Hudson Bay Junction and terminating at The Pas, about ninety miles distant. All the material for the construction of an immense iron railway bridge across Saskatchewan river at The Pas is freighted on this line.

On May 23 we moved to Tisdale, where we arrived the following day. We traversed a lake in township 42, range 13, upon completion of which we went by trail to Kinistino, a distance of about one hundred miles. I have already reported on this part of the country. However, I may add that settlement seems on the increase in every direction in this very fertile section, which I have previously termed 'The Garden of the Prince Albert district.' On June 2 we moved into township 48, range 21, west of the second meridian and commenced the resurvey of this township the following day.

Access to this township is easily obtained by various routes. A surveyed trail passes through it from Prince Albert to Fort a la Corne, and there is also a fine graded road to Kinistino, a thriving little town on the Canadian Northern railway, about fifteen miles distant. The soil of the southern two-thirds of this township in general is black loam with clay subsoil, while the northern third is sandy and practically unfit for cultivation, although all kinds of grain and vegetables are produced in the southern portion.

The surface throughout is rolling, about sixty per cent being covered with poplar, tamarack, jackpine, willow and various clumps of spruce.

In the northern part of the township considerable jackpine and some spruce is available for manufacturing purposes. There are numerous hay marshes scattered throughout, which supply sufficient good hay for the settlers in this vicinity. Good fresh water is found in Saskatchewan river, in fairly large lakes in sections 1 and 19, and in many smaller lakes and ponds. The water in these lakes is permanent, and the land is not subject to flooding. We were informed by the settlers that the climate is most desirable, there being no summer frosts of any account. Great quantities of jackpine and poplar furnish unlimited fire-wood. We did not notice any indications of coal, lignite veins, stone for quarrying, or minerals.

There are a few moose and jumping deer in this vicinity. Ducks are numerous and a few prairie-chickens and partridges were seen. All the agricultural land in this township is settled on. This section of the country is ideal for mixed farming, and as such is taken advantage of. In connection with our work we traversed several lakes and a portion of Saskatchewan river, connecting our lines, when possible, with monuments on surveyed trails.

Our next work was the resurvey of township 49, range 27, west of the second meridian, which is north of the Saskatchewan and about six miles northwest of the city of Prince Albert. We commenced the work of subdivision July 6 and finished August 9.

This township is very easy of access, there being two well-travelled surveyed trails passing through it. The one about the centre runs to Shellbrook, Mont Nebo, and thence to Green Lake. The other trail farther north leads to Sturgeon lake. About seventy-five per cent of the soil of this township is very light and sandy and is unfit for agricultural purposes, but at the south and north there is about one and one-half tiers of sections in which the soil is principally black loam of varying thickness. Nearly all, if not all, the sections suitable for homesteading are filed on. There is no scarcity of water, as Saskatchewan river flows through the south part and Shell river, about a chain wide, meanders diagonally across the township entering the Saskatchewan in section 3. In the northeast corner there are numerous sloughs and muskegs containing very good water, the supply being permanent.

The Prince Albert Lumber company send a large number of logs from Sturgeon lake district down Shell river, thence down the Saskatchewan to their mill at Prince Albert. In the spring Shell river is from eight to twelve feet in depth with a current of four miles per hour, and, while there are no natural falls or rapids where power might be developed, still, with some outlay, a dam might be constructed which would develop the necessary head of water for power, as the banks are high in places and comparatively close together.

Indian Reserve No. 94A consists of sections 32, 33, 34 and 35 of this township. The Canadian Northern railway, which has been extended from Prince Albert through Shellbrook, passes through this township and crosses Shell river on a high wooden trestle bridge. The extension of this line is invaluable to the settlers between Prince Albert and Battleford and opens a vast tract of excellent country for settlement.

Our next work necessitated a journey of 150 miles by trail to the Lost River country, where we arrived on August 18. During this trip we passed through some beautiful fertile country via Fort a la Corne, an old Hudson's Bay trading post. There are but few settlers along this route, a considerable portion of the country not being well adapted for settlement. However, in the Lost River country a great change has taken place in the past year; houses have sprung up in every direction and a fair quantity of land is under cultivation. This is an ideal country for mixed farming, there being plenty of hay, pea-vine, water, fuel in abundance, rich black loam and timber of all dimensions. One of the finest gardens I have ever seen in the west I saw here in township 50, range 14. The cabbages, cauliflowers, carrots, potatoes, cucumbers, tomatoes and corn were exceptionally large and fine. The climate is all that could be desired and game of all varieties is plentiful, particularly moose. The country is easy of access by good trails. Several new post-offices have been opened during the past year, and the nearest railway towns, Star City and Tisdale, on the Canadian Northern railway, are about fifty miles distant.

After completing our work here we left for Sprague, Manitoba, 550 miles distant, where we arrived on August 28. We commenced our work of inspection in township 1, range 15, east of the principal meridian, a part of contract No. 32 of 1907, after which we inspected contract No. 19 of 1909.

Nearly the whole country, with the exception of occasional sand ridges, is either a tamarack swamp, bog, or open floating muskeg, over which no horse could possibly travel, and at certain periods of the year not even a man could cross them. The surface of these muskegs consists of tangled matted grass and moss held together by fibrous roots, while underneath is muck, water and quicksand, varying in depth from two to ten feet.

The greater part of this district is swamp and muskeg, only a small percentage of which can ever be reclaimed by drainage, there being little difference between its altitude and that of Lake of the Woods. There are very few settlers and little land suitable for agricultural purposes, except about two hundred or three hundred acres around Moose lake. This lake, which teems with jackfish, is a fine body of clear water about three miles long and a mile and a half wide, and is surrounded by high banks covered with poplar, birch, spruce, cedar and willow. There are no trails except the Dawson road, which passes through the centre of these contracts from St. Anne to the Northwest Angle and is impassable during the greater part of the year. The soil in these townships, except along Reed river, around Moose lake and on a few ridges that are scattered throughout, is generally moss and vegetable muck. The surface might be classed as level and except on the open muskegs is covered with spruce, tamarack, cedar, ash, oak, poplar, willow and some jackpine, with a little birch along the watercourses and borders of lakes. The timber is of fair dimensions, varying from three to twenty inches in diameter, and is suitable for lumbering purposes, railway ties and fencing. The water is fresh and the supply adequate. Lake of the Woods, Whitemouth lake, Moose lake and Reed river receive a large supply of water from the extensive marshes and muskegs in the vicinity. Except for a few miles along the banks of Reed river, very little hay is to be had. This river rises in township 2, range 15, and flows northeasterly into Lake of the Woods. It varies in depth from one to ten feet, and its average width is about one chain, although it is much wider towards its mouth. Fire-wood in large quantities is easily obtained, and lumbering is carried on extensively by the Sprague Lumber company who own limits in this district and ship by rail to Winnipeg. Moose, bears and porcupines are numerous, while partridges and prairie-chickens are very plentiful. The Canadian Northern railway has a branch from its main line about ten miles east of Sprague, which extends a mile into township 1, range 16. Sprague is the nearest express, telegraph and post-office, also the last railway station on the Canadian side.

Our next work was the inspection of contract No. 5, of 1910, comprising townships in the vicinity of Mont Nebo and Indian reserves Nos. 104 and 118, west of the second meridian, about seventy-five miles northwest of Prince Albert. We entered this contract from the south by a good trail which is surveyed from Prince Albert to Green Lake, passing through Shellbrook and Mont Nebo, the former being the nearest telegraph and express office to this work. There are numerous trails in this vicinity radiating in every direction, this being a flourishing lumber district and comparatively well settled.

The soil in general throughout the townships comprising this contract is alluvial black loam varying from six to ten inches in depth, with clay and sandy subsoil, suitable for the production of wheat, oats, vegetables, etc. The surface in general is rolling, mostly covered with tamarack, jackpine, poplar, willow and considerable spruce of fair dimensions, well adapted for lumbering purposes. There are large patches of "park land" with small scattered bluffs of poplar and willow making ideal homesteading. Township 53, range 7 is mostly covered with poplar three to nine inches in diameter interspersed with a network of lakes and marshes. Hay is not very plentiful in this vicinity, but great quantities can be easily obtained from the swamps and marshes to the west. Shell river meanders through several of these townships, and at the time of inspection was from two to four feet deep. The volume of water is not sufficient for the development of power. The climate is agreeable and not subject to sudden changes of temperature. Great quantities of fire-wood can be readily obtained in these townships. We observed no indications of coal, lignite veins, minerals, nor stone in sufficient quantities for quarrying. Moose, elk and jumping deer are frequently seen, while prairie-chickens, partridges and ducks are very plentiful.

The Canadian Northern railway has a branch line from Shellbrook which passes through the eastern portion of this contract to Ladder lake, where the Big River lumber camp is situated on Cowan lake.

We finished the inspection of this contract on November 7 and moved camp to Witchekan lake, a large sheet of water in townships 51 and 52, range 11, west of the third meridian, and commenced the inspection of contract No. 6 of 1910, comprising townships 50 and 51, ranges 12 and 13, west of the third meridian, finishing it on November 17.

These townships are pretty heavily wooded with poplar, willow, some spruce and jackpine and contain numerous small lakes of fresh water. A trail crosses Big river in township 53, range 11, passes through this contract and joins the main trail from Battleford at Glenbush post-office in township 49, range 14. There are no settlers, although there are some excellent quarter sections admirably adapted for settlement. The surface is rolling and the soil sandy loam. From here we moved into township 53, range 15, a portion of contract No. 7 of 1910, and commenced the inspection of this work, finishing it on November 28. The townships comprising this contract are thickly covered with poplar, willow, spruce, tamarack and heavy windfall. The soil is black loam and sand, and the surface is generally rolling. These townships are too heavily wooded for settlement, there being but little, if any, open country. Long lake in townships 52 and 53, range 15, is a beautiful sheet of fresh water about ten miles long and from three-quarters to one mile in width, with sandy shores and good banks surrounded at the southern end by marshes of very good hay. Great quantities of fire-wood can be readily obtained in these townships. Moose, jumping deer, bears and timber-wolves were seen occasionally, and also great numbers of partridges. The nearest post-office is Glenbush, thirty to forty miles distant, while Battleford is the nearest railway station and telegraph office. There are no settlers in these townships.

After completing our work here we moved to Prince Albert, where we arrived on December 8, and from there went to Prairie River to inspect the remainder of contract No. 4 of 1910. The snow now was twenty-two inches deep on the level and the weather exceedingly cold. We examined townships 44, ranges 7, 8, 9 and 10, west of the second meridian. These townships are heavily wooded with large poplar, spruce, tamarack, willow and windfall, a large portion of which is suitable for lumbering purposes. There are no settlers; in fact the country is not well adapted for settlement, there being too much timber and muskeg. The surface is level and the soil black loam with clay subsoil. There is a trail used by lumbermen from Prairie River to Red Deer river, a distance of nine miles, and there are also several pack-trails.

From Prairie River we moved our outfit by train to Mistatim and finished the inspection of these townships on December 21, this being the last work of the season.

In general terms the weather conditions for the production of crops in northern Saskatchewan were very good, a splendid yield being the result, but in southern Saskatchewan lack of rain in a measure prevented the usual bountiful harvest. The season on the whole was excellent for surveying operations, as there had not been for many years so light a snowfall as the previous winter and so small an amount of rain during the summer. Lakes, swamps and creeks which heretofore had been overflowing were comparatively dry. This was especially noticeable in the muskegs of the south-east portion of Manitoba. In the early spring lumbering operations had to shut down considerably earlier than usual on account of the scarcity of water in the rivers which were left filled with logs beached high and dry. Consequently many of the mills closed and men were thrown out of employment earlier that usual.

Moose, elk, bears, porcupines, timber-wolves, coyotes, beaver, skunks, mink, rats and rabbits were quite numerous in different localities. Prairie-chickens, partridges and ducks were very plentiful.

In many of the larger lakes and streams jackfish abound, also some sucker, white-fish, gold-eye and pickerel, especially in Greenwater, Moose, Long and Birch lakes and Red Deer river.

There are some excellent large ranges for horses and cattle along the valley of Big river (northwest of Mont Nebo), also around Witchikan, Birch and Meadow lakes. A good trail has been made recently from Battleford to Meadow lake which is about one hundred miles north of Battleford. Several ranchers have already taken advantage of the opportunities afforded them by these splendid ranching sections and have located there with numerous bands of horses and herds of cattle.

A very marked increase of settlement is noticeable throughout great tracts of country, which a year ago had but few, if any, settlers. Houses have sprung up in every direction. Post-offices have been established, schools built and roads and trail improved, while a fair proportion of land has been put under cultivation.

# APPENDIX No. 28.

## REPORT OF F. H. KITTO, D.L.S.

SURVEY AT ST. ALBERT SETTLEMENT, ALBERTA.

OTTAWA, October 24, 1910.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I have the honour to submit the following report on miscellaneous surveys performed in and near St. Albert settlement, Alberta, during the past season.

My work consisted of rerunning certain boundary lines in St. Albert settlement adjacent to Big lake and in townships 53, ranges 25 and 26, west of the fourth meridian, and in traversing part of Atim creek, in order to secure additional information required in issuing new plans of St. Albert settlement and adjacent townships.

I left Ottawa on August 13, and reaching Edmonton I hired a light team and buckboard and prepared to leave for the field in the morning. I began on some scattered work in open country with one man to assist me, securing farm help for digging pits when needed. After completing the most scattered parts of the work I dispensed with the horses. I secured accommodation for myself and men at a farm house on lot E., St. Albert settlement, later moving to the Astoria hotel, St. Albert, and again to the Acme Brick company's boarding house three miles south in order to keep close to my work as it progressed. Transport was secured locally for moving our baggage from place to place, and this method was found both an economical and convenient substitute for a regular camp.

After completing the work in open country thick second-growth bush was encountered. I then sent to Edmonton for additional help, and had no trouble in getting more men. The work was done with all despatch, though the weather during this time happened to be very bad, being the usual summer break-up.

On lot E of the settlement was a market garden producing a most abundant crop of all our common vegetables. Harvesting was under way in the district and all crops were exceptionally good. On the large marsh about Big lake hay was being cut and would yield about three tons to the acre. Apparently this marsh and much of Big lake could be easily drained by dredging Sturgeon river below the village, thus opening up many sections of valuable land. First-class brick is being made in section 21 of township 53, range 25, by the Acme Brick company of Edmonton. Much of the land in the township appears to be held for speculation and is covered by second-growth woods.

I completed my work on September 2, and on the following day returned to Edmonton and disbanded the party. I left for home on September 5, reaching Ottawa on the 9th.

I have the honour to be, Sir,
Your obedient servant,
F. H. KITTO, D.L.S

# APPENDIX No. 29.

## ABSTRACT OF THE REPORT OF J. L. LANG, D.L.S.

### SURVEYS IN SOUTHWESTERN ALBERTA.

Leaving Cowley on June 13, I reached my first work in townships 7 and 8, range 5, west of the fifth meridian on the 16th, and was engaged there until the middle of July. About that time fires broke out, due to the excessive drought, and the whole party was engaged in fighting them for about three weeks.

On August 11, I moved to township 6 and 7, range 4. These townships are very rough and packhorses had to be used for all the work done there.

On October 5, I proceeded to township 5, range 4, where I worked till November 12. The frequent snowfalls then made work impossible, and I was forced to move out of the mountains.

During the remainder of the season, until December 12, I was engaged on retracement work in townships 6 and 7, range 3, and townships 5 and 8, range 1. I also made a traverse of part of Oldman river in township 8, range 1.

The outstanding feature of the district in which I was working is the coal deposits. These seem to be widespread and of very great value. The principal companies are the International Coal and Coke company of Coleman and the West Canadian collieries of Blairmore. In addition to these there are several smaller companies, largely in a development stage, operating along the Crowsnest branch, and also a number of prospects usually some distance from the railroad.

In the valley of the Southfork there are three properties being developed which have, apparently, great possibilities, together with numerous prospects of which little can be said save that they seem promising. Until a railroad is built up this valley these properties cannot of course be put on a shipping basis. A line has already been located, however, and it is understood that the road will be built shortly. In section 34, township 5, range 4, lie the remains of an oil company floated a year or two ago. Absolutely no prospecting work had been done; the machinery is lying on the ground as it was brought in, and there is no trace of oil to be found in the vicinity. The resting place of the machinery is known locally as 'The Oil Wells.'

After the coal deposits, the principal natural resource of the district is the timber, and this has been sadly depleted by fires. The southern part of township 8, range 5, was burnt over some years ago; the northern part contains some very good timber, mainly spruce and jackpine, and lumbermen have been and are operating there. Part of this, however, was burnt this summer. Township 7, range 5, contains some good timber, but is also being cut over. Township 7, range 4, was almost entirely burnt over some years ago, but there is still some good timber along its western boundary. Township 6, range 4, is very well timbered with large spruce, jackpine and scattered fir. The country south and southeast of this township appears also to be well wooded and to be yet untouched by fire or lumbermen.

## APPENDIX No. 30.

### ABSTRACT OF THE REPORT OF A. LIGHTHALL, D.L.S.

SURVEYS IN THE NEW WESTMINSTER DISTRICT IN THE RAILWAY BELT OF BRITISH COLUMBIA.

About April 16, 1910, I engaged my party at Vancouver and proceeded to lay out a piece of agricultural land cut off from timber berth No. 510 in township 6, range 7, west of the seventh meridian. This is situated at the head of the north arm of Burrard inlet and was reached by steamer from Vancouver. It is a flat alluvial strip of land in a narrow valley on the east of Mesliloet river. It will make a good piece of fertile land when the stumps and underbrush are removed.

On May 2 we moved camp to township 39, west of the coast meridian, to survey timber berth No. 535, comprising all of section 28. We reached that place by taking steamer to the British Columbia electric power plant on Burrard inlet and crossing to Buntzen lake. The berth lies on the side and top of a mountain about two thousand feet high, on the east shore of this lake. The land is too high and rough to be suitable for agricultural purposes, but a strip at the southerly end of the lake is being logged by the Patterson Lumber company.

We next proceeded to Dewdney by rail and thence by wagon to Hatzic prairie, a strip of low wet land in a valley about a mile wide and extending north and south between Fraser river and Stave lake. We first ran some section lines on the east side of the valley in township 21, east of the coast meridian. The land here is heavily wooded and lies on a fairly steep hillside. A few settlers have taken up farms. The land in the bottom of the valley is good where not too wet, and the many settlers seem to be doing fairly well in dairying and fruit-growing.

We then subdivided about three thousand acres on the west side of the valley in sections 10, 16, 21, 28, 27 and 34. Here there is an extensive tract of bench land heavily wooded with second-growth fir, hemlock and cedar. Quite a number of settlers are located here, but have done little up to the present. When the land is cleared it will be valuable for fruit growing and dairying, the soil being a sandy loam with a gravelly subsoil. When a new road is opened up the district will develop rapidly. Beaver are plentiful, their dams being found on all the small streams. Bears and deer were also seen. No minerals were found.

The survey was continued north into township 4, range 3, west of the seventh meridian. The land here, which is lower and slopes towards Stave lake, is well settled, but much of it will be flooded when the power plant now under construction on this lake is completed. The occupations of the settlers are mixed farming and lumbering on a small scale.

Our next work was in township 40, east of the coast meridian, where we surveyed timber berth No. 537. The land in this township south of Pitt river is known as 'Pitt meadows.' It is low and flat and covered with hay and small brush. It will have to be dyked and well underdrained before it can be successfully farmed. This has been done on a great part of it and it is now an important dairying and stock-raising centre. The land to the north is rough and rocky and nearly all that is suitable for agriculture has been homesteaded or taken up as timber berths. A stone-quarry is in operation in section 22; the stone is shipped to New Westminster.

We then moved to the head of Pitt lake and surveyed timber berth No. 537, on Scott creek, a swift-flowing stream, about thirty feet wide and two feet deep, emptying into Pitt lake from the east, about a mile from the head of the lake. The timber here is about the best I have seen, fir, cedar and hemlock growing to enormous sizes. The timber can be easily taken out as the land all slopes to Scott creek. Considerable water-power could be developed on this creek. About fifty or seventy-five acres of land will be available for agriculture when the timber has been removed.

Our last work was in township 41, east of the coast meridian. This township is fractional and consists of four sections in the valley of Silver creek. The land is mostly low, flat prairie, flooded at high water. By dyking and draining it can be made into good dairying or grain-growing land.

The party disbanded at Westminster Junction on November 22.

# APPENDIX No. 31.

## REPORT OF G. J. LONERGAN, D.L.S.

INSPECTION SURVEYS IN ALBERTA.

BUCKINGHAM, QUEBEC, February 18, 1911.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I have the honour to submit the following report on inspection and miscellaneous surveys carried on in the Edmonton district last season.

I left Ottawa on April 20 for Edmonton and arrived there on the 25th. After spending a few days organizing my party and purchasing supplies, I started for Clover Bar to make a restoration survey of the east boundary of sections 18 and 19, township 53, range 23, west of the fourth meridian. After a little difficulty this matter was settled to the satisfaction of all parties. Clover Bar in the winter time may be reached by a short route from Edmonton, but in the summer the only way is by Strathcona, this making a somewhat lengthy way for the farmers to haul their produce to market, which could be avoided by placing a ferry at or near the Grand Trunk Pacific railway bridge; in connection with this matter I might say that it is regrettable that the government did not come to some terms with the railway company so that a traffic and railway bridge could have been built in one, as has been done at Fort Saskatchewan. I would like to mention that Clover Bar is one of the most fertile sections of Alberta. It would require but a short drive through the country to satisfy the most skeptical that farming in this part is as profitable an occupation as a man could apply himself to.

After completing the work at Clover Bar I moved to township 53, range 28, for restoration surveys required in that township; I travelled on the graded roads from Edmonton to St. Albert, thence in a westerly direction along the north shore of Sturgeon river and around Big lake, crossing the Michael Calahoo Indian reserve. This country is very rolling and covered with poplar from four to ten inches, and a thick growth of scrub; the soil in most places is clay, or clay and gravel mixed. Although this township is not more than thirty miles west of Edmonton, the land has but recently been taken up, and it is not yet safe to speculate on the success of the settlers. However, judging from the way they have started hog-raising, they appear to be a people up to the times, and are looking after their share of easily-earned money.

My next work after completing the survey in this township was in township 53, range 3. To get there I went almost straight east, passing through the Beaver hills, a rolling and timbered country. In every direction we could see a settler's shack, and here and there more successful farmers were living in houses that would compare favourably with the average farmhouse to be seen in either Quebec or Ontario. Leaving the hills we came out in the wide open prairie at the town of Tofield. Here is exemplified in a striking manner the feelings and ideas of the westerner that nothing is impossible. Acting on this idea they have shifted their town around on three different sites. However, judging from the buildings they are now putting up they appear to have decided to remain stationary for the future.

Moving east from here to Vermilion, you pass through a town, then a thickly-settled farming district; the settlers getting gradually farther and farther apart, then the district becoming gradually more thickly settled till you finally come into the next town, and so on from town to town; good graded roads are found on either side of the towns, and between them the old travelled trails.

We camped at night near farmhouses where the owners, with happy and contented minds and a great faith in the future, were generally speculating on the number of bushels to the acre, the price, and if they could afford to go east this year to see their friends or wait till next year.

Completing this survey I moved to Hewitt Landing and started in a northerly direction to Cold lake to commence the inspection of survey contracts. We arrived at Cold Lake Indian reserve on July 15, and at the Roman Catholic mission I visited one of the best vegetable gardens that I ever saw in any part of Canada. Everything in that line was growing luxuriantly, and not a weed was to be found inside the boundary fence. The reserve has a black loam soil, varying in depth from ten to thirty inches, but little farming is carried on by the Indians. However, the government is starting an Indian farm and last summer had two hundred and fifty acres broken. This, no doubt, will be an incentive for the Indians, as game is getting scarcer every year and now the reserve is almost surrounded by white settlers.

We forded Beaver river and moved north to Cold lake, where about a dozen families are settled. The soil is good for at least eight or ten miles around the south and west parts of the lake, and the lake itself is teeming with whitefish, jackfish and trout. One evening the men caught about two hundred and fifty pounds of the latter, which we salted and brought with us for future use.

From Cold lake we moved westward to lac la Biche. The soil between the lakes is suitable for farming purposes except a strip about ten miles wide near Punk creek or Sand river as it is known in the district. On this strip are rolling sand-hills and tamarack swamps. A very good country is to be found around Beaver lake, which, I might say, is covered in most places with four to eight-inch poplar and scattered spruce; the latter runs from eight to twenty inches in diameter, but is not found in sufficiently large quantities to warrant the establishment of a sawmill, although there is ample for the requirements of settlers. My survey party was the first to open a trail from Cold lake to lac la Biche. La Biche settlement, one of the oldest in the west, has not improved or changed in the last ten years. This is not to be accounted for by a poor soil or climate, but is due to the settlers themselves. They are half-breeds and not inclined to follow agriculture. Fishing, hunting and freighting give quicker returns for their labour and they are always in want of money so earned. White settlers have not yet started to settle the district, the reason for which, I believe, is the roundabout way to get there from Edmonton, the natural landing place for all newcomers. They would have to go first to Saddle lake, thence north a hundred miles, making about two hundred miles in all, while in a direct line the distance does not exceed one hundred and ten miles. No doubt when railways are constructed in that district it will soon be settled, and many more acres will be added to those under cultivation in the province.

Settlement is somewhat retarded along the north shore of the Saskatchewan from Edmonton eastward, and apparently the cause is the distance from a railroad and the difficulty of marketing produce. I do not hesitate to say that a railway must be built, and built soon, from Battleford west, as the country is too large and fertile to remain idle much longer.

Leaving lac la Biche we went westward over a very bad road to Athabaska Landing. The trail follows Pine creek for a distance of seven or eight miles and there passes through a large colony of negroes. From the Landing I went north, following the Lesser Slave lake trail. This road is in poor condition and the future traffic to the north country would warrant the spending of considerable money for its improvement. There are practically no settlers north of Athabaska river, although the country is fairly good agricultural land. A few large tamarack swamps that may be easily drained will make as good a country as man would want to live in. I returned the way I went to a distance of about thirty miles south of the Landing, where I turned straight east to examine six contracts. I borrowed a pack outfit from another surveyor and started with six weeks' supply of provisions. The country south of township 61 and west of range 17 is practically tamarack swamp; the remainder will make good farm land, but at present it is covered with poplar or scrub and a few patches of spruce. The soil consists of a few inches of black loam with a clay subsoil.

The inspection of these contracts completed, I returned to Edmonton, placed my horses in winter quarters and with a small party went by trail to Olds. Here I engaged a couple of teams and went west to inspect townships 31 and 32, ranges 6 and 7, west of the fifth meridian. These townships are well up in the foot-hills and consequently very hilly and rolling with practically no wagon trails leading to them: nevertheless, the settlers here seem to be more enthusiastic about a railway being built through their territory than those of other parts of the province. They insisted on showing us the easy location through their quarter sections and did not regard the high hill at one end of their proposed railway and the deep ravine at the other as obstacles; in fact, they are only interested in having the station conveniently close to their shacks.

After completing this inspection I returned to Olds, left the horses with their owner, and took the train back to Edmonton. Here I stored my outfit, discharged the remainder of my party, and left for home, arriving at Ottawa December 12.

I have the honour to be, Sir,

Your obedient servant,

G. J. LONERGAN, D.L.S.

## APPENDIX No. 32.

### ABSTRACT OF THE REPORT OF C. F. MILES, D.L.S.

INSPECTION OF CONTRACT SURVEYS NEAR BATTLEFORD AND MISCELLANEOUS SURVEYS IN SASKATCHEWAN AND SOUTHERN ALBERTA.

I left Toronto on May 17, 1910, for Maple Creek, south of which place I commenced work, reinspecting contract No. 8 of 1909.

Establishing the remaining monuments in township 24, range 4, west of the third meridian, was accomplished by the 23rd, and on the following day we left for Maple Creek, arriving there on May 30. After outfitting there, we left again for Battle Creek post-office, and thence started for section 31, township 3, range 28, in Mr. Kimpe's contract No. 8 of 1909, arriving there on June 2.

I completed the reinspection here on the 3rd and the following morning started for township 3, range 3, west of the fourth meridian.

I reinspected a block of four sections there, completing the work on the morning of June 7, when we left for the Hooper and Huckvale ranch on Manyberries creek, passing on our way the Penlan ranch, where we saw a number of horses, but no cattle. North of this ranch several new settlers' shacks were passed, and quite a few new houses were observed at a distance to the north.

Owing to the late and dry spring, the outlook for the new settlers did not appear propitious, and I was credibly informed that several contemplated moving to another section of the country where the rainfall is somewhat heavier than in this southern country. I have stated in previous reports that I consider the country along the international boundary fit only for horse and cattle ranching; nevertheless, homesteaders crowd in there, break up the land and then abandon it as being too dry. After the land is broken up it is fit for nothing, the native nutritious grasses being exterminated and a rank growth of weeds taking their place.

From there we travelled on to section 9, township 8, range 8, passing Spring lake on the way in the vicinity of which there are several sheep camps. One of these belonging to Mr. Young aggregates 10,000 head of sheep. His main winter camps are in the vicinity of lake Pakowki.

We completed the reinspection of contract No. 8 of 1909 on June 11, and on the following morning started on our return across country, passing through a fairly well-settled country towards Maple Creek.

On the arrival of my outfit there on June 15 we stopped over a day to lay in a supply of provisions and engage a few more men, then left for township 14, range 25, west of the third meridian, where I was to make a restoration survey of several townships around Bigstick lake.

From the valley of Maple creek north, the country is well settled, the soil consisting principally of a sandy loam, but on approaching the lake it becomes lighter until in the immediate vicinity of the lake to the southeast and east it becomes almost pure sand and shifting sand-hills.

Cattle and horse ranching is carried on here on a limited scale. Though the soil is light the vegetation appeared to be of a fairly vigorous growth.

Although the vegetation here was more luxuriant than in the south, yet the short grasses of the south are much preferred by cattle and seem to contain greater fattening qualities.

I closed my work here, leaving the northerly one-third of township 15, range 25, undone, and started for Maple Creek on July 11 with the intention of shipping my outfit and horses by rail to Prince Albert.

I arrived at Prince Albert on the 15th, but had to wait for the car containing the wagons, harness, &c., until the 22nd, an exceptionally long time between Maple Creek and Prince Albert. However, I hired some teams to take us out to township 48, range 27, west of the second meridian, where my restoration surveys were to commence.

I noticed a gradual improvement in crops and verdure generally after leaving Maple Creek.

From an agricultural point of view, the soil on the prairie, more particularly in southern Saskatchewan, is generally composed of a stiff clay, verging on hardpan, whereas the soil in a bluffy or wooded country has a greater or less covering of vegetable matter or humus, making the latter more productive than the former. The latter is frequently underlaid by a light sandy soil, which, while producing more luxuriant vegetation, does not demand the same amount of humidity as the heavier clay soils.

From Prince Albert I first moved west, north of Saskatchewan river. It is nearly all wooded, except where fires have destroyed the timber; there is a great deal of jack-pine, which indicates a light sandy soil. Near the banks of the river vegetation is generally more exuberant in growth, and the soil, although sometimes light, is overlaid by a covering of decomposed vegetable matter.

A few settlers are scattered along the north side near the river, but on the trail leading to Shellbrook there are miles of sandy stretches covered with jackpine and unfit for settlement.

A railway is constructed from Prince Albert to Shellbrook, but no regular trains were running at the time. When once in operation it will probably result in opening up the good country said to be in the Shellbrook district.

After completing the resurvey of fractional townships 48, ranges 27 and 28, I moved eastward, passing Prince Albert along an old trail, fair in places, but rather rough where cut through the woods in township 49, range 24.

I completed the resurvey of this township on September 9, and after making a traverse survey of Badger island, which is thickly wooded and is a part of this township, I returned to North Battleford, going by the Canadian Northern railway from Prince Albert.

My outfit arrived at North Battleford on September 15, and after repairing wagons, shoeing horses and purchasing supplies we left North Battleford on the morning of the 17th, taking the Jackfish lake trail for the scene of my inspection work in the vicinity of Turtle lake.

North Battleford, altogether distinct from old Battleford, lies on the north side of Saskatchewan river and is a growing town and separate municipality. It has outstripped old Battleford, south of the river, and has a population of about 1,500. Anything a settler may require can be purchased there, and this town seems destined to become the distributing point for a large district to the north. So far it is the only place of any importance on the north side of the river, being always accessible, regardless of the state of the river.

A good traffic bridge spans the river from the north town to the south town, being a drive of about three miles, whereas by rail the distance is about fifteen miles.

After travelling for about thirty miles along the old surveyed trail, running northwesterly from North Battleford and nearly parallel to a branch of the Canadian Northern railway, we touched the western shore of Jackfish lake, a large sheet of water, slightly alkaline, where quite a little settlement has sprung up with the expectation of this becoming a future summer resort.

At Jackfish lake we left the old surveyed trail, which continued northwesterly to the Onion Lake Indian reserve and mission, and followed the trail that runs in a more northerly direction called the Turtle lake trail. The country in this vicinity seems very well suited for farming.

Brush and scrub became more frequent as we proceeded north, and when at last we reached the vicinity of Turtle lake we entered almost solid bush.

On the south half of section 26, township 52, range 19, at the outlet of Turtle lake, there is a store or trading place kept by a Mr. Warner, an old trapper and trader.

From the outlet of the lake one follows a narrow Indian wagon road, cut northerly through the bush on the west side of the lake to township 54, range 19, west of the third meridian, this being a part of contract No. 9 of 1910.

This township and the whole of this contract may be more easily reached from the south by a trail that runs westerly from Warner's store on section 26, and thence westerly and northerly east of Brightsand lake.

In the westerly part of this township there are some openings, the timber having been cleared off by repeated fires, but north from here it is nearly all solid bush.

The open parts may be made available for homesteads almost at once, and on the northeast side of Brightsand lake up to range 24, township 54, there are areas of open country, but northerly it is more densely wooded.

Trails to Loon lake and to Meadow lake, north and northeast of these contracts, pass through these townships, and are travelled principally by Indians and half-breeds who are settled on those lakes.

At Meadow lake there are said to be a number of settlers, principally half-breeds, and also a couple of trading posts.

These trails in the fall were in a very fair condition, but in the spring or in a wet season there must be many places too soft to pass through with wagons. The soil is mostly a black loam, averaging only about three inches in depth, the subsoil varying from white sand to sandy and white clay and hardpan.

Wherever openings are found they are adapted to immediate settlement.

Many trails, that may be utilized in the future by incoming settlers, have been opened out in this district by contract surveyors.

Westerly from range 23 a great many lakes and ponds are found. There are said to be fish in some of them, more particularly I may mention Ministikwan lake in township 58, range 25, on the north side of which there is a newly-surveyed Indian reserve where the Indians were catching whitefish.

In some townships to the north, thousands of tons of hay may be cut in the meadows and many haystacks were seen that had been put up by the Indians for stockmen who were driving their cattle in from the south. Part of this district might be an ideal cattle country, providing the flies were not too troublesome. Domesticated cattle would suffer terribly in a bad or wet season, as at times the little black-fly the worst pest, and the large bulldog fly would become unbearable unless the animals were properly protected with smudges and had sheds for shelter.

Range cattle may possibly be more hardy, and may be better able to withstand the plague of flies and mosquitoes. Cattle, ranging on the open prairie, have not the black-fly to harass them. The past season neither mosquitoes nor black-flies were so numerous, but the latter lasted long into the cold weather, even after several severe frosty nights.

This part of the country is not yet ready for immediate settlement on account of its being almost entirely covered with dense bush or brush.

We finished the inspection work of contracts Nos. 8 to 13 on November 14, and my party broke up camp and started for Onion Lake mission or settlement on the following day.

After completing the subdivision of the dry bed of Many Island lake near Walsh, I closed operations for the season on December 14.

## APPENDIX No. 33.

### REPORT OF R. D. McCAW, D.L.S.

EXAMINATION OF LANDS IN THE RAILWAY BELT, BRITISH COLUMBIA.

CALGARY, February 16, 1911.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I have the honour to submit the following report regarding my operations during the past season in connection with the examination of lands in the Kamloops district of British Columbia.

On May 9 I began the necessary preparations for the season's work, and shipped to Savona, B.C., the packhorses and outfit provided for my own party. I left Calgary on May 12 and stopped off at Kamloops to make arrangements for different items, proceeding to Savona on the 14th.

My first camp was located on Three-mile creek, about five miles southeast of Savona, and examination started in the immediate vicinity. In the meantime I had received word that A. V. Chase, of Orillia, Ontario, had been appointed to take charge of a sub-party which I was to have, and I proceeded to get a party and outfit ready to place in his charge.

With this intent I went to Kamloops and engaged a cook and one man, and also procured part of the camp outfit. On May 24 I went to Calgary to ship packhorses. Owing to delays in getting the horses from Logan's ranch and in getting a car for shipping, I was detained until May 31. On the 30th I had shipped the horses and other necessaries for the outfit in charge of J. E. Smith, whom I had engaged as packer. I reached Kamloops to find that one man whom I had engaged did not put in an appearance, so engaged another and proceeded to Savona on the morning of June 2, and finding that Smith had arrived with the car, at once proceeded with the outfit to my own camp.

During my absence my assistants took charge of the work which I had laid out for them before my departure, and Mr. Chase arrived in camp on May 30.

Camp was then moved to Tunkwa lake and Mr. Chase was assigned a party and outfit to commence examination in that vicinity, working upon the instructions I had received. I then moved my camp south to the junction of Guichon creek and Meadow creek and commenced examination in that vicinity. I then directed my movements westerly through Highland valley along Witches brook and Pukaist creek to Thompson river. I had made arrangements with Mr. Chase whereby he would conduct the examination in townships 18, ranges 21 and 22, and also north of the correction line between townships 18 and 19 to Thompson river. South of this and as far as Nicola river I examined personally, and visited Mr. Chase's camp on June 24 to see how he was progressing.

On the 30th I moved camp to Spence's Bridge. Owing to there being no road for part of the way from Spatsum to Spence's Bridge on the east side of the river, I was compelled to send the wagons to Spence's Bridge via Ashcroft and the road on the west side of the river. Work was then proceeded with on the north side of Nicola river. Camps were located at convenient intervals along the river. The examination was concluded in this area on July 30.

On Monday, August 1, I started to move towards Long Lake Forest reserve. It took me three days to make the trip and locate a camp. The move was made via Lower Nicola and the Nicola-Savona road along Guichon creek and by a settler's road along Meadow creek into township 17, range 20.

By previous arrangement between Mr. Chase and myself it was agreed that he should continue the examination between the fifth correction line and the Thompson valley east to the west limit of Mr. Wheeler's examination of 1909, while I continued the work south of that correction line to the said west limit of Mr. Wheeler's examination.

From August 4 until the 31st I was engaged upon examination in townships 17 and 18 in ranges 18, 19 and 20. Camp was moved along a settler's road following Meadow creek to Trout lake, and then along the graded road constructed from Kamloops to Trout lake. During my stay in this vicinity we had a number of rainy days and experienced the coldest weather during the season, the thermometer registering as low as eleven degrees towards the end of the month.

On August 22, in accordance with instructions from me, Mr. Chase met me in Kamloops and I assigned further work for his party in the Monte Hills and Martin Mountain Forest reserves and lands adjoining that were unexamined.

When the work of examination was completed by me in the Long Lake Forest reserve area, I proceeded to the Niskonlith Forest reserve via Kamloops, and commenced work in that vicinity from a camp located in the northeast corner of township 20, range 15. The next main camp was located near Louis lake, and I then moved to the northeast corner of township 21, range 15, locating my camp beside Louis creek on September 27. From this date on rain and snow greatly retarded work in this locality, so much so that I was losing time. Feed for the horses was getting scarce and I could not procure hay from the settlers. Taking these matters into consideration, I decided that the work of examination to the north of Niskonlith reserve not already done could not be made at that season, so on October 11 I moved my camp to Kamloops en route to Tranquille Forest reserve, where I knew there was feed for the horses and less wet weather in that locality at this time of the year.

On October 13 I located a camp near a small lake in section 34, township 21, range 18, and commenced work in the Tranquille Forest reserve and vicinity. From this camp work was done north and northeast, closing on my examination of 1909 under the direction of A. O. Wheeler, D.L.S. The last main camp was located at Watching creek near the south limit of Tranquille Forest reserve on October 29. In accordance with instructions given him to join me when he had completed examination in the Monte Hills and Martin Mountain reserve and vicinity, Mr. Chase arrived at my camp on November 9 and assisted me in the remaining work that could be done during the remainder of the season. Snow greatly hindered the work during November and I broke up camp on November 21 as it was becoming impossible to accomplish a full day's work.

I paid off all the men except Mr. Chase and the two packers, and on November 23 shipped a car with horses, pack-saddles, &c., to Calgary in charge of one of the packers. I arrived in Calgary on the evening of the 24th, and the car with the horses arriving on the 26th I sent them out to Logan's ranch in charge of the packers, where I had procured winter quarters for them. The packers were paid off on the 28th upon their return from Logan's.

Many times during the season it was exceedingly difficult to obtain feed for the horses. Pasture was poor and the hay crop a partial failure. Often in order to feed the horses I was compelled to pay high prices for pasture and hay.

In conducting the examination the methods employed were similar to those used by Mr. Wheeler in his previous work of examination.

When the lands examined were situated within surveyed territory the survey lines were traced out and sections traversed in such a manner that an intelligent report could be prepared describing the lands. In unsurveyed territory traverses and approximate production of the township subdivision lines were made to locate the areas reported on.

Traverses used as bases for examination were either run out by compass and chain or with stadia.

Throughout, in examination lines were dependent on box compasses for direction and pacing for distance, with the assistance of tally-registers. Elevations were referred to sea-level and were determined by means of aneroid barometers carried in the field by the examiners and compared for fluctuation of atmospheric pressure with stationary aneroids in camp which were read every two hours throughout the day. Elevations along the Canadian Pacific railway and other elevations on the Kamloops and Sicamous sheets according to James White, F.R.G.S., Geographer, were used as authority for altitudes. Records of maximum and minimum temperatures were taken throughout the season.

The report of A. V. Chase, D.L.S., who had charge of the sub-party is annexed.

I have the honour to be, Sir,

Your obedient servant,

R. D. McCAW, D.L.S.

REPORT OF A. V. CHASE, D.L.S., ON OPERATIONS IN EXAMINATION OF LANDS IN KAMLOOPS DISTRICT, 1910

CALGARY, January 26, 1911.

R. D. McCaw, Esq., D.L.S.,
Calgary, Alta.

SIR,—I have the honour to submit the following report on my operations in examination of land in the Kamloops district during the months of June to November, inclusive, season, 1910.

In compliance with the instructions of the Surveyor General to report to you at Savona, B.C., I left Orillia, Ont., on May 25 and reached Savona on May 30. On the arrival there of your packer I proceeded at once with him to your camp on Three-mile creek the same day. As work from that camp was then about completed, I waited for your arrival with my party and outfit on June 2.

After completing the distribution of men, outfits and supplies I moved camp to Tunkwa lake in township 19, range 21, west of the sixth meridian, on June 3, where I commenced work for the season examining lands convenient thereto.

On June 15 I moved camp into Guichon creek valley to a point near the north-east corner of section 19, township 18, range 21, and examined the lands in and adjacent to this valley, using this as a main camp for most of the work, which was completed from a flying camp in the valley just south of the township.

On June 24 I moved the main camp to a point near Divide lake in Highland valley, leaving one tent and two assistants to complete the work in Guichon creek valley, which they did, and arrived at main camp on the following day. As the country to the north of Highland valley is very high and of little value, only a few days were necessary to examine and describe it, so I was able to complete this part from two other camps in Highland valley and move camp to Spatsum on July 5.

From here work was continued along the bench land on Thompson river and back into the mountains to the east. As there was no feed for the ponies in the eight-mile stretch between Spatsum and Thompson's ranch on lot 95, and no drinking water except at these points and in Thompson river, these places were used as camping grounds for examination of this locality.

On July 15 I moved camp to the north end of Barnes lake and continued examination of lands in the vicinity of Ashcroft and to the southeast, moving up Barnes creek to examine lands to the southeast and adjacent to Glossy mountain, on July 20.

From here work was continued easterly examining undisposed-of lands to the south of Thompson river to close on work done in the vicinity of Savona in the beginning of the season. This portion was completed and our first camp on Three-mile creek again reached on August 6. Thence work was continued eastward examining lands undisposed of between the fifth correction line and Thompson river, including lands in the Long Lake Forest reserve and timber berths Nos. 420 and 330, and as far east as the lands included in the examination by A. O. Wheeler, in 1909.

On August 21 I left camp en route for Kamloops to meet and confer with you on further work, and having done so, returned and reached camp on the 23rd. This portion of the work was finished on September 13.

On the 14th I moved camp to Bulman's ranch at the north end of Trapp lake en route for the Monte Hills Forest reserve. Some little delay was here experienced, through the difficulty of finding any one who could direct me to convenient trails and none seemed to know the whereabouts of old survey lines, Mr. Bulman being absent from his ranch at the time.

However, on September 16 camp was established in township 17, range 16, near the south end of Roche lake, and work was commenced, the boundaries of the reserve traced out and examination of lands begun.

On acount of the sharp and continued rise to eastward and the thick growth of small jackpine through which it was impossible to travel at much greater speed than one-half mile per hour, I found it necessary to cut out a traverse line to use as a base for operations in the interior, there being no lines surveyed within the boundaries in this part However, on September 27 the traverse line was completed, and on account of the altitude and nature of the country little detailed examination was necessary in this locality and the work was completed in the southwest portion of the reserve on October 3.

On October 4 camp was moved to a point east of Fish lake and north of the reserve. Similar proceedings were necessary here, but great assistance was rendered by J. A. Bleeker, a rancher, who went to much trouble to show us the trails in this part and the lines surveyed in the locality. Examination of the northwest part was completed, and moving to the eastern part of the reserve was commenced on October 18. The wagon, which my packer had brought from your camp, proved of great assistance here as the pack ponies seemed unable to stand continued long moves for more than three or four days at a time, and it would have been impossible to move our outfit and fresh supply of provisions all at one time on our ponies alone. With the help of the wagon the move to Monte lake was accomplished in three days without any loss of time. Camp was established at the south end of Monte lake on October 20 and examination of the eastern part of the reserve commenced. On account of the altitude and nature of the country here little detailed examination was necessary except in the southeast part, and the whole was completed on October 28. Camp was moved and examination of the Martin Mountain Forest reserve commenced on the east side on October 31, the examination of the same being completed on the west side on November 3.

In accordance with your instructions, I commenced the move to Kamloops on November 4, en route for the Tranquille Forest reserve to join you and assist in the completion of such work as could be done there before the close of the season. I arrived at your main camp on Watching creek on November 9, being delayed one day en route getting supplies for the remainder of the season.

Great trouble was experienced throughout in providing feed for the pack ponies. In a great many localities grazing was burnt out or eaten off completely. Many settlers did not have enough hay for their own use, and the result was that I was compelled to buy much feed and pay rather high prices at times.

I have the honour to be, Sir,

Your obedient servant,

A. V. CHASE, D.L.S.

## APPENDIX No. 34.

### ABSTRACT OF THE REPORT OF J. B. McFARLANE, D.L.S.

SURVEYS IN THE BRAZEAU DISTRICT IN SOUTHWESTERN ALBERTA.

I left Edmonton on April 5 and reached Prairie Creek on the 22nd. As the trails to the head of McLeod river were still blocked with snow we surveyed nine miles of line around Prairie Creek settlement.

We reached 'Indian Grave' near Southesk river in township 45, range 21, west of the fifth meridian, on May 5, and from there proceeded to the eleventh base line. While producing this base line across range 19 on May 11, we had a snowfall of ten inches, which, added to the snow still deep in the ravines, made progress rather slow.

During June and July we were engaged on subdivision work in townships 39 and 40, ranges 16 and 17. These townships can be reached by a trail along Saskatchewan river from Red Deer or Lacombe via Rocky Mountain House. There is also a pack-trail from Laggan through the mountains.

This district is valuable only for its coal deposits, as the short season with frost and snow every month renders agricultural pursuits impossible. That ranching could be carried on is doubtful, as grass is scarce, except in some of the valleys, where it would be difficult to cut on account of the willow growing among it. However, some Indian ponies and cattle were seen which had wintered out.

The country is generally rough, and the Saskatchewan valley crossing township 39, range 16, in a northeasterly direction is bounded by high hills on either side. The Bighorn mountains occupy a large part of township 40, range 17, and these are surrounded by high rocky hills. The soil varies from sand and fine clay, gravel and stones, to solid rock, and the loam on top is usually thin. The land is covered for the most part with scrubby timber, but it is more open along Saskatchewan river. A few small areas of good spruce timber are located in the west and north parts of township 40, range 16. Water is plentiful in the numerous creeks. Power might be developed from the rapids on some of the creeks, but the only distinctly valuable natural power is at the 'Falls' on Bighorn river. This consists of two falls, the upper fifty-one feet and the lower thirty-four feet, and only a few chains apart. Wood fuel is plentiful and coal outcrops were seen over a considerable area. No stone-quarries are opened and no minerals were noticed. The game consists chiefly of deer, black bears, a fairly plentiful supply of partridges, a few beaver and other fur-bearing animals.

We left Bighorn river on July 26 by the well-worn trail to the north and camped near the twelfth base in range 21 on August 1. Here we ran the twelfth base across ranges 21 and 22 and the outlines of township 45, range 22; we also subdivided a large portion of this township and ran seven miles in the southwest corner of township 46, range 22.

This district is reached by pack-trails along Embarras river, thence to Brazeau and Southesk rivers, or by going up McLeod river and following either its easterly or its main branch, or again by travelling from Prairie Creek to the McLeod and thence along this river. This latter route was used as it avoids many crossings of the McLeod and is more convenient to places where feed can be bought.

This district is unsuitable for agriculture on account of the short season, with frost and snow every month, and is chiefly valuable for its coal deposits, some of which are of considerable size. Veins have been opened twenty and twenty-four feet thick and yield a fair quality of soft coal which, it is stated, will coke. The country is mostly rough with many rocky hills; a mountain range crosses the middle of the west boundary of township 46, range 22, running southeasterly across the northeast corner of township 45, range 22, then dropping in altitude in the next range. Bare hills above timber-line cross the west and south boundaries of township 45, range 22. The valleys not drained by large creeks or rivers are usually very soft muskeg so that trails are bad in some places. The surface is mostly covered with small jackpine and spruce, and though some places are valuable for tie timber, the trees are usually too small for lumbering purposes. A patch of spruce of good quality, but not very large in extent, stretches partly up both sides of the mountain on the east boundary of township 45, range 22. There is no hay, but a number of meadows producing 'bunch-grass' afford good pasture all summer. These meadows are all formed by creeks, usually running underground and flooding the meadows after rains or when snow melts. Water is plentiful and fresh in the numerous creeks. It rained twenty-three days in August, the rain usually turning to snow, especially in the latter part of the month. In September and October also a great deal of wet snow fell. Creeks and rivers have rapid fall so that power might be developed by dams. Wood fuel is everywhere plentiful as well as coal. No stone-quarries are opened nor were any minerals of economic value seen. Game consists of deer, caribou, mountain-sheep, bears and a few small fur-bearing animals.

On account of the great amount of snow I was obliged to close my operations for the season on October 21. I arrived in Edmonton on November 3, where I disbanded and paid off my men.

## APPENDIX No. 35.

### ABSTRACT OF THE REPORT OF GEORGE McMILLAN, D.L.S.

SURVEY OF PARTS OF THE SIXTEENTH, SEVENTEENTH AND TWENTIETH BASES WEST OF THE SIXTH MERIDIAN.

I left Edmonton March 18, and crossed the Athabaska on March 23. This was the last crossing made on the ice that spring, and at the Landing we had to exchange our sleighs for wagons. Grouard was reached April 3, but we were delayed at Little Prairie by sickness in the party and because the ferry at Peace River Crossing was not running until April 26. Saskatoon lake was reached on May 5, and our starting point on the seventeenth base on May 26.

The survey was begun in the middle of range 9 where the rise to Nose mountain begins. This mountain is simply a hill higher than any of the surrounding hills. It is a series of three crescent-shaped ridges with the concave sides facing north. It is about four miles long from east to west, and twelve miles north and south. On the north slope, which is timbered, many small streams rise which converge about four miles north, and flowing northwesterly through a valley six hundred feet deep empty into Nose creek about twelve miles north of the base line, which in turn empties into Red Deer river in township 68, range 11. Small poplar and willow grow on both sides of the valley, but there is no marketable timber. The soil above the valley is burnt to a cinder and the boulders are cracked and crumbling from the heat of the fire which swept this district. Willow scrub is beginning to grow.

The general surface north of the line may be described as rolling, with some scrub. When new soil forms here the land will be suitable for farming, and this is the only land along the portions of the sixteenth and seventeenth base lines surveyed this year that will be suitable. Coarse wiry grass grows everywhere, but there are no hay lands.

The valley of Nose creek is about three hundred feet deep and about three miles wide. Some good spruce and poplar grow here and become thicker and larger to the north.

North Sheep creek, which is about four and one-half chains wide, rises in the glaciers, and flowing through a valley about three miles wide and four hundred feet deep, empties into Wapiti river in British Columbia. Its west banks are so steep and slippery that horses cannot climb them. The surface to the west has been burnt over and only isolated patches of green timber remain.

Cutbank river rises in Nose mountain in range eleven, about four miles south of the base line, and flows east to Smoky river. Its valley is strewn with dead timber through which is growing a thick jackpine scrub. The lands above are about the same. At the southeastern extremity of Nose mountain there is a berth of green timber about six miles by two miles. This timber is suitable for ties and with that in the Porcupine valley is the only merchantable timber between the sixteenth and seventeenth base lines and Nose mountain and Smoky river.

The seventeenth base line was completed on July 2, and our starting point on the sixteenth base line at the northeast corner of range 5 was reached on July 19. To reach this point we travelled by the Nose creek trail over Nose mountain and other great hills and then across a series of swamps to Porcupine river. North of the Porcupine, near the trail, is a prairie about five miles long and twenty chains wide; the grazing here is good.

Porcupine river is a swift mountain stream from three to ten feet deep, about five chains wide and having a current of about three miles an hour. It rises and falls rapidly; it may be possible to ford it in the morning and by evening it may be three feet deeper.

The country along the sixteenth base in ranges 5, 6 and 7 comprises an area of high dome-shaped hills covered with large fire-killed spruce and jackpine. The fire here was more recent than farther north and the trees are still standing firmly rooted. In range B there is a forest of green spruce and jackpine, extending about six miles southwesterly. This contains considerable marketable timber fit for ties and lumber.

The valley of the Porcupine was entered in range 8, and the base line continues in this valley to its crossing in range 11. To the south of the valley is a series of hills extending back to the Rockies, which in range 9 are about ten miles south, in range 11 about five miles south, and intersect the line in section 32, range 13. Range 11 west of the Porcupine is hilly, and the mountains may be said to be entered at the beginning of range 12, although the obstruction was not sufficient to stop the work until section 32 in range 13 was reached.

Ranges 12 and 13 are well timbered with fir, spruce, jackpine and balsam. This timber is accessible by both branches of Stinking creek. They rise in the mountains and converge in range 13, and flowing north and west empty into North Sheep creek in British Columbia. The west branch is about two chains wide, two feet deep and very swift, and has a valley averaging about three miles wide and eight hundred feet deep.

On October 12 I left for Grande Prairie and the twentieth base line. We followed the trail by way of the west branch of Stinking creek, Two lakes, Nose creek and Jasper trail, to Grande Prairie. After a few days rest here to allow the horses to regain their strength, we left by wagon road for the twentieth base line on October 26. A snowstorm came on unexpectedly on November 2, and we were delayed some days awaiting the arrival of our flat sleighs from Grande Prairie, and did not reach our starting point at the northeast corner of range 13 until November 21.

Ranges 15 and 16 contains some poplar, spruce and jackpine timber suitable for building, ties and lumber. Range 17 is hilly and largely covered with fallen timber and jackpine scrub.

Pouce Coupe prairie begins in range 14 about eight miles north, and runs in a northwesterly direction to Kiskapiska river. The prairie is rolling and scrubby, and appears to be the result of forest fires. The soil is a rich clay loam with a white clay subsoil. It comprises hay lands and sufficient timber for fuel and building purposes, but surface water is scarce. There is a community of five families of half-breeds and eleven white settlers on the prairie, now located in about township 78, range 14.

In June and July the thermometer registered from 60° to 110° in the daytime but the nights were cool. August was very wet, and mists and fogs were prevalent. A snowfall of one foot occurred on August 22 and 23, and the leaves were shed by September 1. On October 11 the ponds were frozen over, and there was an inch of frost in the ground and four to six inches of snow. Real winter began November 2. Snow fell almost every day during the month, and the thermometer varied from 0° to —40°. December was fine but in the last of January —60° was registered.

Fresh water is abundant everywhere, no bad water being met with all season. There was an absence of mosquitoes and kindred pests.

No minerals were met with but many of the boulders scattered over the district carry iron. Springs in the vicinity of Nose mountain deposit a white solid substance like lime, but the water is tasteless and colourless. There is considerable building stone along the tributaries of the Porcupine.

Moose are plentiful everywhere, and grizzly and black bears roam in great numbers south of Red Deer river. Foxes, marten and lynx are almost extinct. Muskrats are numerous, but there are no beaver. Ducks and partridges are rarely seen while whitefish are plentiful. In Pouce Coupe the following animals are to be found although none of them are numerous: moose, black bears, grizzly bears, wolves, foxes, lynx, mink, marten and coyotes. Jackfish are caught in Bear creek.

All streams have sufficient natural fall for the development of water-power, but the volume of water is not always sufficient. Porcupine river and North creek have sufficient volume at all times, and Nose creek and Capton creek at high water. The building of dams would not be expensive as the banks are high and often approach the water's edge.

## APPENDIX No. 36.

### ABSTRACT OF THE REPORT OF A. L. McNAUGHTON, D. L. S.

SURVEYS IN THE BRAZEAU DISTRICT, WESTERN ALBERTA.

I arrived in Edmonton on April 26 but my horses and camp outfit which had been wintered at Duck lake did not arrive until the 30th. We did not leave Edmonton until May 17, as the season was late and feed for packhorses scarce. The intervening time was spent in purchasing horses and completing my outfit, and in preparing returns of the surveys performed by me during 1909.

We travelled by train to Wolf Creek and from there by wagon and pack-train to 'big eddy' which we reached on May 21. Thence we travelled by pack-trail to the junction of the two branches of Embarras river about half a mile north of the thirteenth base line. From this camp we began our work on May 28 on the east boundary of range 19 southerly. We then began the survey of the east boundary of range 20 and were occupied with these surveys and the subdivision of township 47, range 19, until August 12.

An attempt was made to reach the twelfth base and run the east boundary of range 19 northerly but, having reached the Brazeau by trail along the Pembina and thence southerly, no trail could be located leading westerly along the Brazeau and we were compelled to return to township 47, range 19. On September 19, we moved to township 48, range 21 and were occupied until December 8 with subdivision surveys in townships 48 and 49, ranges 21 and 22. This district has been burned over and is covered with very dense dead timber.

On December 9, we left the field and arrived in Edmonton on the 17th. We left Edmonton again on January 9 and arrived at the coal mines of the Pacific Pass company on January 17 and following the same route as in the summer we reached the Brazeau on the 21st. By means of ropes the flat sleighs were let down the high steep banks of the river and reached the junction of the Brazeau and Southesk on January 23. We then ran the east boundary of range 9 north from the twelfth base about two and one-half miles and did a few miles of subdivision in the neighbourhood. We then moved north along this outline where we continued work until February 27. We then closed operations and I returned to Bickerdike to send in supplies for the next season. The supplies were purchased and forwarded to the Pacific Pass mines and I returned to Cornwall, Ont., on March 16.

With the exception of township 48, range 19, the country traversed during the season's work lies within foot-hills which vary in height from one hundred to fourteen hundred feet. Most of this country has been swept by forest fires and is now covered with dead and fallen timber and usually a second growth of small jackpine. The only timber of any value seen during the season is in townships 48 and 49, range 22 where a heavy spruce and jackpine forest remains as an indication of what the timber in surrounding districts must have been before destruction by forest fires. Spruce up to three feet in diameter were frequently encountered along our lines and in the surrounding brule country, we sometimes found dead spruce of even greater size. There are also some large green spruce along Pembina river both above and below the mouth of the Little Pembina.

Good coal is found in the range of hills which forms the divide between Pembina and Embarras rivers and in the hills northwesterly from this point to McLeod river. These deposits are being prospected by two companies, the Pacific Pass Coal company and the Yellowhead Pass Coal and Coke company, both of which have in view extensive mining operations in the near future.

At present the only way of reaching this district during the summer months is by pack-trails, of which the most convenient starts from 'big eddy' and follows south along the valley of McLeod and Embarras rivers. About five miles south of the mouth of the Embarras this trail divides, one branch following the west fork of the river to the Yellowhead Pass Coal and Coke company's property and the other the east fork to its source, thence crossing the watershed to Little Pembina river on which is situated the property of the Pacific Pass Coal company. In winter both properties can be reached by sleigh road. The Coal Fields branch of the Grand Trunk Pacific railway, now under construction will, when completed, open up this district.

Suitable land for agricultural purposes is limited to small flats found here and there along the river valleys. The largest of these I have seen is on Pembina river, near the mouth of the Little Pembina. Summer frosts are too frequent and severe to make these flats valuable other than as grazing spots for horses and cattle.

Game is very scarce, only a few deer being seen during the season. Caribou are found in the Brazeau valley but not farther north. Partridges are very plentiful in districts that have not been touched by forest fires.

During the summer months our work was somewhat hindered by rain, thunderstorms occurring frequently in the afternoons, the morning being generally fine. These clouds come from the mountains and their approach is plainly visible for hours from the hilltops. As a rule, they do not break immediately after leaving the mountains but pass over thirty or forty miles of territory before discharging their contents. The soil is always water-soaked and even the hilltops are covered with a thick spongy moss which I have seen elesewhere only on the Pacific coast of British Columbia. Fine clear nights are nearly always accompanied by frost except during the month of July. To these frosts I attribute the scarcity of mosquitoes and black-flies with which pests we had practically no trouble. "Bulldogs" were not affected by this however, and worried the horses a great deal during June, July and August.

During the winter months, the cold was not as a rule severe being moderated by frequent chinook winds. On several occasions however we experienced very severe weather, the thermometer registering fifty degrees below zero.

Good water was always available, and on Brazeau river there are opportunities for an economical development of water-power. As this must compete with coal, mined on the ground, it is doubtful if there will be any power development in this neighbourhood in the near future.

I would say that the future prospects of this district depend almost entirely upon the success achieved in coal-mining operations. Experienced miners who have visited it say that a good grade of steam coal suited for use in locomotives and for fuel can be obtained and my own observations have convinced me that the quantity is almost unlimited. The experts of the Grand Trunk Pacific and Canadian Northern railways have doubtless made a favourable report on the coal deposits as both of these companies have branches under construction into this district. Such being the case, a large part of the fuel used in our prairie provinces will doubtless come from this source.

## APPENDIX No. 37.

### ABSTRACT OF THE REPORT OF W. F. O'HARA, D.L.S.

#### MISCELLANEOUS RESURVEYS IN SOUTHERN ALBERTA.

My work during the past season consisted of miscellaneous resurveys in southern Alberta, and a survey of villa lots at Waterton lakes and town lots at Pincher Creek.

I reached Milk river in township 2, range 7, west of the fourth meridian on June 29, and commenced the retracement of the township. It was also necessary to resurvey part of township 2, range 8, and the north boundary of township 1, range 7, in order to get all blocks to close within the limit allowed.

These townships are in the semi-arid district. The soil is a hard firm clay and requires to be ploughed about eighteen inches deep in order that sufficient moisture may be retained in the soil to mature the crops. The summer of 1910 was the driest on record. The prairie grass turned yellow owing to the drought, and the oats headed out when only six inches high.

After completing the surveys required in ranges 7 and 8, I proceeded up Milk river by wagon trail to range 20 west of the fourth meridian, where work, similar to that in ranges 7 and 8, was required.

This region consists almost entirely of large grazing leases, and in some cases the land has been patented.

The country here and along the entire route is practically the same, consisting of undulating or rolling prairie with heavy clay soils with a few inches of black loam on the surface. Camp was pitched on Milk river in township 2, range. 20. The water of the river is much better here, being only a few miles from fresh-water springs which feed it. The volume also is much greater. A large amount of the water of the river must be absorbed by the soil and evaporated before it reaches its outlet. The difference in the volume in range 20, and range 7, is very marked. Nearly the whole of townships 2 in ranges 19 and 20, was retraced and a large number of monuments were established to take the place of the old monuments which had entirely disappeared.

The work here was finished about the middle of September. I then proceeded westerly by wagon trail to township 1, range 27. This township is situated in the foothills of the Rocky mountains and is covered largely with pine, poplar and willow. It is suitable for mixed farming and cattle raising.

The soil is exceedingly rich consisting of six to twelve inches of black loam, with a clay subsoil, and is capable of producing large crops of vegetables. There is a bountiful supply of fresh water in the many streams, one of which is found on nearly every quarter section in the township. The altitude varies from 4,000 to 5,000 feet above sea-level. This is somewhat against the raising of cereals as there is danger of summer frosts. However, there are some farmers in the vicinity who seem to be prosperous.

There are many well-known wagon trails, leading into the township from all directions which have been opened by settlers for hauling timber, large quantities of which existed a few years ago. It has however been destroyed at intervals by fire, and that which remains consists chiefly of second-growth and dead pine. A few speckled trout can be found in the streams. Deer, rabbits and grouse are also present. After completing the subdivision of this township I moved to the Waterton lakes, having made arrangements with the Commissioner of Dominion Parks to meet me there. It was his wish to look over the ground, before the survey of villa lots was commenced.

Unfortunately he was unavoidably detained upon other business and was unable to meet me on my arrival on October 23.

In the meantime I proceeded with the retracement of a few miles in township 2, range 27 and township 1, range 30. The commissioner arrived on November 6, and after consulting with him while going over the ground, I began by making traverses of those portions of the lakes where it was decided to survey villa lots.

The commissioner selected what he considered to be the best sites. The sites selected are those which have been chosen by campers and pleasure seekers during the last few years.

There are, however, long stretches on the east sides of the upper and lower lakes, and on the south side of the middle lake which were not considered nor visited on account of the rugged nature of the country which gives no easy means of access.

After making a plot of the traverse, I surveyed the lots in a manner best suited to the requirements of a summer resort, it being desirable that the lots front on the lake.

The locality is entirely within the Waterton Lakes park and consists partly of open country, and partly of forest, with mountains from 2,000 to 3,000 feet high surrounding the lake.

The park at present comprises the east half of township 1, range 30, the west half of township 1, range 29, the southeast quarter of township 2, range 30, and the southwest quarter of township 2, range 29, west of the fourth meridian, a total area of fifty-four square miles.

There is no other locality in western Canada, which I have seen or heard of, which can compare with the Waterton lakes as a summer resort, there being a rare combination of climate, mountain scenery, large bodies of fresh water and trout fishing. Trout have been taken from these lakes recently weighing fifty pounds. The lakes are one and a quarter, two and a half and eight miles respectively in length, and from one-half to three-quarters of a mile wide. The upper lake is the longest and extends about four miles into the United States, the international boundary cutting it into nearly equal parts. The lakes have been sounded in many places and have been found to be about 300 feet deep. The water remains perfectly clear at all times, notwithstanding its being frequently lashed into foam by the hurricanes which blow down the pass almost continuously for nine months in the year, June, July and August being the only calm months. The lakes can be reached by many well-known wagon trails, which converge from all directions, leading from all the towns and villages in southern Alberta.

It was reported that about 3,000 people spent their vacations here during the summer of 1910.

After completing this work I left for the town of Pincher Creek where I arrived on December 15.

My work at this town consisted of a further subdivision of the southwest quarter of section 23, township 6, range 30, west of the fourth meridian. The survey is very regular and in a desirable part of the town which should make the lots attractive. This was the last work, operations being closed for the season on January 4. 1911.

## APPENDIX No. 38.

### REPORT OF THOS. H. PLUNKETT, D.L.S.

SURVEY OF FRUIT LANDS IN KAMLOOPS DISTRICT, BRITISH COLUMBIA.

OTTAWA, January 4, 1911.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I beg to submit the following report on my surveys during the past season in the railway belt of British Columbia.

In accordance with your instructions, I left Toronto on April 3, 1910, and proceeded to Kamloops, B.C. A few days were spent in repairing my outfit and organizing my party, after which on the 13th, we left for Notch Hill, where by launch we crossed Shuswap lake and camped in township 23, range 10, west of the sixth meridian.

Our work here consisted of the survey of suitable fruit lands in township 23, ranges 10 and 11. We found a large area of good agricultural land in township 23, range 10, lying along the northerly shore of Shuswap lake, and extending back an average distance of about three miles from the water. This land lies on two main benches. The lower with an average breadth of about a quarter of a mile, extends almost the entire width of the township, attaining at section 11 a width of about half a mile and narrowing gradually toward the eastern edge of the township, while at the western edge this bench entirely disappears.

Along the northerly limit of this bench there is a somewhat steep rise reaching at the western limit of the township an elevation of about 1000 feet above Shuswap lake but rapidly becoming lower and of a much more gradual slope as its summit is traced easterly through the township. At the northeast corner of section 9 this rise attains an elevation of only 212 feet, with a slope so gradual as to permit of farming operations, and continues approximately at this elevation and slope to the eastern limit of the township, except in the westerly portion of section 10, where for a short distance it becomes rocky and precipitous.

North of the summit of this rise, lying on a gradual southern slope, is the larger and by far the more fertile of the two benches. It has an average width of about two and a half miles north and south, and extends the full width of the township east and west. This bench extends northerly to the base of the mountains, which rising somewhat precipitously, render agriculture impossible any farther north.

Portions of the lower bench are naturally somewhat gravelly, lying so close to the lake, but in the south half of section 9 and in sections 11 and 13 some rich brown loam was found well adapted to fruit or general farming. Just below this bench in section 11 there is a limited area of bottom-land of a very rich brown or black loam.

On the upper bench, the conditions for agriculture are very favourable. The soil in sections 15, 16 and 17, and in the south halves of sections 21, 22 and 23, is for the most part a rich black loam with a gravel or gravelly clay subsoil. The remaining portions of the bench have a brownish loam soil with the same gravelly clay subsoil.

This district is of course a bush country. West of the east boundaries of sections 9, 16 and 21 the timber consists principally of fir, cedar and hemlock from one to two feet in diameter. In addition to these varieties, spruce, birch and poplar up to eighteen inches in diameter are very plentiful. The undergrowth in this portion of the township is very dense, consisting of alder and willow brush with scrub maple; clearing is a very slow process. The fact that there are very few meadows where cheap fodder can be obtained renders it out of the question for the settler to provide himself with horses, and most of the clearing until now has been done by manual labour. In one or two cases where horses had been employed, the cost of their feed at prices in British Columbia, has compelled the settler to dispose of them. Although slow, progress in this district is nevertheless steady, and gradually the settler, convinced of the fertility of the soil, is carving out of the bush a comfortable home, and finding to his great satisfaction that a very small portion of land, probably from ten to twenty acres, when cleared and looked after properly, will afford him and his family a good living.

East of the east boundaries of sections 9, 16 and 21 clearing is very much more easily done. There is in this portion a much larger proportion of poplar, small spruce and fir. On almost every homestead in this section of the township there can be found from five to ten acres that can be easily cleared and very rapidly made to produce a living for the occupants of the land.

Agriculture in this locality is as yet in its infancy, but sufficient has been done to show the fertility of the soil. Vegetables of all varieties are being raised successfully. Small fruits yield abundantly, and the appearance of the fruit is excellent. Mr. H. A. Fowler's ranch in section 18, Mr. Blake's in section 11 and Mr. Beguelin's in section 16 demonstrate convincingly what the land in this township in general will produce. In addition to these there are several farms scattered well over the township in a more or less flourishing condition. Fruit raising has as yet not had time to develop, but almost without exception the settlers have planted small orchards which, although young, appear to be in a remarkably healthy condition, presaging the future development of the country along this line.

In township 23, range 11, we found a small portion of good farming land lying along the valley of Meadow creek, and extending northwesterly through sections 13, 23 and 24 to the valley of Scotch creek. The bottom-lands are narrow, but the side slopes and lower benches can be utilized to some extent. Several fairly large meadows are found in these sections.

The soil consists of sandy loam with a clay subsoil.

The bottom-lands are heavly timbered with fir cedar and hemlock up to four feet in diameter, but the slopes and benches are covered with small fir, spruce, poplar and birch of no commercial value.

This land is elevated from 500 to 700 feet above Shuswap lake, and judging from the flourishing condition of Mr. Fowler's ranch adjoining, it has a bright future as an agricultural district.

The climatic conditions in these districts are well adapted to fruit or mixed farming. Summer frosts are sometimes experienced. A severe frost this season on the night of August 23, affected this district in common with nearly all portions of British Columbia, but from what information I could obtain this was very exceptional. As development goes on it can, I think, be safely assumed that the danger of summer frosts will be entirely eliminated. It is the practice in this district at present to delay the planting of potatoes and the more tender crops until the beginning of July, it having been found that the rapid growth during July and August causes the crops to develop so rapidly as to equal crops where seeding has been done earlier, and thus the danger of destruction by frost is eliminated.

With the removal of the forest growth, irrigation during some seasons will probably become necessary, as this district lies so close to the dry belt. However, in this respect, this locality is favoured by having excellent facilities for irrigation. Manson and Meadow creeks supply ample water, easily available. In addition, Manson creek presents several splendid water-powers.

Until recently, the settlers in the above-described districts have had difficulty in disposing to advantage of their farm produce, but of late, a regular weekly boat service has been established on Thompson river and Shuswap lake between Kamloops and Salmon Arm. These boats stop on signal anywhere along the shore of the lake to take on passengers or freight. The owners also supply the settlers with winter work cutting cord-wood and piling it on the lake front where the boat replenishes her fuel supply or carries the wood to markets along the lake. Several merchants from towns along the Canadian Pacific railway on the south side of Shuswap lake are now contemplating a gasoline launch service to trade with the settlers. At least one of these boats owned by W. J. Smith of Notch Hill, is in commission, and two others, I understand, are to be put on in the coming spring.

Game, including deer, bears and lynx, is plentiful in this neighbourhood. The mountains to the north are a favorite resort in the fall for hunting parties in quest of big game.

Having completed our work in this locality, we moved to Adams lake, where in addition to some traversing on the lake we subdivided some land in sections 17, 18 and 19 of township 23, range 12, and sections 24, 25 and 26 of range 13.

The land in these sections adapted to agriculture is very limited. The mountain slopes in general are too steep to permit of farming operations. Occasionally small benches of good land were encountered, and these, with the somewhat narrow strip of land between the edge of the water and the foot of the mountain, provide the only land where farming can be carried on. I do not think that much activity in farming will characterize this locality. Good grazing land, however, is found on all sides, and cattle raising might flourish if sufficient hay land can be located to provide winter feed.

Fish are plentiful in Adams lake, and game, including bears, deer and lynx is to be found on the mountainsides.

Climatic conditions are favourable to agriculture. Summer frosts do occur, but are not generally of a very severe character.

Irrigation will probably be necessary but ample water can be found in almost all localities where it is required.

From Adams lake, we moved to the northerly end of Niskonlith lake in township 21, range 13, west of the sixth meridian.

In the immediate vicinity of Niskonlith lake, namely in sections 6, 7, 17 and 20 we found very little good land, except in sections 6 and 7 where there is a limited area of agricultural land.

The timber in this locality consists almost entirely of bull pine and fir, from one to two feet in diameter, with, in sections 6 and 7, some poplar and willow. The land in sections 17 and 20 and portions of 6 and 7 lies on a somewhat steep slope, which however, provides excellent bunch-grass. In the east halves of the southwest quarter of section 7, and the northwest quarter of section 6, some first-class agricultural land was found, but only to a limited extent. Irrigation too is necessary, and the source of water supply for it is not evident.

North of the lake, however, along the valley of Loakin creek we found a considerable area of first-class farming land.

Our work this season, north of the lake, included surveys in sections 29, 32 and 33 of township 21, range 13, and sections 4 and 9 of township 22, range 13, but if time had permitted these surveys could have been extended into sections 16, 21, 22 and 15 where excellent farming land exists.

Loakin creek apppears to have its source in a chain of small lakes, lying about the southwest corner of section 22. If on the removal of the bush, irrigation is found necessary, ample water could be obtained from these lakes and creek.

This land is elevated from 500 to 800 feet above Shuswap lake. The soil in the bottom-lands along the creek consists of a rich black loam, with a sand or gravel subsoil, while farther back on the side slopes and benches the soil is a light loam, sometimes sandy with a gravelly clay or gravel subsoil.

This country is also covered with bush, fir, cedar, hemlock, pine, birch and spruce being the prevailing woods. Some fairly good patches of merchantable timber were found on the bottom-lands along the creek. This consisted chiefly of cedar. In the northwest quarter of section 4, and the southwest quarter of 9 some fine fir, spruce and cedar were found from twelve to thirty inches in diameter, so that clearing the land, while necessarily a slow process, will not present any special difficulty.

The climatic conditions render this an ideal farming and fruit raising district. Summer frosts are not severe enough to damage the crops, while in winter the district is favoured with a sufficiently heavy snowfall to protect young orchards.

Agriculture has been carried on for a number of years on the northeast quarter of section 20, township 21, range 13. Here gratifying success has been attained in strawberry culture, and a few apple, plum and cherry trees, probably about ten years old, produced excellent fruit this season, notwithstanding the fact that their condition shows neglect. If under the condition in which these few trees were found they can at least retain life, let alone bear fruit, no doubt under proper handling this locality will be found to be a profitable fruit country. Except this farm, no attempt at agriculture has as yet been made in this locality.

Our next work led us into Mabel lake country in townships 19 and 20, range 5, west of the sixth meridian, where in addition to the traverse of that portion of the lake lying within the railway belt, we planted posts along the lake convenient to suitable agricultural land, and subdivided portions of sections 26 and 27 of township 20, range 5.

This from a settlement standpoint is a new country.Lying adjacent to the Okanagan valley, twenty-five miles east of Enderby it is favoured with an ideal climate. Frosts are unknown in this district from May until November, and the rainfall seems to be sufficient to render irrigation unnecessary. If, however, experience proves the contrary, sufficient water is easily available in every locality where farming can become established.

By far the largest areas of land adapted to agriculture lie in the Frog and Noisy creek valleys.

Extending up Frog creek from its mouth in section 27, a distance roughly estimated at from six to eight miles northeasterly, there lies a valley with an average width of about one mile admirably adapted to mixed or fruit farming.

The soil of the bottom-lands immediately along the creek is of a rich black loam, while that on either side is of a brownish loam with a sand or gravel subsoil.

The land is very heavily timbered with cedar from three to ten feet in diameter, resembling very much the country on the lower Columbia river below Revelstoke. The cedar from three to five feet in diameter is generally sound, and easily handled by driving it down Frog creek and ratting it through Mabel lake to Shuswap river, down which it is taken to the mills at Enderby.

Considerable difficulty was experienced in making the surveys in this locality, owing to the fact that the beaver have dammed the country along the valley, flooding it for miles up Frog creek. Wading these meadows or rather lakes, in November, is work to which the axemen do not take kindly, and it was found advisable after having subdivided a few quarter sections, to abandon the work for this season.

At Noisy creek no subdivision surveys were made, but examination showed that a considerable area of good land lies in the neighbourhood of sections 17 and 20.

Some good bench land is also to be found in section 30 of township 19, range 5.

Deer, bears and caribou are very plentiful in this district. Beaver are very numerous, and marten and mink are also to be found.

A fairly good wagon road leads from Enderby to Mabel lake, while the lake permits of navigation throughout its entire length. Along this road the intending settler has convincing proof in the flourishing fruit orchards and farms of what can be done in the locality. No portion of British Columbia can boast of better produce. Conditions here should lead to the early settlement of this land.

This completed our fruit land surveys, and from here we went to Ashcroft and thence up the Cariboo road, where several small surveys occupied us for the remainder of the season.

The attention of ranchers in this locality is taken up mainly with hay and cattle raising. Potatoes and other root crops are successfully raised, the former in large quantities.

Irrigation here is imperative, and very little agricultural land remains where water is available.

The only new country visited was in sections 24, 25, 26 and 35, of township 23, range 25, west of the sixth meridian along the valleys of Scottie creek and its tributaries. Considerable good level land was found in this district, and our surveys could have been greatly extended if a solution of the irrigation problem had been evident.

Small portions of sections 25, 26 and 24 can be easily irrigated, and these were surveyed. It is doubtful if the remaining areas of suitable land are sufficiently extensive to warrant the expense which would have to be incurred to provide water for irrigation.

Surrounding the above-mentioned land are large areas of excellent grazing lands, very convenient to permanent water courses, which provide sufficient water at all seasons for cattle.

We finished our work here on December 15, and concluding that the season was too far advanced to undertake any further work, left for Kamloops where the party was paid off and our survey outfit stored for the winter.

I have the honour to be, Sir,

Your obedient servant,

THOS. H. PLUNKETT, D.L.S.

## APPENDIX No. 39.

### ABSTRACT OF THE REPORT OF A. W. PONTON, D.L.S.

SURVEY OF PARTS OF THE FIFTH MERIDIAN AND TWENTY-EIGHTH AND TWENTY-NINTH BASES WEST OF THE FIFTH MERIDIAN.

Having organized my party at Edmonton I left on June 4, 1909, and reached Athabaska Landing on the 16th. We got away by boat on June 24 and arrived at a point on the Athabaska, about four miles above Grand rapids, on the 25th.

On the 26th we began exploring and cutting a trail northwesterly towards Wabiskaw river. In this work we were greatly retarded by wet weather and the flooded condition of the creeks and swamps. Further delay was caused by the necessity of returning to Athabaska river for supplies. On August 9 we reached Prairie river on the Wabiskaw river trail, and on the 17th arrived at Chipewyan lake. With one man I then proceeded by canoe down Wabiskaw river to Fort Vermilion, while the rest of the party went by trail to the junction of Red river and Peace river. At Fort Vermilion supplies were loaded on a raft to be taken to Red river. When within about five miles of Red river, during an attempt at mooring, the raft accidentally went over the rapids and all the supplies were lost, together with the tripods of my two transits, my level tripod and level.

Leaving my assistants to cut trails and pack hay at certain points, I returned to Edmonton by way of Peace River Crossing, Lesser Slave lake and Athabaska Landing, arriving there on October 9. I left Edmonton with other instruments on October 26 and at Athabaska Landing met my packer, whom I had instructed to return with the horses.

We proceeded by Wabiskaw across country and reached the starting-point of our surveys on December 1. The work was carried on without intermission until July 7, 1910.

By that time we had produced the fifth meridian from township 107 to township 112, had projected the twenty-ninth base across range 1 and the twenty-eighth base across ranges 1 to 17 inclusive. On July 8, we began mounding back over the lines run in 1908 and 1909 and continued until August 8. A great part of the mounding could not be done owing to the flooded condition of the country. We then closed operations and the party arrived back at Athabaska Landing September 13.

Township 107 along the meridian is generally suitable for agriculture, but townships 108, 109 and 110 are low and swampy. A chain of meadows extends across from east to west through the four townships. They are capable of producing an enormous supply of hay. Stunted spruce and tamarack are found scattered in the swamps. Township 111 is in the valley of Peace river and appears subject to flooding to a depth of 10 feet. There is much valuable spruce timber here and logs and manufactured timber can be easily got out. Some pine occurs on sandy ridges in the south half of township 112 but the north half is low and swampy.

Along the twenty-eight base between range 1 and the middle of range 3 the land is low and swampy, with occasional narrow sandy ridges, and is unfit for agriculture. But many hay meadows occur, and there is some small spruce, tamarack and jackpine. Fox lake surrounded by extensive meadows, lies in the west of range 3. The land surrounding this lake is good and well drained, covered chiefly with poplar suitable for pulp-wood. Ranges 4 and 5 south of Peace river contain good agricultural lands, but range 5 north of the river is low and wet. Range 6 is high upland with poplar and spruce brush, the soil having vegetable mould and fine sand with clay subsoil. Range 7 being level will require drainage before it will be fit for agriculture. In range 8 extensive grassy swamps occur, but range 9 is undulating and well drained, having a soil of from three to six inches of black mould with clay subsoil. The timber in these two ranges is poplar and spruce from four to ten inches. Range 10 is undulating but cut up by the valley of a creek. The bank of Peace river is fifty feet high. The soil is good and the timber large comprising spruce, poplar and cottonwood. Range 11 is mostly prairie, but range 12 is again cut up by Peace river. Good agricultural land lies both north and south of the river. From ranges 13 to 17 the country is level. Numerous marshes and muskegs occur and the water is strongly alkaline. The timber is chiefly small poplar.

The summer season in this district was unfavourable to the early maturing of grain, but not more unfavourable than in southern Alberta where it is hot and dry. The rainfall is ample but summer frosts are frequent.

The Cariboo mountains, north of the twenty-ninth base, seem to be eruptive in nature and there is a prospect that valuable minerals may be located there. The exploration, however, is extremely difficult owing to the lack of feed in summer and fuel in winter.

Good water is plentiful as far west as range 13, but farther west is strongly alkaline.

A power site second to few on this continent occurs at the chutes of Vermilion falls. There is another site at the confluence of Red river and Peace river. Here a head of twenty-five feet could be obtained.

Devonian limestone rock occurs in situ on the Peace river between Red river and Vermilion falls. Many of the bedded masses of this stone will make good material for masonry work.

Fish are not plentiful in this district and the Indians do not depend on them for food. Bears were plentiful and moose fairly numerous. Ducks were found in large numbers in all the ponds and lakes. Prairie-chickens and partridges were not very numerous.

## APPENDIX No. 40.

### ABSTRACT OF THE REPORT OF E. W. ROBINSON, D.L.S.

SURVEY OF PART OF THE PRINCIPAL MERIDIAN AND OF PARTS OF THE EIGHTH BASE EAST AND THE NINTH BASE WEST OF THE PRINCIPAL MERIDIAN.

Upon receiving your instructions dated February 24, 1910, I obtained all the information possible as to the nature of the country in which I was to work, and concluded that packhorses would be the best mode of transportation. I arrived at Winnipeg on May 2 and soon discovered that it would be impossible to procure ponies suitable for packhorses in Manitoba at anything like a reasonable price, and in view of the fact that other surveyors were experiencing difficulty in obtaining packhorses in the other prairie provinces, I decided to go at once to British Columbia where I knew I could buy without any delay as many horses as were necessary. I accordingly left Winnipeg and arrived at Vernon in the Okanagan valley on May 5. By the 7th, I had purchased twenty-three horses and on the 10th they were loaded on the car and shipped to Gimli in charge of a man I had hired to act as packer. I returned to Winnipeg to hire the men and buy my outfit and supplies, and left there for Gimli on May 18.

Gimli is a thriving little town on the shore of lake Winnipeg and is the present end of the railway. It is the market town for the Icelandic settlement in the immediate vicinity and a Galician and German setttlement to the west. The fishing industry on lake Winnipeg has also assisted very materially the commercial progress of Gimli. Situated as it is on one of the few harbours on the west side of the lake, it forms a convenient base for the fishing in the central part of the lake. Unfortunately, too many of the settlers in this part of the country neglect the improvement of their farms preferring the immediate returns obtained from fishing to the slower but surer profits resulting from increased acreage under cultivation. Gimli has the advantage of an excellent supply of artesian water; in fact this can be obtained as far north as Icelandic river and possibly farther, but no wells have been drilled north of this point. It is necessary to put the wells down about ninety feet to tap the water-bearing strata, and the water rises from four to ten feet above the ground. The water, although somewhat hard, is suitable in every way for domestic purposes. Gimli is also becoming a summer resort for the people of Winnipeg and this will further assist in its progress. The horses arrived at Gimli on the evening of May 19 in poor condition after their long travel from Vernon. The two following days were occupied in arranging the outfit and on the 23rd a start was made. Owing to the horses not having been worked for some time, they had their own views about packing and a stampede occurred, which distributed my outfit near and far. Fortunately no serious damage was done, but it was the 25th before I could make another start. By this time the horses had submitted to the inevitable and no further trouble was experienced.

There is a wagon road running from Gimli to Fisher river which is in good condition, except after a heavy rainfall. Stopping houses are kept at convenient intervals along the road, although some of them are run only during the winter months, when there are many freighters bringing fish down from Fisher bay.

The party arrived at Fisher river and camped on the Indian reserve there. I had returned in the meantime to Winnipeg to hire some more men and arrange about further supplies. I travelled back by launch to Fisher bay on June 4. The land bordering Fisher river and occupied by the Indian reserve is a black loam on a clay subsoil. At this time of the year it was very wet, water and mud in every direction, in fact it was only by digging little drainage ditches that we could get a place dry enough to camp on. I was informed to my surprise, that it had been a drier spring than usual and I was accordingly thankful it was no worse. Fisher River Indian reserve has several stores and mail is received and despatched every two weeks.

The settlement is a well kept one and the inhabitants are prosperous, due in no small measure to the untiring efforts of the resident missionary, the Rev. F. B. Stevens, who labours to improve their temporal as well as their spiritual condition. Mr. Stevens has carried on agriculture for a few years and it has proved an unqualified success and the mission grounds furnish an excellent object-lesson of the productiveness of the country. The coarser grains all do well but wheat has not been given a sufficiently extended trial to demonstrate that this will ever make a wheat-growing district. Certain varieties of corn can be raised with success and in the autumn I obtained from the councillor at the Jackhead Indian reserve, situated about thirty miles north of Fisher river, three cobs of corn in which the grains were fully matured and well ripened. The natural grasses seem to be deficient in nutriment. Although my horses had very little work to do all summer they never seemed to thrive and as the fall approached they failed rapidly. I was told that cattle, fed in the winter with all the hay they can eat seem just to exist. Timothy has been tried and has proved a success and I am of the opinion that many other cultivated grasses would do as well. Although the summer was dry, the crops did not suffer as in the southern part of Manitoba and farther west. The first summer frost which came in the night of August 3 was sufficient to blacken the potato crop and this appears to happen most years. This is not to be wondered at, considering the vast extent of the surrounding muskegs, in some of which ice was found in the middle of summer. When the country is drained on a wholesale scale, as will be necessary to render the land available for agriculture and when clearing takes place these early summer frosts will probably disappear judging by the results obtained from similar operations in other sections of the country. All the usual vegetables thrive, such as potatoes, carrots, turnips, beets, peas and onions and Mr. Stevens' garden during August would prove a surprise to those not conversant with the possibilities of agriculture in northern Manitoba. Fisher river is from two to five chains wide at the mission and runs into Fisher bay.

I commenced the survey of the eighth base line east of the principal meridian after retracing the short portion already run. This line passes through the northern part of the Indian reserve and across a fine stretch of hay land belonging to it. Leaving the reserve there is muskeg and swamp land to the shore of Fisher bay with the exception of a narrow belt of poplar, spruce and birch growing on a natural dyke around the shore. Some two miles north on the shore of the lake is the small settlement of Fisher bay from which a large quantity of fish is shipped during the winter.

I sent the horses round by the south end of the bay to where the line meets the east shore and it was only after repeated attempts that they succeeded in reaching that point. There is a large area of muskeg and swamp extending to the south and southwest of Fisher bay. Apparently this bay at one time extended much farther to the south than at present but has gradually filled up, resulting in the present muskegs. Fisher bay is an arm of lake Winnipeg and is the scene of considerable activity during the winter fishing season. Pickerel, jackfish, goldeye, tullibee and whitefish are in the earlier part of the season caught in large numbers and shipped to Winnipeg. On the east side of Fisher bay there is a fringe of flooded land and then a ridge varying from five to twenty chains wide covered with spruce, tamarack and poplar up to ten inches in diameter. Between this ridge and the ridge along the shore of the main part of lake Winnipeg lies one immense muskeg, broken by one ridge with a general southeasterly trend, and which starts from Fisher bay at a point about five miles north of where the base line crosses. This ridge is timbered with spruce, tamarack and poplar up to fourteen inches in diameter. There are numerous islands scattered throughout and these generally carry spruce and tamarack of small size. The muskegs vary in nature, some consisting of partially decayed moss to a great depth, some having a clay or hard-pan bottom at a depth of two or three feet, while others are floating bogs—a semi-liquid mass of decaying vegetable matter.

There is at present very little agricultural land of any value on this peninsula, and even if the country were drained it would take some years before these muskegs could be utilized. The district is a favourite hunting ground for moose. In some of the drier muskegs moose trails were crossed every twenty or thirty yards and it was no uncommon sight to see three or four of the animals in one day. Considering the noise made by the average survey party, this is sufficient evidence of their number. One fine buck moose stood on the line and gazed with undisguised astonishment at the instrument. I was unable to use horses across this peninsula, so I hired six men as packers. I finished this line on July 8 and commenced to move camp back to Fisher river where I arrived on the 11th.

I made enquiries there regarding the country north of Fisher river through which the principal meridian would pass and found that it would be possible to use pack-horses at least up to lake St. George, so I cut a pack-trail from the Indian reserve to the south end of this lake. The trail follows the ridges and crosses only a few swampy places, so that it would be passable at any season of the year. About seven miles from the reserve and again at eighteen miles from it we crossed some burned country where there was a good growth of pea-vine and this is the only good feed my horses obtained all summer. I moved camp by means of this trail and afterwards took a supply of provisions to the south end of lake St. George. The principal meridian starting at the eighth base line runs along a ridge with some fair spruce, tamarack and poplar but soon leaves this and enters muskeg, which continues until approaching lake St. George, where another ridge is encountered, on which is some excellent spruce, poplar, and small tamarack, together with a second growth of these and other varieties. The spruce, although scattered, is a fair size, some trees measuring twenty-six inches. This was the largest timber we met with in the season's work. I reached lake St. George on August 6 and found it shallow, especially at the southern end. The northern end is deeper but the light skiffs used in the country can navigate anywhere. The water is good and fish fairly plentiful. Goldeye can be obtained at all times and jackfish at certain seasons. I was informed that a stream, Jackhead river, flowed out of the north end of the lake to lake Winnipeg and I took advantage of this to send a large supply of provisions by a sailboat from Fisher river to the mouth of Jackhead river and thence up the river by skiffs to lake St. George and by Round river to Split lake, since renamed lake St. Patrick, where I made a cache. It was owing to my being able to do this and subsequently get provisions by water down Mantagao river to the ninth base line that I was able to practically complete the work outlined for the season.

On August 8, I attempted to commence the triangulation of lake St. George, my intention being to run a series of triangles up the lake in order to calculate the chainage, and on a very clear day to produce the line up. I soon found, however, that the task was almost hopeless. The shores of the lake, especially the south end, are marshy with high reeds and rushes growing thereon, and as the land bordering the lake is so very little higher than the lake itself, it was impossible to select triangulation stations which would be visible from one another. I, therefore, ran the adjoining section lines on the west side of the lake. This line is principally in muskeg and crosses two small lakes. I crossed east to the principal meridian, and, running north, came to lake St. Patrick, and, finding the condition of the shores the same as at lake St. George, had again to resort to running adjoining section lines. I reached the ninth base line on August 26 and running easterly to lake St. Patrick found that the intersection of the base line and the meridian fell in the lake. There is a ridge about ten chains wide lying along the west side of Lake St. Patrick carrying spruce, tamarack and poplar up to fourteen inches. As I knew the country through which the ninth base line would run to the west, I reduced my outfit to the smallest possible dimensions and again resorted to man-packing. The following is the method I adopted. The line gang would each carry a fairly light pack, say forty to forty-five pounds, to the end of the line and leaving them there, would proceed with their work. The other men during the day would bring up the supplies and the rest of the outfit and make camp, the line gang returning to that point at night. This was the daily routine and although the life was a strenuous one and totally devoid of the least suspicion of comfort it was the only method by which satisfactory progress could be made. My information about the country was correct; to all intents and purposes the whole country is a muskeg. There are narrow ridges running approximately north and south but they are only a few feet above the surrounding country and, as the soil appears to be very retentive of moisture, even these are usually wet. Moose are very plentiful here and as they are little hunted are easy to obtain. On September 7, I reached Mantagao river which at this point is a stream from five to ten chains wide and about fifteen feet deep, with a sluggish current. It rises in some muskegs to the south and pursuing a very meandering course flows into Sturgeon bay of lake Winnipeg. I was informed that there is a dry jackpine ridge extending all the way from Fisher river settlement up to Mantagao river, but I had no time to investigate the truth of this. I had previously sent my assistant back to lake St. Patrick to superintend the taking of some supplies by skiffs from my cache there around to Sturgeon bay and thence up Mantagao river.

Proceeding westerly along the ninth base line, we crossed the same class of country—muskegs separated by narrow ridges.

On September 10, three inches of snow fell, but this all disappeared in two or three days. Frosts were of almost nightly occurrence. On September 16 we reached the marsh bordering lake St. Martin and procuring a boat from the Indian reserve to the south, proceeded to triangulate the lake. I found without much difficulty the end of the ninth base line already established on the west side of lake St. Martin, and triangulating to it, found the error of closing. On the west side of the lake the land is higher than on the east side and the soil is good. It was a welcome relief to walk on dry land after the months of never-ending muskegs.

According to instructions, I reran the ninth base line, distributing the closing error, back to lake St. Patrick and arrived there on October 11.

I then continued the production of the principal meridian to the north, although I found it necessary to run adjoining section lines until the north end of lake St. Patrick was reached and from there I was able to keep to the meridian. The country passed through is very similar to that described along the ninth base line and I used man-packing for camp transportation throughout. A heavy fall of snow occurred on October 22 and this remained on the ground making work even more disagreeable. We reached lake Winnipeg on the 26th.

I moved most of the outfit back, by means of a skiff, to lake St. George while the party returned by the line to lake St. Patrick. The weather was steadily getting colder and I was afraid of the lakes and creeks freezing up, so made the best possible speed. I arrived with the boat on lake St. George on the afternoon of the 29th and camped on an island. That night we had a severe frost and in the morning I found that lake St. George was frozen across. The party arrived at camp that afternoon having managed to cross the ice on lake St. Patrick with small loads. I waited several days hoping that the ice would become strong enough to enable us to bring the whole outfit down to the south end of lake St. George by means of hand toboggans. Snow, however, fell and the weather turning mild, I saw that it would be necessary to wait for some time and then get the outfit out by dog trains. We, therefore, proceeded to Fisher river where I endeavored to procure these. The fishing season on lake Winnipeg had just begun and considerable difficulty was experienced in obtaining the necessary dog trains. I left my assistants to superintend the bringing of the outfit from lake St. Patrick while I proceeded to Gimli with the horses. I left Fisher river on November 14 and took the trail via Vidir and Ardal. This passes through better country than I had yet seen. The land is higher and the growth of grass good. A small town is starting at Ardal, being served by a branch railway line from Teulon. From Ardal I proceeded to Hnausa through a well-settled and prosperous community and eventually reached Gimli with the horses on November 18. My horses were in poor condition and, acting on instructions received, I arranged for their sale by auction at Winnipeg in the meantime feeding them well in the hope of realizing better prices.

I proceeded to Winnipeg and thence to Hudson Bay Junction to make arrangements for my winter's work. It was my intention to go to The Pas, but no trains were running north of Hudson Bay Junction owing to the line being blocked. I, therefore, returned to Winnipeg and thence to Gimli on December 1, where my assistants had arrived with my outfit from Fisher river. Having shipped this to Winnipeg for storage I left for Ottawa where I arrived December 7.

## APPENDIX No. 41.

### ABSTRACT OF THE REPORT OF E. W. ROBINSON, D.L.S.

SURVEY OF PART OF THE SECOND MERIDIAN AND PART OF THE FIFTEENTH BASE WEST OF THE PRINCIPAL MERIDIAN.

I left Ottawa on December 9, 1910 and arrived at Winnipeg on the 12th. I interviewed Messrs. Turnbull & Armstrong of the Hudson Bay railway as they had several survey parties working in the vicinity of The Pas and obtained from them some very valuable information. It was my original intention to use horses and toboggans for camp transportation and dog trains for bringing supplies from my base at The Pas to camp, but hearing that the muskegs were not yet frozen up owing to a heavy fall of snow early in the winter, I knew it would be impossible to use horses. I therefore decided to leave my horses in Winnipeg until such time as I could utilize them.

A discussion here of the relative cost and usefulness of the dog and horse for winter travel in the northland might possibly be of some help to other surveyors. Until recent years the horse was unknown in northern latitudes, the "husky" being employed exclusively for hauling. The husky probably originated by crossing the grey wolf with some domestic breed of dog, but it is now a distinct breed reproducing its kind with great fidelity. One has to go to the far north to obtain the real husky, all those in the valley of the Saskatchewan being mongrels. Owing to the demand for dogs in the last few years it is now somewhat difficult to obtain huskies or even mongrel huskies in any number, and one is compelled to resort to the domestic dog. Any of the larger varieties such as mastiff, Newfoundland, collie or shepherd make excellent toboggan dogs and with care will perform as much work as the mongrel husky. If trained carefully and this takes only a few days, they seem to enjoy hauling a heavy toboggan, in pleasing contrast to the husky who vents his displeasure in blood-curdling howls and fiendish snarls when being harnessed up. In fact the difficulty with most domestic dogs is to prevent them expending all their strength in the early part of the trip. If a stretch of exceptionally good trail is encountered they delight in tearing along at full gallop with a chorus of joyful barks. The first task of most Indian dog drivers with a train of huskies after harnessing them is to give each dog a severe thrashing with a loaded whip, with apparently the double object in view of impressing the dogs with a fear of their drivers and warming themselves up. Many writers of travels in the north have spoken of the cruelty with which these dogs are treated, and it certainly is heartrending to see, as I once did, a dog which after being worked until it dropped with exhaustion, unharnessed and with its eyes fast glazing in death, kicked off the trail with a curse. A toboggan train usually consists of four large dogs or five small ones, and the average load they can haul on a fairly good trail is four hundred pounds. The customary dog feed is fish, and dogs brought up on it seem to thrive well with an average daily ration of six pounds per dog. Contrary to what might be expected even in a country where the lakes abound with fish, it is not easy to procure enough for any number of dogs. Sometimes all the fish caught by the fishermen is contracted for by some dealer, in other cases owing to the migration of fish very few are caught, and Indians and half-breeds owing to their incurable laziness, rarely have enough for their own consumption. It is advisable therefore except on very long trips to take one's own dog feed.

Corn-meal and tallow and dog-biscuits are the substitutes and with domestic dogs are more suitable than fish for food. The corn-meal is first boiled for about half an hour and the tallow then added, the ration being two pounds of corn-meal and one-quarter of a pound of tallow per dog per day. The dog-biscuits are put up in boxes of twenty-five pounds each and are fed without soaking, two pounds per day being a full ration. The price of fish varies but an average price is three and a half or four cents per pound for whitefish at the fishing station. Inferior varieties such as jackfish, goldeye and sucker are cheaper, say two cents per pound, but these are not fed to working dogs when whitefish, tullibee or sturgeon are procurable. The wholesale price of corn-meal in Winnipeg is about three cents per pound and dog tallow eight cents per pound and of dog-biscuit seven and one-half cents per pound. Feeding on fish will therefore cost per dog about twenty-two cents per day, on corn-meal and tallow eight cents per day and on dog-biscuit fifteen cents per day. All these prices are exclusive of freight or transportation. As one travels north, the price of fish drops very rapidly, and where one is beyond the point where it can be profitably shipped to market, it is by far the cheapest dog feed. The general experience is that it costs more than eight cents per day to feed on corn-meal and tallow owing to the quantity wasted and it has the additional disadvantage of requiring cooking. As it is difficult to get men at the end of a day's trip to spend the time to properly boil the corn-meal it is usually insufficiently cooked and in this state is quite unsuitable for dog feed. Biscuits are always ready to feed and if any are not eaten they can be gathered up.

Some of the varieties of dog-biscuit on the market are carefully made and containing as they do, meat scraps, tallow and ground bone, form a balanced dog ration. I used dog-biscuits during the whole winter and found them most satisfactory.

Most of the dogs I had were domestic and they took at once to the biscuit and thrived well. It takes a little while to accustom huskies to the use of corn-meal and tallow or biscuits and it is better to start feeding them some fish as well.

Portability is an all important item and a dog train using corn-meal or biscuit can haul enough to last them three times as long as if they were fed on fish. If however, fish can be obtained at intermediate points this advantage disappears.

Opinions differ as to the best dimensions for a dog toboggan. Undoubtedly a narrow toboggan has many advantages, but for survey work where so much of the outfit is bulky rather than heavy, I am of the opinion that a fairly wide toboggan, say sixteen to eighteen inches, is the most suitable. This enables one to keep the load low down.

If one decides to use horses it is better to select the ordinary cayuse or Indian pony rather than a heavier horse. Certainly on a good hard trail a heavy horse shows to advantage, but if the trail is bad and the feed poor and scarce a cayuse would live where a larger horse would die; and these conditions generally prevail on survey work. An average ration for a pony on this kind of work is fifteen pounds of hay and fifteen pounds of oats per day. As the cost of these vary so much it is not possible to give a general figure for the cost per day. The hay should be baled in sizes to fit the toboggans. Although an experienced man can bind a surprising quantity of loose hay on a toboggan, it saves both time and hay to have it baled.

A horse toboggan should be twenty-four inches wide and about sixteen feet long. If any hills have to be descended, shafts are absolutely necessary, but in flat country and particularly along a crooked trail simple traces on a whiffle-tree seem to be the most satisfactory. There is, however, considerable divergence of opinion on this point. On the average bush trail made by the surveyor a pony will haul from six to eight hundred pounds, and when it becomes packed and well frozen twelve hundred can be taken with ease. The ponies stand the cold fairly well provided one keeps them sheltered from the wind and well covered with, say, two thicknesses of blanket and a canvas cover. They are better un-shod unless one has to cross lakes, or in the spring when the trails are sometimes icy. One man can look after one or even two horses each hauling from eight to twelve hundred pounds, whilst every dog train hauling from three to four hundred pounds must have a driver.

It is much easier to make trail for dogs than for horses. Two men can readily make in a day six to eight miles of trail for dogs through ordinary country, and if they use snowshoes and allow a day to elapse before travelling upon the trail, it will be hard enough to carry dogs without sinking. For horses a wider trail must be cut and it takes several trips with loaded toboggans and severe frost to make the trail hard enough to carry the horse without sinking. As one generally moves camp along a new trail, the progress is slow at the very time when rapidity is all important. Another point of importance is the crossing of a large lake or open place. After a few trips with the dogs across an open space the trail will be built-up, the light snow drifting in and each trip building it higher and higher until it is level with the surrounding snow. Subsequent winds cannot then block it up. With horse toboggans owing to the greater depth to which the toboggans sink and the plunging of the horses it is rarely possible to make a satisfactory trail across an open place and every trip a fresh trail has to be broken.

The surveyor has therefore many points to consider in making his decision as to which method of transportation to adopt—horses or dogs—and as the success of survey depends so largely on successful transportation, no trouble should be spared. In a few cases teams and sleighs can be used, but as surveyors are now being pushed farther into the northland and usually beyond any settlement, this is rarely the case, and the toboggan must be resorted to. Generally speaking if in a bush country, and if the trails made can be constantly used, horse transportation is cheaper than dogs, but in a partly open country and particularly on base line and meridian surveys, where one is constantly moving on, dogs will be found the most satisfactory. Even in the severest winters some rivers never freeze hard enough to carry horses while one can always find a place strong enough to carry dogs. Last winter some muskegs in the neighbourhood of The Pas did not freeze on account of the depth of snow and if I had used horses I should have been compelled to make wide detours with my trails. It might sometimes be advisable to use both horses and dogs; establish a main depot at some suitable point and have horses bring supplies there from the base of supplies and then use dogs for camp transportation or *vice versa*, the object being to avoid having to carry horse or dog feed farther than necessary.

I left Winnipeg on December 19, by the Canadian Northern railway with my outfit and men, arriving at The Pas on the afternoon of the 20th. I had previously sent my assistant there to make inquiries as to the available supply of dogs, and he reported that there were very few to be had, and those were small; also an exorbitant price was asked, viz., twenty to thirty dollars per head. Mr. E. N. Joyal offered to supply me with six dog trains complete and undertake my transportation, and this I accepted. A little time elapsed before he reported at camp with the dog trains but during the winter he performed his services with considerable satisfaction and relieved me of many details of transportation. I left The Pas on December 26, having been delayed there by the non-arrival of my freight. I travelled by team and sleigh to Birch river at which point I had to send the horses back owing to the unsafe condition of the ice. From here I moved across Birch river Indian reserve to my starting-point on the second meridian by means of hand toboggans, a slow and laborious task. Without much difficulty I found the iron post left on the south bank of Saskatchewan river. We passed little land of present agricultural value between The Pas and my starting-point. Along the river there is a strip of dry land from ten to forty chains wide, and also along Birch river one can find some dry land where tillable crops could be raised. The remainder of the country is of a swampy nature which would need draining on a wholesale plan to render it fit for agriculture. Hay can be cut around the edges of some of the marshes. It was reported to me that in some seasons of extreme high water the whole country is flooded. I did not have many opportunities for examining the soil owing to the depth of snow, but in most cases I found a rich black muck which would prove very fertile if drained. North of Saskatchewan river along the second meridian the country continues to be swampy with willow and alder growing thereon. Tearing river which we crossed is a rapid stream carrying the waters of Cumberland and Namew lakes into the Saskatchewan. At certain times of the year this river provides excellent sturgeon fishing.

Arriving at the north boundary of township 56, I started the survey of the fifteenth base line eastward. In sections 34, 35 and 36 range 31, I crossed a belt of spruce and tamarack from four to six inches in diameter. This strip of timber stretches in a northwesterly direction and contains a considerable quantity suitable for pulp wood. Through range 30 the base line is in a marshy country drained by small sluggish creeks. To the north lies Barrier lake a shallow lake or more truly a marsh. Saskatchewan river was crossed in section 36 and along its banks is a dense growth of grey willow with black and white poplar up to twelve inches in places. Through range 29 the Saskatchewan was crossed twice, the country being still of a marshy nature with a rich black muck soil. On the south side of the Saskatchewan lies Saskeram lake. This is more truly a large marsh containing some small lakes connected by sluggish creeks. Several small islands exist covered with spruce, tamarack, poplar and birch up to ten inches. The main winter dog trail between The Pas and Cumberland House crosses this lake. The base line again crosses Saskatchewan river in section 33, range 27; the banks are covered with willow, alder and white and black poplar up to fourteen inches in places. At ten chains from the left bank of the river the line enters the south end of Reader lake which is shallow, about six miles across and six miles long. Stretching along the east bank of Reader lake is a rocky ridge covered with jackpine and scattered birch, spruce and tamarack up to twelve inches. All this ridge is included in Indian reserve No. 21. Small patches of good land exist and some of these are being utilized by the Indians as gardens. A wagon road starting from the north bank of the Saskatchewan opposite The Pas runs along this ridge as far as Atikameg lake. In the winter this road is used for bringing the fish down from Atikameg lake where they are caught in large quantities. Leaving this ridge the line enters a spruce and tamarack muskeg crossed by a few small ridges until in section 34, range 26, a prominent ridge about a mile in width is encountered covered with spruce, tamarack, jackpine and poplar up to six inches. Along this ridge is the located line of the Hudson Bay railway. To the east there is a large expanse of swamp and muskeg about twelve miles in width. Small lakes and some sluggish streams occur at intervals.

A growth of willow generally covers the country, with some small spruce and tamarack along some of the creeks. In ordinary seasons hay can be cut around some of the marshes. In section 36, range 24, there is a ridge from half a mile to one mile in width timbered with spruce, tamarack, poplar, birch and jackpine, averaging eight inches. This ridge has a general northwesterly and southeasterly trend and the timber is sound and would make good milling timber. On the east side of this ridge one again enters swamp and muskeg some ten miles across and of a similar nature to that on the west side of the ridge. On the east side of this swamp on the shore of Moose lake there is some high land. Here we found a small quantity of spruce, tamarack, poplar and jackpine up to six inches and the soil was a sandy loam with considerable rock. Moose lake is a deep water lake of large expanse and is one of the principal fishing grounds in this part of the country. Whitefish, jackfish and trout are caught in large numbers annually. I produced the line across a bay of this lake finishing on the east side of the first timbered point that projects from the south shore of the lake where it can be readily found when required.

I then commenced to move my camp and outfit back to the second meridian arriving there on March 3. My work at this time was somewhat delayed owing to the non-arrival of freight to be brought by the Canadian Northern railway to The Pas.

We commenced work on the second meridian on March 6. The line passed through some willow swamp and then crossed the ridge along the south side of Belanger lake. This lake is deep and about two and one-half miles in length and two miles in width. The main winter trail from The Pas to Cumberland House crosses the northern end. North of the lake is some higher land carrying spruce, poplar, jackpine and tamarack up to ten inches with patches of brule. The soil is generally a sandy loam with considerable rock, but some strips of excellent clay loam soil were encountered. The country remains of this description until English narrows, a portion of Namew lake was reached. Namew lake which is connected by English narrows and Whitey narrows with Cumberland lake is deep and well stocked with trout, whitefish and jackfish of a large size. The second meridian runs through its entire length crossing some points projecting from the west side. The banks are generally well covered with spruce, tamarack, poplar and birch up to ten inches, some of it excellent milling timber. The northern shore of Namew lake was reached in section 24, township 61, and the land rose steadily from the lake shore. The timber increased in size until near the north boundary of section 36, township 61, where the spruce reached a diameter of thirty inches, with scattered birch, poplar, tamarack and jackpine up to twenty inches. The soil was a sandy loam with some surface rock. I reached the north boundary of township 61 on March 27, and decided to finish my season's operations here. There was every sign of an early spring, in fact the lakes were then covered with water. I reached The Pas on March 31, and paid off my party. This town, for some time a prominent Hudson Bay post, has made considerable strides during the last few years. It has a population now of about 400, and has five general stores, a doctor and a dentist, school, etc. A steel railway bridge across the Saskatchewan is now in course of construction to connect with the Hudson Bay railway at present being located. A branch line of the Canadian Northern railway enters the town and gives a semi-weekly train and mail service.

Owing to the lack of agricultural land in the immediate vicinity of The Pas, agriculture has not been carried on to any great extent. All the usual vegetables seem to thrive well and it is reported that they are not unduly troubled by summer frosts. Undoubtedly if the country were drained the climate would be considerably improved and I am of the opinion that it would make excellent wheat raising land. There is a considerable quantity of natural hay meadow, and consequently the raising of cultivated grass has not been necessary, but I was informed that timothy grows well.

## APPENDIX No. 42.

### ABSTRACT OF THE REPORT OF O. ROLFSON, D.L.S.

SURVEYS IN THE BRAZEAU DISTRICT, SOUTHWESTERN ALBERTA.

We left Edmonton on May 3, 1910, and proceeded by rail as far as Wolf Creek. Thence we followed the wagon road to Whitemud and the pack-trail southerly to Brazeau river, arriving at our destination in township 44, range 20, west of the fifth meridian exactly one month after leaving Edmonton.

The trail followed crosses McLeod river about a mile above the mouth of Embarras river, which it, in turn, crosses four miles farther on. To the east of Embarras river, near Whitemud, it branches off, one branch following the east fork of the river to the Pacific Pass coal mines on the Pembina, and the other following the west fork to the Yellowhead Pass Coal and Coke company's mines. Following the latter branch of the trail, we proceeded from the mines southwesterly to McLeod river, and thence mostly along the river-bottom to the divide between the McLeod and the Little Brazeau. Reaching the Little Brazeau we followed it to a point near a camping ground known as the 'graveyard,' from which a day's travel brought us to our field of work.

As far south as the divide between Pembina and Embarras rivers, the country is gently rolling with jackpine on the higher lands, and spruce or tamarack muskegs on the lower lands; some fairly level areas, however, are covered with poplar. The water in the rivers and streams is fresh and good.

Near this divide and east of the 'graveyard,' on Little Brazeau river, the country on both sides of the river has been burned over and is now covered with dead timber, windfall and young jackpine. Farther south it is much higher and rougher, and timbered with pine, spruce, and some fine tamarack and balsam, up to twenty-four inches in diameter. There are many meadows, from five to forty acres in extent which provide splendid feed for horses.

South of Little Brazeau, the mountains rise high and rugged, the long ranges running northwesterly and southeasterly, with deep valleys between. The high peaks projecting above timber-line make the scenery beautiful. Rivers and streams are numerous, the larger ones having steep cut banks.

Coal seams were noted in the cut banks of Brazeau river in townships 43 and 44, range 20, but no other minerals were found.

The country south of Little Brazeau river is not suited to farming, but some parts might make good ranching land when cleared, as feed in the meadows and on some of the hillsides is good.

The air is always clear and the heat never oppressive, while the nights are cool and summer frosts are frequent. On the morning of August 25, there was ten inches of snow, but by noon of the following day it had all disappeared.

Game is abundant, consisting of sheep, goats, bears, deer and elk, rabbits, mink, ermine, &c., in the vicinity of Brazeau river. Partridges are numerous in the fall and mountain trout abound in the rivers.

Returning at the close of the season, the party followed the trail down the Little Brazeau from the 'graveyard' for a distance of about ten miles, mostly along the river-bottom and thence through a long muskeg valley and over a low divide to the Pembina. They then proceeded along the Pembina to the forks, and thence up the Little Pembina to the Pacific Pass coal mines. From here the trail led over a high divide and down into the valley of the Embarras and northerly to meet the trail from Whitemud.

## APPENDIX No. 43.

### REPORT OF JOSEPH E. ROSS, D.L.S.

SURVEYS IN THE KAMLOOPS DISTRICT, BRITISH COLUMBIA.

KAMLOOPS, B.C., December 17, 1910.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa.

SIR,—I have the honour to submit the following report of my season's operations in the Kamloops district of the railway belt of British Columbia.

On April 8, I started from Kamloops for Monte creek and Ducks range, to define the north boundary of the Martin Mountain Forest reserve. The land to the north of this reserve has been all settled within the past few years and only a few of the poorest quarter sections remain unoccupied.

After completing this survey I moved to the Jamieson creek country, on the west of North Thompson river, to survey the sections immediately to the east of, and to locate the east boundary of, the Tranquille Forest reserve. This land is mostly open or openly wooded, and not very hilly. The soil is fairly good and if water were available for irrigation it would be well suited for farming. As it is, the extreme dryness has prevented the few settlers who have located here from meeting with success.

From here I moved to lac du Bois to begin the main work of the season, subdivisions in, and ties between the Tranquille, Copper creek, Criss creek and Deadman valleys. This was the largest continuous stretch of work I have had for some years, the work being usually composed of small scattered surveys.

The wagon road does not extend beyond lac du Bois so it was necessary to get a pack-train of six horses for transportation purposes. However there were generally good pack-trails throughout the country, and only on Criss creek was it necessary for us to clear out trails for our use.

The most promising farming land we saw during the season was in sections 1 and 11, township 22, range 20, west of the sixth meridian, on Tranquille river, where there is good soil, and water is available for irrigation. With the exception of this land, on which there are now three settlers, the Tranquille valley is narrow and rugged, with steep mountainsides 2,000 feet high and picturesque canyons. While the soil in the settled quarter sections is excellent and easily cleared, an occasional summer frost has each year killed the potatoes, and it seems very doubtful if the settlers will be able to raise them. At an elevation of 4,000 feet there is a plateau covered with dense bush, chiefly jackpine, and unsuitable for agricultural purposes.

The early advent of the Canadian Northern railway will be of great assistance to the settlers of Copper creek and Tranquille river if a siding is made at Copper creek. A road from there could be built at moderate cost up Copper creek and along the route of the present trail to Tranquille river.

After running ties to Copper creek and Kamloops lake from the Tranquille valley, I extended the survey up Copper creek and around the Red lake and Frog creek valley, in which there is no land suitable for settlement, on account of the dry climate and the impossibility of procuring water for irrigation. The land is suitable for grazing, and that is the best that can be said of it. One settler has located on a wild hay meadow in section 34, township 22, range 21, west of the sixth meridian.

A tie was run to the existing surveys on Deadman river, crossing a canyon on Criss creek and a high ridge between Criss and Deadman valleys.

The work was carried northward to Criss creek valley and another tie run to the end of the old surveys in Deadman valley.

In the northeast quarter of section 36, township 23, range 21, west of the sixth meridian, the valley of Criss creek becomes wide and partly open and for five miles to the north limit of the railway belt, there is a good strip of arable land in the brushy meadows along the creek. Just outside of the 'belt' there is a wild hay meadow, 100 acres in extent. While the land along Criss creek is good, and would be excellent agricultural land if situated at a lower altitude, its height, 4,000 feet, with prevalent summer frosts, renders it unsuitable for general farming. It may be a good valley for hay growing and oats may be raised but no test has yet been made. For years this valley has been used by stockmen of the district as a grazing ground. The boundary of the 'belt' was run from Criss creek to Deadman river, crossing a plateau wooded with jackpine.

A wagon road ascending the hill from Tobacco flats, on Deadman river, leads across this plateau to a settlement recently formed by some settlers on the upper Deadman river, in the provincial lands. A road has been built by the settlers from there to another settlement on the upper Bonaparte, where it connects with a government road leading to Seventy-mile House on the Cariboo road. The road from Tobacco flats is steep and rough, with rocks and side slopes that make travel difficult, and at times dangerous. We thought that we had found the worst road in British Columbia, but we were undeceived on finding a branch leading from this road to Snahooshe (Deadman) lake, on which there was a descent of twenty-five chains at an angle of twenty-four degrees, with a sharp curve in the middle to add interest. For this descent a sled is used, a wagon being too difficult and dangerous to handle.

Deadman river is in a steep, rugged canyon. The 'belt' boundary crosses the valley at the north end of Mowich lake, over a mile south of Snahooshe, or Deadman lake, where a company which owns the land at Walhachin (formerly Pennys) is building a big dam for the purpose of holding water in the lake. This company has spent a great deal of money procuring water for irrigating their property. From Deadman river, at the mouth of Criss creek they have built a large flume about eighteen miles in length, while they have also built flumes and ditches from Barnes creek. As a result of their efforts the old Penny ranch has become the thriving village of Walhachin, a prospective fruit centre, with a population composed almost entirely of English people starting orchards which should, in a few years, be very productive.

Having completed work in the Criss and Deadman valleys I moved to the Summer range, south of Savona, and ran a tie between the existing surveys on Guichon and Barnes creeks. The land here, 4,000 feet above sea-level, is very similar to that on all the plateaus, rolling, wooded country, with occasional hay meadows.

Having completed this work I sent the packhorses to Monte Creek to be wintered, and we went to Ashcroft, moving by train from there to Kamloops.

The remainder of the season was spent on subdivision surveys to the south of Kamloops in townships 17, 18 and 19, range 18, west of the sixth meridian. This land is about 4,000 feet above sea-level, rolling and broken and thickly wooded with jackpine. Each year sees some venturesome settler discovering an anticipated 'Mecca' in a wild hay meadow deeper in the jackpine forests than other settlers have penetrated. Thus the demand comes each year for an extension of the surveys in this district. After one attempt at raising a crop on the high meadows the majority of these hopeful settlers quit in disgust. On November 23, I completed the work in these townships and returned to Kamloops, closing field operations for the season.

The year was exceptionally fine and dry, only one day being lost on account of rain. The summer was too dry for the farmers and crops were poor throughout the district. In July and August the country was covered with a pall of smoke from several bush fires, but no great damage was done to timber, the flames keeping to the jackpine plateaus.

Tranquille and Deadman rivers and Criss creek are well stocked with small trout. Deer and bears are quite plentiful in the districts visited, while coyotes are everywhere present, making the night hideous with their yelping.

On Criss and Guichon creeks beaver have built long series of dams, flooding many small meadows. In no part of the year's itinerary were the beneficial results of the 'close season' so strikingly evident as on Guichon creek, where we were fortunate enough to see the animals at work. They are marvellously tame, and took very little notice of our presence. However the surveyor whose lines are continually striking ponds and dams, with dense willow, rising out of a couple of feet of water, is apt to consider the renaissance of the beaver a doubtful blessing.

The Summer range, between Savona and Guichon creeks is one of the foremost duck-hunting grounds in British Columbia. On the numerous lakes, ducks and geese abound in the fall. Red lake is a favourite breeding ground for ducks.

A surveyor's report from British Columbia is incomplete without some reference to the mosquito pest. This year we were fortunate enough to avoid it, being in country where the nights are cool, and stagnant water scarce. On Copper creek we encountered swarms of black-flies, and endured two weeks of misery.

Of the 230 days in the field there were thirty-three Sundays, one day was lost through bad weather, nineteen in moving camp, while the remaining 177 days were occupied in running 172 miles of line and marking corners.

Mining men have for many years had their eyes on the Tranquille. Near its mouth a gold dredge was tried unsuccessfully. At the 'forks,' that is the junction of Tranquille river and Watching creek, some placer mining was done in the early days, but the ground has long lain idle. There is undoubtedly free gold there but up to the present it has not been found in paying quantities. Some prospectors were on the river this summer, and we heard rumours of wealth untold, and saw glowing advertisements of the prospective value of shares offered for sale, but the rumours remain unconfirmed.

At Copper creek and Criss creek we ran across mining claims. At the former a company built a concentrator several years ago, and did considerable development work on cinnabar properties, but nothing is now done except assessment work.

Only a few years ago this Pacific province based its hopes of future greatness on its vast mineral wealth, but the pay-streaks of the past have dwindled to nothingness, and the few substantial mines that now operate are mostly of low grade ore. There have been many small booms, towns of rough buildings and tents rising with startling rapidity, only to fade away to the realms of unpleasant memory. British Columbia at last realizes that minerals are not her great asset, that the fertile soil of her valleys, her forests of giant trees and her salubrious climate are more reliable, and productive of greater wealth.

While the farmers were in bad luck this year on account of the exceptionally dry summer, other businesses throve. Ashcroft, the outfitting point of the Cariboo district was very active. The points of the northern interior, Fort George, Cariboo and Nechacco districts import their supplies through here. From Ashcroft automobiles, stages and wagons leave daily with passengers and freight for Soda creek, the foot of navigation on the upper Fraser river, 165 miles distant. The great rush to the north during the past season threw life into this usually quiet town. Accommodation was scarce, but Ashcroft strove to fulfil its duty to the itinerant throng, and prospered.

Savona, too, was busier this year than it has been since the days of 'construction.' The lumber mill there worked steadily, supplying material for the buildings and flumes incidental to the development of Walhachin. It is probable that in the near future the flats of the Deadman Creek Indian reserve, between Savona and Walhachin, will be the site of the largest fruit raising colony in British Columbia.

Kamloops increases in size from year to year, and now contains a population of nearly 3,800. The spirit of optimism is here deep rooted, the coming of new railways is looked for with great expectation and realty speculators are busy. There is a good fruit and agriculture area contiguous to the town and its winter climate is one of the best in the Dominion, so optimism is justified.

Three or four years ago the fact that the country is drying up began to grow apparent; ponds that were in existence two years ago are now dry, while the flow of water in the creeks is gradually diminishing. The heavy snow in the hills, upon which the water supply of the district is dependent does not come as it used to. Unless a change comes soon and the snow falls deeper in the hills the district will be face to face with a serious problem.

In conclusion I wish to state that throughout the season the work progressed smoothly and there was very little time lost. Both the weather and the country in which we were working were favourable to progress.

I have the honour to be, Sir,

Your obedient servant,

JOS. E. ROSS, D.L.S.

## APPENDIX No. 44.

### ABSTRACT OF THE REPORT OF A. SAINT CYR, D.L.S.

SURVEY OF PART OF THE THIRD MERIDIAN AND PART OF THE SEVENTEENTH BASE WEST OF THE THIRD MERIDIAN.

During the winter six tons of supplies were forwarded with a great deal of difficulty to the north shore of Crean lake. We left Prince Albert May 3, and reached the third meridian on May 12. The line was produced from township 60 to the seventeenth base line, which was then projected westerly across ranges one to twelve inclusive.

East of the third meridian the country is rolling with a descent towards Montreal lake which is about six or eight miles distant. The soil is stony and in many places the surface is covered with windfall. Some large areas of poplar and birch, up to ten inches in diameter, were seen near the meridian but in the vicinity of Montreal lake the timber is small and scrubby. The western shore of the lake is low and swampy.

In township 61 the soil is light but improves towards the north; large boulders, however, are numerous. There is a little hay land and feed was scarce.

In townships 61 and 62 there are several lakes which abound with fish. They are drained by a small stream which flows through a narrow valley, between steep hills as far as its junction with Crean creek. From here to Montreal lake the valley becomes a series of flats, often swampy and covered with dense willow or coarse hay. The stream is navigable only a short distance beyond the third meridian.

Just south of the north boundary of township 60, a belt of spruce, eight to twenty inches, extends east to the stream above mentioned, and west across ranges 1 and 2. This area has never been burned over though fires have swept the district immediately to the north.

North of township 60, the country is hilly and this is followed by several miles of almost level surface, covered with scrub poplar, birch and jackpine.

Wehakwao (Swearing) lake is situated in townships 63 and 64, and is bordered by impassable bogs. The lake which is shallow and well stocked with whitefish and pike, covers an area of about twenty-five square miles and the distance between the opposite shores along the meridian is six miles. Two streams enter the lake from the west while the outlet is from the east shore southeasterly to Montreal lake.

West of the meridian the seventeenth base line crosses several miles of undulating land, alternating with burnt-over areas of willow, dense jackpine or tamarack swamp. A prominent landmark called 'Thunder hill' by the Indians, lies about two miles north of the base line in range 2. Its base is surrounded by muskegs which drain into a lake on the line in the same range. North of the hill are some hay meadows followed by stony land with little vegetation.

The north of township 65 is hilly with the tops of the hills covered with clumps of jackpine and poplar of large size. These blocks of timber taken together cover about half a square mile and average 22,000 feet B.M. to the acre.

In range 4, the country is partly open along the line and the land, being high and rolling, is suitable for grazing. Grass grows in profusion and there are many creeks of fresh water. In range 5, the soil is lighter. Many tamarack swamps occur in township 63, with trees from six to eighteen inches. North of the base line the country is rolling or hilly and dotted with lakes.

Smoothstone lake lies in range 6. It extends from a mile south to about eleven miles north of the line, and has an area of ninety-five square miles. An island occurs in this lake with an area of nearly three square miles. This island is covered with poplar and spruce suitable for pulp-wood.

West of Smoothstone lake the country is undulating. A block of timber estimated to contain seven million feet B.M., stands about one mile and a half west of the shore and another block along the shore will give seven hundred and twenty thousand feet, B.M.

A lake covers about two-thirds of township 64, range 8. This lake is shallow and drains through a creek into Sled lake in township 63, ranges 9 and 10. The lake lies in the centre of a low and boggy district, the northern extremity of 'caribou muskeg' which extends south to township 60.

High hills wooded with poplar, birch, jackpine, fir and spruce, rise in ranges 8 and 9, about two miles north of the base line. These hills extend north of Dore lake. Their southern slopes will produce two million feet of lumber.

On the north shore of Sled lake about six miles south of the base line some half-breeds took up land twelve years ago. They have comfortable houses and on the land they have cleared they grow all the ordinary vegetables, and some have raised oats and barley. The soil is a clay loam free from stones. They also own horses and cattle for which they procure feed from the hay meadows around the lake in township 64, range 8.

Good land was again seen in range 12, near Beaver river. Benches heavily timbered with large poplar and birch extend from eight miles south of the base line to three miles north of it. Beaver river is one hundred yards wide where it crosses the base line. This river is the only one in the country explored which is suitable for driving logs.

Moose, caribou and red deer roam at will in these districts and bears are quite common. I was frequently warned by the natives to beware of timber-wolves. Their tracks were frequently seen. The fur-bearing animals are coyotes, foxes, otter, mink and lynx. Prairie-chickens, partridges and ptarmigan were also seen.

The best varieties of fish caught are whitefish, tullibee, pickerel and pike. Carp are also plentiful.

Hay ,which I ordered to be put up during the summer near Sled lake, was not available at all; the hay in the vicinity had been retained by the Isle a la Crosse Fish company, and oats which I had ordered to be forwarded to Green lake had not been delivered. We were consequently forced to break camp on December 20. We returned to Green lake and travelled from there to Big river and thence to Prince Albert.

I returned to the third meridian later and made a tie survey to Montreal lake.

## APPENDIX No. 45.

### ABSTRACT OF THE REPORT OF B. J. SAUNDERS, D.L.S.

SURVEY OF PART OF THE NINETEENTH BASE LINE, WEST OF THE FOURTH MERIDIAN.

For this survey my supplies were sent in from Edmonton to Lloydminster via the Canadian Northern railway and thence by horse teams to a point about fifteen miles beyond the north end of Primrose lake, where a permanent cache was built. This work was done in February and March. From the cache a small portion of the supplies were pushed on by dog teams ten miles farther north to a point near the intersection of the base line with the fourth meridian, but this work had to be discontinued owing to the snow going off suddenly and early. It was important and necessary to get these supplies in at this time of the year as the country for about twenty-five or thirty miles south of the base is practically one mass of muskeg and nearly impassable in summer-time even for the packhorses. Two men were left in charge of the supplies to protect them from being looted and from fires, and at the same time to do some work in trail making between the cache and the line.

In June, I set to work to organize my party and get everything ready. Owing to the great demand for labour throughout the West last year in railroad construction and other work, I found great difficulty in engaging suitable men for the survey and had to take a number of inexperienced men, many of whom were comparatively new arrivals in Canada. Packhorses for use on the work beyond Cold lake were purchased in Calgary and brought up by rail to Edmonton and on July 12, a start was finally made.

The route taken from Edmonton was by trail via Fort Saskatchewan, Bruederheim, Wostok, Whitford Lake, Saddle Lake, St. Paul de Metis and Cold Lake Indian reserve to Beaver river where a day was spent getting everything ferried across. I was able to take teams and wagons loaded with additional supplies as far as the eighteenth base line to supplement what had been taken in during the winter. The packhorses were loaded lightly so as to save them for the actual work beyond the end of the wagon road. From the eighteenth base we travelled practically over the same trail which had been used by Mr. Wallace when surveying the fourth meridian in 1909. After about one week's tedious work, camp was pitched on a widening of Calder river near the beginning of the line, this being the only place where there was any semblance of grass for our horses. In six weeks time we had run only about eleven miles of line, so much time being required making and repairing trails to enable our horses to get along. It is no exaggeration to say that as many miles of corduroying were necessary in trail making, as there were miles of line run.

There being practically no feed for the horses along or close to the line, I concluded that the only thing to be done to push the survey along was to endeavour to get the line ahead to the Lac la Biche-McMurray dog trail, and to take in supplies by this route if possible. Reports were current that plenty of hay could be put up in the vicinity of Whitewood lake, which the line would probably intersect, or run close to in range 7 or 8. These reports I found to my sorrow to be misleading and untrue. Having returned to Edmonton in October for more supplies, I made the attempt to meet my men, or some of them, as definitely arranged before leaving camp, at Whitewood lake, but this proved unsuccessful after a most arduous trial in which two or three of my men, as well as myself, nearly perished by drowning and freezing. On New Year's day I returned to Lac la Biche and went in again via St. Paul and

Cold lake and met my party coming out. Of the twenty horses left with them, only one was alive, the others having succumbed to the cold, starvation, and attacks of wolves.

The section of the country traversed by the nineteenth base line up to range 6, lies practically on the watershed of streams flowing easterly, southerly and northerly, and in consequence there are no streams of any size met with. Small muskeg lakes are quite numerous and muskeg is met with everywhere.

The timber consists of small spruce, tamarack and pitch-pine; only an occasional poplar was seen. Fires have no doubt swept the country periodically and as a result, the timber is small and scrubby and quite unfit for commercial purposes.

Where there is any soil it is poor, and in my opinion unsuitable for agricultural purposes.

Moose and caribou are very plentiful, as are also timber-wolves.

The weather was extremely cold in December and January, quite the severest I have ever experienced and snow lay three feet deep on the level.

Should it be decided to continue the survey of this line, it would be best to take in supplies via Lac la Biche in winter and cache them at points where the line would intersect the two dog trails leading from Lac la Biche to McMurray, and a trail running from Owl river to House river. Necessary supplies, if horses are used on the survey, should include plenty of hay and oats.

## APPENDIX No. 46.

### ABSTRACT OF THE REPORT OF W. A. SCOTT, D.L.S.

MISCELLANEOUS SURVEYS IN SOUTHERN ALBERTA AND SASKATCHEWAN.

Upon receipt of instructions I left Pincher Creek on May 7, and on the 11th arrived at our first work in township 9, range 30, west of the fourth meridian.

On the completion of the work in connection with the Peigan timber limit in township 9, the party moved to township 10, and enclosed the block composed of sections 1 and 12. The work so far was in the Porcupine hills, a range 1,500 feet above the level of the prairie to the east. The summit runs almost due north and south slightly to the east of the fifth meridian. The hills are timbered with fir up to four and a half feet in diameter. On the whole, the east and south slopes of the ridges may be said to be bare or covered with small poplar, and the creeks in the valleys contain many open patches. The soil is a rich black loam with a light subsoil but owing to the hilly, wooded nature of the country and to frequent summer frosts, it is not suited for farming. It does however afford an excellent opportunity for ranching. There is much merchantable timber left in the hills although a great deal of the best of it has already been taken out. No difficulty is experienced in reaching almost any part of the Porcupine hills by wagon road, as there is one crossing the summit from east to west every few miles.

Our next work was the subdivision of part of township 11, range 2, west of the fifth meridian, which is easily reached by a good wagon road. The country here is very similar to that in the Porcupine hills but there is little heavy timber except on the tops of the ridges where there are a few scattered fir; the remaining timber is small poplar and willow. The valleys are open and afford good grazing for stock. Very little effort is here made to raise a large quantity of grain, the time of the people in this vicinity being devoted to the raising of stock.

On the completion of this work the party moved, on June 11, to the third base line to connect up three miles which crosses the summit of the Livingstone range. This was a rather difficult piece of work and as it could not be completed from one end, necessitated a two days' move, by wagon and pack-train, around through the Crowsnest pass to the other end of the three miles. The Livingstone range here is 2,500 feet above the level of the land to the east and marks the dividing line between hilly prairie to the east and a rough mountainous country to the west. The easterly slope of the range is more precipitous than the westerly slope.

We moved to township 10, range 4, going by a wagon road to the 'Gap' in the Livingstone range, thence up the valley of Racehorse creek four miles by wagon over a trail cut by ourselves, and the remaining distance of two miles, by pack-train. The atmosphere soon began to become very smoky on account of forest fires to the south. When the work for which I had instructions in this township was completed I considered it advisable to move camp to some point where the party could be moved from all danger of the fire in a short time, as the fire from the south had reached a point only six miles south of our camp, and there was a forest fire in township 12, range 4, to the north of us, which at that time was under control but which at any time might break out again. Two men from my party were assisting the Dominion Forest Fire Ranger at the northerly fire. I accordingly, on July 21, moved camp to the 'Gap' and completed the traverse of the North Fork of Oldman river. This traverse took three days and from the completion of the traverse until August 6, the entire party were fighting forest fires under the supervision of Dominion Forest Fire Ranger, Mr. Hart. At one time only, was any danger encountered when, due to a heavy wind and big timber, the fire suddenly increased in violence and camp had to be moved from the 'Gap' to a point of safety several miles east, outside of the Livingstone range. In this case the outfit was started only fifteen minutes in advance of the fire on account of having some difficulty in finding the horses which were two or three miles from camp. Various methods of fighting the forest fires were employed, but during the day when the wind freshened it was impossible to do anything.

On the evening of August 5, the rain started and continued all the following day; this effectually put an end to the fires. I considered it advisable to work outside of the mountains until such time as the grass in the burned area would have grown sufficiently to afford feed for the horses, so on August 8, I moved camp to township 10, range 1. The eastern half of this township is in the Porcupine hills and much of this part is covered with timber, poplar on the lower and fir on the higher hills. The western half is rolling prairie and is suitable for farming purposes, while the eastern half is suitable only for the grazing of stock. This township is readily accessible by good wagon roads.

On September 5, we moved back to township 12, range 4. Owing to a two days' snowstorm on the 6th and 7th work was not commenced until the 9th. It was found that the grass had grown sufficiently to afford feed for the horses but baled hay had to be supplied to the picket horse. Owing to the fire the production of lines was made easier than formerly as all underbush had been burned up, as well as the fallen timber of previous fires, which was so dense in this part. The timber previous to the fire was on the whole a dense growth of small second-growth jackpine. The westerly boundary of the burned area may be roughly said to be one mile east of the east boundary of range 5, and the northerly boundary one mile north of the fourth base line. The best timber in this section is in range 5. A fire in the mountains is a more serious setback to the country than a similar fire in a flat country. Where the fire burned furiously up hill or was fanned by a heavy breeze, everything was consumed. There is at best but little soil covering the rock and stones and this was entirely consumed, leaving nothing in these parts but dead charred poles still standing in their bed of stones, gravel, and ashes. Under these conditions it may be many years before vegetation will again obtain a hold on these hills.

There is a good wagon road from Cowley or Lundbreck as far as the 'Gap' ; here a bridge was burned out which makes the passage of a heavy load impossible without 'doubling up'. From the 'Gap' a wagon road follows the valley of the North Fork as far as section 11, township 12, range 3. Another wagon road branches from this road at the mouth of the northwest branch and follows the valley of this stream as far as section 9, township 12, range 4, at which point the deserted camp of the Great West Coal company is situated. There are numerous old Indian pack-trails following up the valley of almost every creek but they are only passable for an Indian and require to be cut out if they are to be used to any extent.

The general direction of all the ridges is north and south coinciding with the strike of the rocks. The tops of the ridges are usually bare rock of either grey or black shale, or a hard cherty conglomerate. The Livingstone range is an exception to this rule consisting of limestone or grey shale with limestone greatly in predominance. There is a large amount of coal in the hills, it being found immediately beneath the conglomerate. The dip of the rocks is towards the west and varies from 30 to 60 degrees. Outcrops of coal may be seen at the tops of most of the hills.

No doubt in the near future these coal areas will be made accessible by a railway.

The fall in the rivers I have estimated to be about fifty feet to the mile. Such a fall as this, combined with the nature of the country affords an unexcelled opportunity for the development of water-power.

The work in township 11, range 4, was complete and work in township 12 in the same range was commenced. This was proceeded with until the end of October when I considered it advisable to bring in the party and start on miscellaneous correction surveys in Saskatchewan. The party was paid off in Pincher Creek on November 1.

After surveying the east boundaries of sections 29 and 32, township 13, range 2, west of the fifth meridian, I and my assistant took the train for Swift Current, Saskatchewan on November 11.

Work was commenced in township 16, range 13, west of the third meridian on November 14. I retraced the east boundaries of sections 3, 10, 15, 22, 27 and 34 and the north boundaries of sections 10 and 11 and reported that a resurvey of the entire township would be advisable.

I left Swift Current on November 19 for Froude and arrived there on the 21st. I drove to township 7, range 10, west of the second meridian and after chaining twelve miles of meridians, I reported that a resurvey of the entire township was necessary. On November 24, I left Froude and took the train for Zealandia arriving there on the following day. I drove to township 28, range 12, west of the third meridian and completed the subdivision of this township, establishing a new northerly boundary of Lake No. 1.

I left Zealandia for Quinton on December 1, arriving there the following day and drove to township 27, range 17, west of the second meridian to investigate the boundary of Mission lake in ranges 17 and 18. I found that the boundary was not shown correctly on the township map and I made a traverse of this lake. I returned to Quinton on December 7, and as the ground was covered with snow to a depth of eighteen inches I did not consider it advisable to continue work. I accordingly disbanded the party and left for home arriving at Galt on December 10.

## APPENDIX No. 47.

### ABSTRACT OF THE REPORT OF H. W. SELBY, D.L.S.

MISCELLANEOUS SURVEYS AT ATHABASKA LANDING AND McMURRAY.

The subdivision of lots at Athabaska Landing was completed on May 12. The surface of the part subdivided was timbered and the survey required more cutting than I had anticipated. The land is rough and stony, and the soil sandy and gravelly so that nothing but vegetables could be grown on it.

The weather during the survey was fine but bush fires in the vicinity rendered the atmosphere so smoky that it was difficult to secure an observation for azimuth.

On May 21, I left Athabaska Landing for McMurray where I made some settlement surveys. My party had gone on, May 16, by the regular Hudson's Bay company's transport, but I was detained by illness until the next transport left on May 21. I reached McMurray on June 8 and my assistant, who with the party arrived a few days before, had established camp and traversed a part of the shores of Athabaska and McMurray rivers. He had plotted the information gained so that when the Minister of the Interior arrived on the 9th the plan was of very material assistance in determining what surveys were to be performed.

The old Hudson's Bay company's fort, now abandoned except for a short period in winter, is picturesquely situated on a bench overlooking Athabaska river towards the north, and at the base of a range of hills 200 feet high. These hills are composed mainly of a substance known as tar sands overlying limestone and covered by a thick layer of clay soil. The surface is heavily covered with poplar and scattered spruce with much underbrush and vegetation. The flat on which the fort is situated extends southeasterly from the main river along the foot of the hills above described for a distance of two miles, where it is cut by Hanging Horse creek and McMurray river. It has a width of about three-quarters of a mile. The greater part is covered with a thick growth of poplar and willow, but there are several prairie openings caused no doubt by fire cleaning up the land from which the timber for the use of the fort and other houses which have been occupied from time to time had been cut. It is only some twenty years since the Hudson's Bay company began bringing their supplies for the north from Edmonton and down the Athabaska river. Formerly these were brought down from Winnipeg via the Saskatchewan and McMurray rivers. One can imagine that the large number of boats needed to carry these supplies in one trip over the many portages met with by that route, would require also a large crew of men, who, having reached the end of their troubles, would probably camp at McMurray, resting for several days, before starting on their long return trip up stream perhaps leaving large camp fires to spread. This, I say, going on for many years might account for the prairie openings found here and on the island but nowhere else for many miles around. Athabaska and McMurray rivers have cut a channel which leaves an island between the main branch of Athabaska river and the confluence of the other branch with the McMurray, and this channel, through which at high stages of water part of McMurray river discharges, forms the easterly boundary of this flat. Very little attempt has been made to grow any grain except in the vicinity of the fort and on the island. Wheat, oats and barley, besides all kinds of vegetables have been grown on the island, for at least thirty five years, and, I am told, without being damaged by frost. Upon this flat of land I found seventeen squatters. Having laid down on paper the area claimed by these squatters, I divided it into twenty-four lots and apportioned to each squatter his improvements and as much of the land as the lot lines would permit without encroaching upon the improvements of his neighbour. With the exception of about half a dozen who have been living here for some years and have habitable houses, and fenced gardens, these squatters have made very little attempt to improve their land. I think, probably, the cause for this was that until a survey was made, no one wished to improve a piece of ground he was not likely to get. Since the survey was made two have begun breaking and several are arranging to build better houses, and are sending for horses and implements to make improvements with. There is very little use for much grain growing until railroad transportation is established. As the quantity required is at present so small one ten-acre field would supply more than could be disposed of. It may be thought that the finding of petroleum, the mining of salt, tar sands, limestone and coal ,together with the prospect of iron and copper in the vicinity, would encourage the development of the agricultural areas. This no doubt would be the case, but there is not the least chance for any of those industries being carried on until the facilities for importing machinery and supplies and exporting the minerals are improved to a great extent.

There is another feature that will influence the settlement of the country and that is the enormous areas of pulp-wood which are tributary to Athabaska river and which cannot be taken up-stream. This would be manufactured at some point either here or farther down the river where power could be readily developed. East of the mouth of Hanging Stone creek, along the banks of McMurray river, there is a flat from half a mile to a mile wide, heavily timbered with poplar and spruce,

At the request of those occupying lands on the base line, I laid out a road ninety-nine feet wide through the settlement which they desired in anticipation of the building up of a town of some importance should a railway be built into the settlement.

## APPENDIX No. 48.

### ABSTRACT OF THE REPORT OF D. A. SMITH, D.L.S.

SURVEYS IN THE RAILWAY BELT, BRITISH COLUMBIA.

We left Kamloops on May 29, 1910, and reached our first work which was in township 25, range 8, west of the sixth meridian, on the 31st.

The land surveyed in this district all lies within a few miles of Shuswap lake and is easily reached by boat from Sicamous. Launches and steamers run on Shuswap lake and will land passengers or freight wherever desired. Violent and sudden storms, however, render travelling by small craft dangerous.

Hunakwa lake is reached by portage from the head of Anstey Arm. The portage is about a mile long with good firm ground and very little climbing. In high water a small boat may be taken up Hunakwa creek but during the time of survey June, there was not enough water to float an empty canoe.

The survey was commenced from the northeast corner of section 27, township 25, range 8, a point established by Mr. J. E. Ross, D.L.S., and was carried by triangulation across to the east side of Seymour Arm, where all the work lay. From Seymour Arm the survey was carried as far east as was expedient and the remainder of the work in that district was completed from Anstey Arm and Hunakwa lake.

During the early part of the work and from the latter part of September to the middle of November, when we left Shuswap lake, there was scarcely a day without rain and frequently the rain lasted all day. The thick underbrush was always wet so that it was almost as disagreeable on a fine day as on a rainy one. During July, August and the early part of September, the weather was exceptionally good. Considerable time was necessarily lost in going to and from work, since much of the land surveyed lay at some distance from the shore, and owing to the rugged nature of the country it was a slow and difficult undertaking to pack a camp outfit to a convenient place.

The land rises generally from the shore of Shuswap lake from two to eight hundred feet, with steep rocky slopes of which very little is suited for agriculture. Back of this there is generally a gently rolling bench or series of benches extending to the foot of the mountains. At the north end of Anstey Arm is a level tract of land about a mile in width extending to Hunakwa lake; this lake is about three miles long and half a mile wide. There are numerous small creeks, Anstey creek being the largest. During high water it may be used for bringing down logs, and from its rapids and falls considerable power might be developed.

By far the most valuable of the resources is the lumber though much of this part has been swept by fires in recent years. Most of the valuable timber has already been disposed of, and, outside of the timber berths, the good timber is scattered and difficult to get out. No minerals of value have been discovered, but the country has not been thoroughly prospected. Fish are plentiful but they are more of a sporting than a financial asset. Game is scarce, a bear, a deer and a few grouse being all that were seen in the district though signs of bears and deer were frequently noticed.

So far no attempts at cultivation have been made with the exception of small gardens, indifferently cared for, but the results, considering the work done, were promising. A few miles to the north, the common varieties of garden produce have been tried with excellent results. At the head of Seymour Arm a large tract of land is being planted with fruit trees, but what success will attend this industry remains to be seen. Early frosts especially on the higher levels, is the greatest danger that threatens them. Irrigation is not considered necessary, and, judging from the past season, the rainfall is sufficient for all purposes. Small wild fruit grows abundantly wherever a chance is afforded and there is no doubt that all small fruits would yield well. The swamp land can be drained and used for grain, hay and garden produce.

The quality of the land is very variable. There is a great deal of land in the territory surveyed that is useless from an agricultural standpoint largely on account of the rock and steep slopes, but it was necessary to survey it to take in what was good. The prevailing soil is a sandy loam with a gravel or gravelly loam subsoil. The swamps are generally of rich black loam, at present wet but easily drained.

On the completion of the work in the Shuswap district I moved to township 25, range 20, west of the fifth meridian about fifteen miles southeast from Golden. This part is easily reached by a wagon road following up the Columbia valley from Golden to Fort Steele. The Kootenay Central railway is graded out about fifteen miles from Golden but only about a mile of track has been laid yet.

During the time we were working in this district, the trees were heavily laden with snow. This, with from one to two feet of snow on the ground made fair progress impossible. Most of the work lay on the bench land where there is a thick growth of trees, the more open land in the bottom having been previously surveyed. The snow in the bottom was about six or seven inches deep.

The land rises from the river-flat with a very gentle slope which extends back varying distances to the foot of the steep slope leading to the upper bench land. Most of this lower land is good and has already been taken up. The upper bench extends in a gentle slope or a series of benches to the steep rocky sides of the mountains. The steep slope leading from the lower to the upper bench land is useless for agricultural purposes. So far as soil is concerned much of the upper land is good. It is generally clay loam, sometimes with sandy or gravelly subsoil, and is suitable for grain or fruit.

In this township, there is some good timber, chiefly fir, but here as in the Shuswap district the best has been disposed of and what remains is very difficult to get out. No mineral discoveries have been made, at least no mines are at present being worked.

The township is intersected by numerous small creeks some of which are being used to irrigate the lower land and small areas of the upper land. Irrigation will have to depend almost entirely on the rainfall which I believe is not sufficient for requirements.

In the settled parts, a number of apple trees have been planted, but have not given satisfactory results, many of them having died. The apples that I saw, which were grown in the district, were small but of good quality. It is doubtful if the upper benches will be suitable for fruit owing to the early frosts. Small fruits of all kinds give very large returns and are easily grown. From experience it would seem that on these, rather than on apples, the settlers will have to depend. Alfalfa has been grown and yields well.

Game is scarce, nothing but grouse being seen, though brown bears and grizzlies, deer, sheep and goats are reported to be fairly plentiful on the higher lands. Nearly all fur-bearing animals are becoming scarce in the railway belt.

## APPENDIX No. 49.

### ABSTRACT OF THE REPORT OF L. D. N. STEWART, D.L.S.

SURVEYS IN THE KAMLOOPS DISTRICT IN THE RAILWAY BELT, BRITISH COLUMBIA.

After organizing my party at Kamloops we left on May 27 for township 23, range 9, west of the sixth meridian on the north shore of Shuswap lake. The land in this township rises somewhat abruptly from the lake except at the mouth of Ross creek where there is a flat of seven or eight hundred acres in sections 17 and 18.

The land in townships 22 and 23, ranges 9 and 10, where I worked is well adapted to fruit growing and mixed farming, being a sandy loam with a clay and gravelly subsoil. Several settlers are located on this part of the lake and some have orchards bearing fruit equal in quality to that of the Okanagan district. The climate is excellent being very similar to that of the Niagara peninsula of Ontario. There is plenty of rain in June; August and September are dry, while October, November and December are wet. There was a slight frost one night about the middle of August but this is unusual.

The water is excellent in both Shuswap lake and the tributaries, but the small streams usually become dry in August.

Shuswap lake abounds with fish of several varieties, the principal being grey, rainbow, dolly-varden and silver trout, while in autumn the salmon run up from the sea, frequently in immense quantities. Brook-trout are found in Ross creek.

Grouse are plentiful in the district and wild ducks are found on Shuswap lake in the fall. Black-tailed deer are plentiful and caribou are found on the higher elevations.

Shuswap lake seldom freezes over and steamers run all winter. During the winter of 1910-11 there was a tri-weekly service from Sicamous to the head of Seymour arm.

There is a wagon road from Notch Hill to Archie Redman's on section 30, township 22, range 10, which could be continued at a small cost around the south shore of the lake. There is also a wagon road on the north side of the lake extending the greater part of the way across township 23, range 10.

The land around the lake is well timbered, but in some places it has been more or less cut for lumber purposes, and there are frequent evidences of forest fires. In these cases thick second-growth is springing up.

## APPENDIX No. 50.

### ABSTRACT OF THE REPORT OF P. B. STREET, D.L.S.

SURVEYS IN THE RAILWAY BELT, BRITISH COLUMBIA.

On June 12, we left Sicamous Junction up Shuswap lake to Cinnemousun narrows through which we passed and proceeded northerly up Seymour arm. This lake is very treacherous and dangerous as it is subject to sudden and violent storms. The country at the head of Seymour arm is rather rough and for the most part covered with timber. Township 26, range 7, west of the sixth meridian, in which my first work was situated, is made fractional by the boundary line of the railway belt which divides the Dominion and Provincial lands. Practically all this township lies on the east side of Seymour arm. The surface is broken by a series of ridges and valleys running northerly and southerly for the most part, the mountain range to the east also following a northerly and southerly direction. The northerly portion of Hunakwa lake lies in section 4 of this township; this lake is fed by creeks to the north and east, and empties into Anstey arm to the south. A well-cut pack-trail runs southwesterly from the head of Seymour arm to Hunakwa lake. Along the lake shore the timber is fairly open and easy to walk through, but farther back there is a great deal of second-growth cedar and hemlock, which is so dense in places that it is almost impossible to force a passage. The greater part of the south half of this township is rather dry and stony, but irrigation might be successful as two lakes of considerable depth occur in sections 5 and 6. The best timber in this township has long since been logged off or burned, the only timber of any value being some cedar in the southeast quarter of section 17, and a very few scattered white pine and fir in the other sections. Very little marsh or hay land is found in this township, but a small patch in section 16 and another patch in section 21 produce some slough hay of fair value.

None of the settlers in this township have been there long enough to have fruit trees which are producing, but the trees that I saw seemed to be doing well. There are patches of nearly level land varying from five to fifty acres which would be suitable for fruit farming, especially small fruits, and if irrigation can be resorted to, probably fifty per cent of this township can be successfully cultivated. The soil varies from a light sandy loam on the ridges to a heavy clay on some of the flat lands, but this clay does not occur extensively. One settler in section 16 showed me some good vegetables grown without irrigation. In sections 7 and 8, where there was once a logging camp, timothy and clover were growing most luxuriantly, which suggests that the ridges unsuitable for fruit or root crops might make very good pasture.

Rain fell freely during June and July, but August was rather dry and very warm. The lake rises until the first week of July and then commences to fall, the water falling rapidly in August. No minerals were found in this township, although small pieces of rock containing good mica samples can be found almost everywhere. About twelve miles north of here there are a great number of claims staked out, and some very good samples of silver and lead ores are brought down every week. The old pack-trail to the 'Big Bend' country starts at the head of this arm and the provincial government are building another road up to the mining claims.

There seems to be no game in this district, as none of our party saw any grouse, ducks, rabbits or larger game during the ten weeks we were in the district. Some very good trout can be caught at certain seasons of the year, and the annual salmon run provides the settlers with their winter supply of fish, the salmon being easily speared in the shallow water, and either salted or smoked for future use.

On completing this work I moved across the arm into township 26, range 8. The Arrow Lakes Lumber company have their offices and supply post here on Celista creek, and have four camps up the creek. This township is also fractional and is still partly held under timber berth. Some excellent land is found here, and Celista creek would make irrigation very easy. In section 2 there is land almost entirely cleared, consisting of good rich clay loam. There is considerable timber left in this township yet, but it is mostly hemlock. Some birch, for which there was a good demand last summer, when cut into cord-wood, grows on the ridges. The Arrow Lakes Lumber company have a large stern-wheel steamer which makes occasional trips up to this camp, and which will carry and deliver any freight for the settlers. The Fruitlands company are going to build a small steamer to run from Sicamous Junction to their property, for the benefit of the settlers. This company built a hotel and a store and succeeded in getting a post-office, 'Seymour Arm,' started this summer. They have about twenty settlers on the lands now. Considerable water-power could be developed along Celista creek, there being a series of falls just inside the railway belt. There is also considerable water-power on Seymour river, but this will probably be utilized when mining operations begin. On completing the work here I received instructions to proceed with the survey of agricultural lands in township 22, range 1, west of the sixth meridian and accordingly moved my party to Revelstoke. I sent my assistant, who had arrived just before the completion of the work on the lake, down to Greenslide with the party and outfit, and took my rowboat and a load of provisions down Columbia river to the camp at the foot of the slide.

The surface in this locality is much more rugged than in Shuswap, there being less bottom-lands and the bench lands being much more sloping. Practically all the best farming lands in this district are held by timber berth leases and immediate settlement is prevented. There are plenty of large fir on the bench lands here and less hemlock than on the lake, but the most valuable and accessible patches of timber are under timber berth licenses. The south half of this township is very rocky on the east side of the river, and is useless for agricultural purposes. The soil in this district is mostly clay loam, and the settlers are getting exceedingly good results. Some hay lands occur along the river, but the floods deposit so much mud on the hay that I am told it is next to useless. I think that this district is best suited to raising small fruits as these require little moisture after July. We noticed some grouse, rabbits, ducks and a great many signs of black bears in the district, while goats, caribou, deer and grizzly bears were found above the snow-line.

Lumbering is the chief industry, there being a large mill at Arrowhead, and many camps at various points on the river and on the Arrow lakes.

A wagon road is being built from Revelstoke, and during the present year was completed to the north boundary of this township. The Arrowhead branch of the Canadian Pacific railway also gives ready access to this district.

On completing the work here, I moved into township 24, range 2, west of the sixth meridian, to survey some legal subdivisions which are withdrawn from timber berths. As this township adjoins the town of Revelstoke, the lands here are decidedly valuable, and although the available farming land is limited in extent the soil is very rich, and the land is practically all logged off, making clearing very easy. Settlers in this district are making money hauling cord-wood to Revelstoke. A good wagon road runs through this township. I left Revelstoke on November 3 and moved to Golden. Fearing early snows I decided to survey the higher lands first, leaving the flats till later and accordingly placed my camp on Hospital creek, about three miles by road from Golden.

The country in this district is more easily accessible than the valley south or north of Revelstoke, wagons being used almost entirely. There are more bottom-lands and considerably more bench lands here than in the lower Columbia valley, and as most of these benches are lightly timbered, they are very easily cleared. The land being much less rolling, such crops as fall wheat are raised and yield good results. The uplands, over 3,500 feet above sea-level, are frequently found covered with hay which makes fair pasture. Small fruits do well here but up to the present no fruit trees have proved a success, the trees all beginning to bear profusely in the second or third year and succumbing early. Root crops, however, do well.

The Columbia River Lumber company have a large mill at Golden which is at present supplying the town with electric power and lighting. This company own large limits in this district and furnish employment to hundreds of men.

The Kootenay Central railway, which is to run from Golden to Cranbrook, is being pushed rapidly to completion, and will open a large and fertile country to the south.

As in Revelstoke, fuel is rather expensive, and the settlers were making money this fall selling cord-wood, some of which was cut within a mile of the town. A great many logs have been taken out by settlers in this township, and a great deal of cord-wood has been cut under permit. This has removed the bulk of the large trees, and in many cases clearing would be easy, the second growth being mostly poplar, birch and jackpine.

## APPENDIX No. 51.

### ABSTRACT OF THE REPORT OF J. N. WALLACE, D.L.S.

#### SURVEY OF PART OF THE FOURTH MERIDIAN.

During the season of 1909 the fourth meridian was surveyed as far as the twenty-first base line, at the north of township 80. This last season it was continued to the middle of township 95, being a further distance of eighty-seven miles.

I had sent a large quantity of supplies from Edmonton, expecting to be able to get them up to township 80 on sleighs, but as a road had to be cut out, and the spring opened up nearly a month earlier than in 1909, the result was that these supplies had only reached township 71, when the snow suddenly went off, and they had to be cached there. Subsequently they had to be taken north on packhorses, and during the season I had to pack everything from township 71 until the line reached McMurray (formerly Clearwater) river in township 89, a distance of one hundred and eight miles in a straight line, and about one hundred and fifty miles by pack-trail.

In order to carry the survey north of McMurray river, it was necessary to find some means of transportation other than by pack-trail along the meridian from Cold lake, and two routes presented themselves. One of these was to follow the old route from Prince Albert, by way of Isle a la Crosse and Methye portage, to McMurray river. The other was to send freight in scows down Athabaska river to McMurray and from there up McMurray river.

By the Prince Albert route freight can go by railway one hundred miles northwest to Big river. From there it must go to Isle a la Crosse by sleighs in winter, then to the north end of Buffalo lake by steamer, and from there to the head of Methye lake by canoes. From what I know of the difficulty of getting freight from the north end of Buffalo lake to the crossing of the meridian on McMurray river I do not think this route would be satisfactory.

By the Athabaska route there is no great difficulty in getting freight to the Cascade rapids on McMurray river. There are no rapids between McMurray and this point, which is only twelve miles west of where the meridian crosses McMurray river.

For the next eight miles above Cascade rapids there are many other rapids. There are fairly good portages past them all, and in former years these were utilized, and freight went right up to the end of the wagon road leading from McMurray river to Methye lake, then down this wagon road and so to Prince Albert. However, when freight has to ultimately go only as far as the fourth meridian which crosses the river about twelve miles above the Cascades, and only three miles above the last of the other rapids, it does not pay to take it over these portages and use the short stretches of navigable water intervening between them. It is much better to have freight taken in scows to the Cascades, and from there on to the meridian by packhorses or sleighs.

Before leaving Edmonton in April to commence work on the survey of the meridian I ordered a large amount of camp supplies and oats. These together with some sleighs and harness and a number of survey posts were to be sent to Athabaska Landing, and from there to be taken on contract to Cascade rapids on McMurray river, or farther up the river, as circumstances would permit. The total weight of all was fourteen tons, and the rate was six dollars from the Landing to the Cascades. One of my survey party went with this freight as it is necessary to send some representative to see that proper care is taken of it, and moreover a house had to be built at the Cascades to hold the goods. There was practically nothing lost on the way, and the whole came through in good condition in face of the numerous small difficulties which are of such common occurrence in northern transportation. A very substantial house, capable of holding the entire load, was built on the north side of McMurray river at Cascade rapids, and this house should prove of value for several years.

On April 21, the party left Edmonton for Onion lake, and I followed next day. From Onion lake we proceeded to Cold lake, and then travelled northerly around the west shore of Cold lake, and Primrose lake to the intersection of the fourth meridian. So far we had used hired teams with wagons, but north of here we had only the pack-trail cut out during the season of 1909. Mr. Christie, D.L.S., has however this last season cut out a wagon road for some eight miles farther north ending at the north-east corner of township 68, range 1. Half of my packhorses were at the time engaged in picking up the supplies which had been left in township 71, so I could not take on all the party at once north of Primrose lake. This delayed the arrival of the whole party at Calder river so that we could not leave this river till May 23, when I had the full outfit of horses.

After five more days travelling north along last season's pack-trail we reached the north of township 79. From here a new trail was cut out, the old trail having been made in the end of the season of 1909, when the ground was frozen and it was not therefore fit for summer use. This new trail had to be cut almost due west for about five miles to avoid swampy land and then it turns north along the east side of Landels river to the junction of Graham creek. From there it runs northeasterly to a point about a mile west of the northeast corner of township 80, range 1, which was the nearest we could get to our starting-point, the survey having ended in 1909 at the north of this township. This involved cutting out altogether about eighteen miles of new trail.

Work was commenced on the meridian at the north of township 80, on June 2. Even here at the commencement of the season every pound of outfit and supplies had been packed on horses a distance of sixty-five miles from the cache where it had been left when the snow melted.

By July 1, seventeen miles of meridian had been run north but the great distance which supplies had to be packed proved a serious hindrance especially as the season became very wet after the middle of June. It was very dry farther south, but with us the country was flooded for weeks at a time.

The meridian reached the south shore of Garson lake on July 10; it runs almost across the middle of the lake, the distance being very nearly six miles.

The following is a general description of the country to this point, commencing at the north of township 80. For the first couple of miles the land is undulating, generally burnt over with much swamp area and many small lakes. After this it rises, and the timber is heavier. The land to the east is hilly with a generally hard and in places rocky surface. There is a general growth of large poplar on the high land, and small spruce grows thickly on the lower land. Newby creek, a stream twelve feet wide and four feet deep flows west across section 12, township 82. It is a tributary to Landels river, which it joins about twelve miles west. On both sides of this stream the country is composed of ridges of jackpine. There is hardly any grass along the creek the valley being very narrow and rising almost at the edge of the creek. For the remainder of township 82, the land is high and rolling, becoming more level towards the north where the line runs through small spruce partly burnt, with scattered patches of poplar. Jackpine is not so common as it is to the south. The soil in the spruce lands is the best, while the higher lands are composed of a surface soil of a few inches of black loam overlying a somewhat hard white clay with a few small boulders. This is the usual type of soil where large poplar occurs. This class of country continues to Kimowin creek, which crosses the line in section 24, township 83. There is some good land to the west of the meridian.

For about half a mile north of Kimowin creek the land is dry and carries some large poplar and pine. It then becomes very swampy for about four miles, the line crossing a small lake, called Formby lake, which is surrounded by bog land. The northeast corner of township 83 falls in this lake, which drains westerly by a stream flowing to Landels river. Its surface is at an elevation of 1,670 feet, this being the lowest elevation met with on the meridian between Cold lake and McMurray valley. The district is exceptionally swampy with much flooded slough land, bog land and tamarack swamp.

About two and a half miles farther north the meridian intersects the south shore of Garson lake, the last mile before reaching this lake being through a high dry country covered with large poplar. It crosses the lake a little to the east of its centre, the distance along the line over the water being almost six miles. The intersection of the twenty-second base line occurs in the middle of the lake. From this point it is about three miles to the east shore and about five miles to the west shore. Measured along the meridian it is two and a quarter miles from this intersection of the base line to the north shore of the lake.

Garson lake is about ten miles long, running in a northeast and southwest direction, and about six miles wide. It contains about forty square miles. The lake is shallow, and, as the locality is very much exposed to the wind, the surface is seldom calm, consequently the water is generally very muddy from the fine sand which forms the bed of the lake.

Except on the southeasterly part the shores are low and very swampy, being almost surrounded by a belt of tamarack and spruce swamp half a mile in width. Along the southerly half of the east side of the lake, and for some distance around the south, the land is high and dry. There is a small Indian village consisting of seven or eight houses and a floating Indian population of about forty persons who remain there on account of the whitefish in the lake. Potatoes and other vegetables are grown here by the Indians and do well, as the soil is somewhat sandy. The village is situated at an elevation of about thirty feet above the lake in a small open area. There is no other open land near the lake, but there is a considerable area around the southeast of the lake which is only lightly covered with small poplar, and there is good feed for horses.

From Garson lake two routes can be travelled to the Hudson Bay post at Methye portage. The most direct runs a little north of northeast and is about eighteen miles in length. It is a purely winter road and while well opened out for one-horse sleighs it is quite unfit for travelling with horses in summer, as it runs through continuous swamp land. The second route takes a long detour to the south, and is about twenty-eight miles long. Packhorses can travel by this trail in summer, but if carrying a load there are breaks near both ends where canoes must be used. For freight going from the Hudson Bay post to Garson lake the only way is to have it taken in canoes down the west side of Methye lake for a distance of about two miles, and then across a small portage for a hundred yards into another small lake. At the south end of this lake the load is picked up by packhorses and taken southerly. A load cannot be taken directly from the post on horses as the trail down the south shore is too swampy and a deep inlet has to be crossed. From the south end of the small lake the trail runs southerly for about a mile along the lake, and then for about six miles southwesterly. A sharp turn to the west is made here and a new branch trail running westerly is used. After about thirteen miles on this new trail, which runs through dry poplar and pine country, the crossing of Garson river is reached. The last half mile to the river is through a very bad tamarack swamp. The load is taken from the horses at the river and sent about three miles up this river in canoes to Garson lake.

Garson river is here a very slow deep stream, about fifty feet wide, with a belt of slough land extending on each side from fifty to three hundred feet. The river leaves the lake about three-quarters of a mile north of the Indian village.

From the foregoing it will appear that, although on the map it may look as though Methye portage would be a good basis for supplies for the survey of the twenty-second base line west of the fourth meridian, it is really practically useless for this purpose unless freight is sent across to the Indian village at Garson lake in winter.

A route which might be feasible for summer is the following: Freight from Buffalo lake could be left at a small settlement on the west shore of Methye lake about five miles south of the Hudson Bay post. From here it could be taken by teams a few miles southwesterly across a portage to Garson river, and then sent up this river in boats to Garson lake. This river is navigable for boats.

On the whole, however, I think the best way to get freight to this base line would be by McMurray river, a trail being cut southerly to intersect the base line some miles west of Garson lake. The immediate neighbourhood of the meridian should be avoided for at least the southerly twelve miles, as it is very swampy.

By July 22, all the camp had been moved across Garson lake and the meridian was surveyed up to the north of township 85.

We had much trouble getting the outfit to the north of Garson lake, owing to the swampy nature of the country around the northeast. The horses could barely get around without any load, and we had only one small boat and a couple of birch-bark canoes, the latter only able to carry a man and about two hundred and fifty pounds of freight. A small stream, called Pennel creek, flows into the north of the lake, its outlet being a few hundred yards east of the fourth meridian. We used it for transportation for about two miles up from the lake, and this got us over the worst of the swampy area.

North of Garson lake the meridian runs through much swampy land, the country rising slowly. The timber is small pine, spruce and tamarack, and the surface all moss covered. Just north of township 85, we encountered another lake with very swampy shores around which we could send the horses without loads only, and had to make a raft to carry the outfit across. There has been so much rain that the shore of this small lake was flooded for over a quarter of a mile inland, and the ground was so soft and boggy that a man would sink in it to his middle, although the water was so shallow that we had trouble in getting a raft to float over the reeds.

Although this lake is connected by a creek flowing from its southerly end to Garson lake, and there is a fall of over forty feet between the two lakes in a distance of four miles, yet for several weeks the stream could not carry off the water quickly enough to cope with the flood. North of this lake for about two miles the country is swampy and partly burnt over. The land then rises and much poplar country is met with in the north of township 86. Through township 87, the country is generally dry and rolling along the meridian, and westerly from it. There is much poplar country and some good land out towards Gipsy lake, the east shore of which is about eight miles west of the meridian. East of the meridian there is, however, much swamp land, an extensive area extending out to Methye lake, and there are many small lakes in the district.

The west end of a very large swamp is crossed in sections 1, 12 and 13, in township 88, the swamp extending for two miles and a half along the meridian, and easterly as far as the road from Methye lake to McMurray river, widening as it goes to the east. The intersection of the twenty-third base line occurs about a quarter of a mile before the sudden descent to McMurray river begins.

On August 31, camp was moved to the south shore of McMurray river. The long haul of supplies from township 71 was over, and fifty miles of line had been run under greater difficulties than I, at least, had ever before encountered.

The valley of McMurray river, where it is crossed by the meridian, is badly broken by ravines on both sides. The horizontal distance between the edge of the high land on the south and on the north sides of the river is nearly three and a half miles. The valley is somewhat wider here than elsewhere in the neighbourhood, as a long tributary valley, running northwest, cuts up the land on the north side of the valley. The depth of the valley from the high land to the water of McMurray river is six hundred feet on the south side, and eight hundred feet on the north side, and there is very little level land near the river. The elevation of the edge of the high land on the south side of the valley is 1,750 feet, and that of the river is 1,145 feet, a total fall of 605 feet in a mile and a quarter, much the greater part of this occurring in the first half mile from the top. The descent is very rough and broken by ravines. The lands are all thickly timbered with poplar and spruce of large size. Within ten miles of the meridian on either side there are only two small open spaces. Both of these are on the south side of the river. One is at the end of the portage road from Methye lake. It has an area of about thirty acres. The other is about a mile west of the crossing of the meridian, and contains about seventy acres. Much of the latter is very wet from springs.

There are many areas of good soil in the valley but it is all very thickly timbered. Spruce and poplar up to two feet diameter are common, and there is a large amount of birch up to eight or ten inches. There are many areas of timber of commercial value, especially farther down the river.

To the north of the river the land rises suddenly, attaining an elevation of 220 feet higher than the water in a little over a quarter of a mile. The northerly slope of the valley is very rough. The edge of the high land to the north has an elevation of 1,935 feet, being 790 feet above the river, although a local ridge some thirty feet higher is crossed before reaching the north edge.

McMurray river varies very much in width along its course. It averages about one hundred and twenty yards. The immediate bank of the river is from three to ten feet high. The bed of the river is usually a hard fine sand. The depth of water varied along its course from three to ten feet in the latter part of August. The season was an unusually rainy one and the water was high all summer. The water is very good, but not remarkably clear. The river is not too swift for a raft, but swift enough to make rafting a very slow means of crossing. It is much better to have a canoe. There are practically no open spaces along the river near the meridian, but enough grass occurs, scattered among the poplar, to feed packhorses for a short time. Horses cannot ford the river anywhere as they would have to swim at least half the width.

The nearest rapids to the meridian are Whitemud falls, which are about three miles west of the crossing of the meridian. The total fall here is probably between forty and fifty feet, and this should be valuable for water-power. To the east of the meridian there are no rapids for about seven miles. Above that it is reported that small rapids are so numerous as to render the river unsuitable for navigation.

By September 13, we had surveyed the meridian as far as the high land on the north side of the McMurray valley, after a very laborious time in getting across this very rough area. From here it runs across a country almost entirely timbered with jackpine. Small local depressions occur carrying spruce, but jackpine is much the commonest timber. There are very few swamps. An extensive area of swamp land occurs across the east of section 13, township 90, and the greater portion of the east of section 25 in the same township is also swamp.

Sutton creek crosses the meridian in section 25, township 90. It is a deep stream about fifteen feet wide, flowing west. The current is rapid, and the water is good.

North of Sutton creek there is very little swamp area, much the greater part of the district being composed of low rolling ridges with very sandy soil, while the timber is practically all jackpine. These ridges become small hills farther north, and wet land of any kind becomes extremely rare. The general elevation of the country is very high, averaging about eight hundred feet higher than McMurray river at the crossing of the meridian. These rolling hills and the general high elevation extend for at least ten miles on either side of the meridian, and fifty miles north of McMurray river. There must be a very large fall in the surface somewhere between the meridian and Athabaska river to the west, and ultimately a great drop in elevation in the north before Athabaska lake is reached.

All the streams crossing the meridian north of McMurray river flow westerly. For some reason many of them have an area of very wet land on either side. For a distance of a hundred yards or so on either side the land is so soft and wet and full of holes, that it is impossible to get horses up to the stream, without first making a roadway, and water cannot be obtained for camp purposes, without getting wet up to the knees. These borders of wet land are more like rough slough land than anything else. The streams flow in a depression, with a hard, dry ridge on either side, but the space intervening between the edge of the ridge, and the stream is nearly always boggy. It is not caused by flood water, for even in times of low water, the same conditions prevail. I think this wet border is due to springs coming out to the river, the rain water over the district having percolated down to a certain level through the sand, and then making its way underneath to the streams, instead of being discharged over the surface, into small tributary creeks, as is usually the case. One of the results is that it is very difficult for horses to get any grass, as there is little of it along the stream, and the ground is there too soft to support a horse.

On October 8, the meridian had reached the northeast corner of section 12, township 91. On this date I sent out thirteen of the horses with some of the party. The grass was practically all gone. We had been feeding oats since September 19, but the number of horses was too great to feed oats to them all. These horses were taken southerly along the meridian and after a difficult journey reached Cold lake, where they were left with the Hudson's Bay Co., and the men proceeded to Edmonton, arriving there on November 8.

I had ten horses left in camp, but as there was no snow we had to still use pack saddles, although such a small number of horses made packing a very slow means of transportation.

Through township 92, the land is generally rolling, becoming very hilly in the north half. The timber is nearly all pine, and the lands all dry, and generally very sandy. In the north half there are many small lakes in the hollows. These have hard dry shores and good water, although they have no streams either flowing into or out of them. In section 36, the meridian crosses a remarkable valley, the bottom of which is three-quarters of a mile wide, and one hundred and fifty feet below the land on either side, the descent being steep. The valley extends for about eight miles a little to the south of west where it joins a large valley running north and south. It also runs for some miles to the northeast of the crossing of the meridian. Viewed from the high land it appears as though it were the valley of a large river, but it only contains a very small creek flowing to the west through flat swampy land in the bottom. The valley is a purely local depression, the land on both sides being much higher for many miles, to the north and south. The general elevation of the country is about 2,000 feet, while that of the creek is 1,865 feet.

Fire has overrun the whole country north of McMurray valley in comparatively recent times. As far north as the middle of township 92, the last fire appears to have occurred about four years ago. These fires were very extensive owing to the absence of any large streams or swamps to stop their course.

This last fire was not strong enough to entirely burn up the timber and a small proportion of the trees still have green tops, although scorched lower down, and even those entirely killed have not had their branches or bark burnt off and have not yet fallen. These latter will make travelling difficult in the next few years, as they will soon blow down. Over this area a light growth of new pine, now about eight inches high, is coming up, but it looks feeble.

North of the middle of township 92, the last fire appears to have occurred about fifteen years ago, and there is now no standing burnt timber, but the ground is strewn with much small windfall. The new growth of pine is very dense through the north half of township 92, and through township 93. It is generally only about ten feet high, but looks strong and healthy. There are small isolated patches of unburnt living pine averaging about six inches in diameter, scattered irregularly over the district, these having for some reason escaped the general conflagration.

If the past history of the area north of McMurray valley is to be judged by the extreme scarcity of any timber over a few inches in diameter, either now living or dead, it is a history which does not augur well for the future chances of the new growth now coming up. The last growth is only eight feet high, and the previous growth was not given a chance to attain over a few inches in diameter. The same record of new growth coming up to replace the one destroyed by fire, only itself to be destroyed before it could reach maturity, has probably been going on for centuries. Fires have not only destroyed the timber but they have burnt off all the decayed vegetation which formed about the only source from which these sandy areas could have derived fertile soil.

It is too late now, even if fires were kept out, for soil to accumulate, but jackpine can grow on these sandy areas where apparently nothing else can grow, and if given a fair chance it will grow at least twelve inches in diameter.

While no doubt there are a few other causes of forest fires in the north, the main cause is a camp-fire left smouldering. The average traveller in that country knows enough to keep a fire under control when he is lighting and using it, but he does not know enough to see the necessity of extinguishing it when he is done with it. The cases where a man cannot extinguish a fire for want of water or for some other cause are very few. The cases where, when he is leaving, he looks back at the half extinguished fire, knows there is a risk, but deliberately chances it, are very common; and such cases are not due to laziness, but are often due to that fault of character, especially common in the Northwest, which thinks it a weakness to take precaution against a danger rather than to risk its occurring.

On November 10, the meridian had reached the north of section 13, township 94, a distance of thirty-one miles north of McMurray river. The snow had been sufficiently deep to use sleighs on November 5, but some of the swamps were not then sufficiently frozen to carry horses. On November 10, the horses were sent back to McMurray river to bring up the sleighs which had been sent down from Edmonton with the McMurray freight, and were now at Cascade rapids. The teams were delayed by the swamps not being sufficiently frozen, and did not get back to camp until November 26, by which time the meridian had been surveyed up to the north of township 94. From McMurray river we had throughout been cutting a sleigh road in addition to a pack-trail, and this road was now called into use. There is now a good sleigh road from the house at Cascade rapids on McMurray river to the north of section 13, township 95.

Through township 94 the country becomes very hilly. Jackpine is almost the only growth of any kind, and the soil is almost all pure fine sand with only half an inch of moss on the surface. The pine is generally very small, often only a few feet high, and does not grow thickly. Very little cutting is required even to make a wagon road, and the surface is all dry. There are numerous small lakes in the hollows, most of which have no streams flowing into or out of them, yet these lakes are all within a few feet of the same elevation although many miles apart.

Township 95 is much more thickly timbered but it is all jackpine. Areas covered with six-inch pine now become much more extensive than farther south, and the surface is more hilly than ever. A remarkably rough ridge, about two hundred feet high, and running for some miles to the east and west crosses the meridian in section 12. The elevation of its crossing is 2,098 feet.

The survey of the meridian was ended at the north boundary of section 12, township 95, at a distance of thirty-seven miles in a direct line north of McMurray river, but apparently the high general altitude, the hills and the jackpine, and the generally barren surface extend for many miles farther to the north.

## LEVELS.

The levels taken last season along the meridian were continued this season using the same basis of elevation throughout. According to this basis the elevation of the water in Primrose lake, at the time of commencing the levels (May, 1909) is taken as 2,100 feet above sea-level.

The same instrument was used, a fourteen-inch dumpy level. The elevations recorded are the surface of the ground at every quarter of a mile along the meridian, all streams and lakes crossed by the meridian, and the surface of the ground, at the transit stations. These last being placed always on the summits of the local ridges may be taken as indicating the higher elevations in the vicinity, while the levels on the streams and lakes indicate the lower elevations.

Bench-marks were left at intervals seldom exceeding half a mile, generally near a section or quarter section post, but if a prominent large rock occurred elsewhere along the line a bench-mark was always recorded on it.

The levels were checked throughout, usually in sections of a mile or a mile and a half, by a second independent line run in the opposite direction. The only exceptions to this rule of running a second line occur for two miles in township 88, where a very bad swamp was crossed by the method of double turning-points, and also when crossing part of McMurray valley where there is a fall of 600 feet on the south side and 800 feet on the north side, and the surface is very broken. This valley was levelled across once in the usual way, and the levels checked by the use of vertical angles with the transit.

At the point of commencement of this season's survey, that is at the north of township 80, the elevation is 1,860 feet, or 240 feet lower than Primrose lake. As the meridian goes north the elevation remains within a few feet of this for nearly three miles when the land begins to rise, and at a distance of four and a half miles from the commencement the line reaches an elevation of 1,961 feet. From here it descends rapidly for five miles to the crossing of Newby creek where the water level is 1,756 feet. This stream flows west in a narrow local valley about fifty feet deep joining Landels river about eleven miles west of the meridian.

After leaving the valley at Newby creek the land rises steadily to the north, attaining an elevation of 1,804 feet after two and a half miles. It then descends for three miles to Kimowin creek, which is crossed in the middle of section 24, township 83, and is at an elevation of 1,674 feet. There is then a slow rise for three miles, the elevation reaching 1,714 feet at the north of section 25, township 83, north of which occurs a rapid fall of 44 feet in three-quarters of a mile to Formby lake where the elevation is 1,670 feet. This is a very swampy region. The lake is at the lowest elevation encountered in the whole distance surveyed in two seasons from township 64 to township 95, except only the local deep valley of McMurray river.

The low elevation continues for two and a half miles north of the lake, after which the meridian crosses a local ridge at an elevation of 1,734 feet in the north of section 12, township 84, and about a mile south of Garson lake. The ridge referred to between Formby lake and Garson lake forms part of the divide between the watersheds of the Athabaska and Churchill rivers. Formby lake drains westerly to Landels river, while Garson lake drains northeasterly and ultimately to Churchill river. The elevation of Garson lake is 1,675 feet.

North of Garson lake, although the land rises steadily, it is very swampy for several miles. At a distance of three miles north of the lake a total rise of fifty-one feet has occurred after which there is a fall of nine feet to the surface of a small lake, called Raft lake. This lake empties into Garson lake by a small creek flowing southerly, but, although there is a gradual fall of over forty feet between the lakes, there is so much moss and vegetation along its course that the land all around Raft lake is very swampy for want of more speedy drainage than this creek can afford, even with such a great natural fall.

The land rises north of Raft lake but is still swampy until the north of section 13, township 86, is reached. Here the land rises more rapidly, reaching an elevation of 1,824 feet in section 25, township 86, being a total rise of 149 feet in sixteen miles from Garson lake. Between here and the edge of McMurray valley there are only minor irregularities, the general elevation being about 1,750 feet. A large tamarack swamp is crossed in sections 12 and 13, township 88, at an elevation of 1,736 feet. The swamp drains both to the east and the west.

About a quarter of a mile north of township 88, the edge of McMurray valley is reached at an elevation of 1,750 feet. The river is at an elevation of 1,145 feet, a fall of 605 feet, occurring on the south of the valley.

A bench-mark was established on the north bank of McMurray river. It consists of a large iron post driven to within ten inches of the top, and stands fifteen feet north of the water's edge and in the centre of the line. The letters "B.M." with a broad arrow are cut on the south side with a cold-chisel. The elevation of the top of the iron post is 1,150.13 feet. The broad arrow cut on its side is 0.26 feet lower. It may be well to repeat here that all elevations given along the meridian are referred to one basis, and that according to this basis the elevation of Primrose lake in township 64, is taken as 2,100 feet above sea-level.

The north edge of the valley of the river is at an elevation of 1,935 feet, a rise of 790 feet from the water, and this high general elevation continues for many miles to the north. In the south half of section 1, township 90, an altitude of 1,984 feet is reached. From here the elevation falls to the crossing of Sutton creek in section 25 township 90, where it is 1,747 feet, being the lowest elevation met with between McMurray river and the end of the survey in township 95. The ridges now become more like small hills and the elevation steadily rises reaching an altitude of 2,063 feet in the north of section 24, township 92, and an altitude of 2,096 feet in section 12, township 93.

North of township 93, the district is very hilly being composed entirely of rolling hills from 100 to 150 feet above the small valleys. Local high points along the meridian reach an altitude of 1,950 to 2,050 feet, the lowest points crossed being a small creek in section 36, township 93, at an elevation of 1,890 feet, and two small lakes in sections 1 and 25, township 94, both of which are at an altitude of 1,884 feet although four miles apart.

A remarkably high and very rough ridge is crossed by the meridian in section 12, township 95, the elevation at the crossing being 2,098 feet. There is then a sudden fall to the north of section 13, township 95, where the survey ends. North of here, however, the land rises again and maintains the same general high altitude.

The divide between the waters flowing to Hudson bay and the Arctic ocean follows the neighbourhood of the fourth meridian for over fifty miles, never going more than a few miles to either side of the line. In this distance the divide crosses the meridian five times. Its first crossing occurs in section 12, township 78, the elevation of the land here being about 2,000 feet. South of this the streams all flow easterly, and ultimately their water reaches Churchill river and Hudson bay. To the north of this place, for a distance of about twenty-eight miles, or as far as the north of township 82, the streams flow westerly across the meridian, all of them being tributary to McMurray river, which empties into Athabaska river at McMurray. The meridian then runs through an area extending five miles north and about five miles west, from which all the water flows east. Conditions are then reversed, the streams flowing westerly from an area extending five miles along the meridian and about three miles east. This reaches section 12, township 84, which is about a mile south of Garson lake, the elevation here being 1,730 feet.

The divide now passes around the south and west of Garson lake, including this lake and all its tributary creeks in the watershed of Churchill river. It then passes around the northwest of the lake, and crosses the meridian for the last time near the north of township 86, its exact location here being not very clearly defined. At this last crossing of the divide the elevation is 1,810 feet. It then runs northeasterly passing about half-way between the north end of Methye lake and McMurray river.

There are no well-marked topographical features along the course of the divide, and there is no apparent reason why it should occur where it does any more than in any other place.

The following are the elevations of some of the more noteworthy topographical features along the fourth meridian between township 80 and township 95.

| Feature. | Locality. | | | | Elevation. |
|---|---|---|---|---|---|
| Creek | Sec. | 1 | Township | 81 | 1859 |
| Creek | " | 13 | " | 81 | 1845 |
| Summit | " | 13 | " | 81 | 1889 |
| Depression | " | 24 | " | 81 | 1851 |
| Summit | " | 25 | " | 81 | 1961 |
| Newby creek | " | 12 | " | 82 | 1756 |
| Summit | " | 13 | " | 82 | 1804 |
| Creek | " | 24 | " | 82 | 1785 |
| Creek | " | 25 | " | 82 | 1717 |
| Summit | " | 1 | " | 83 | 1763 |
| Kimowin creek | " | 24 | " | 83 | 1674 |
| Summit | " | 25 | " | 83 | 1714 |
| Formby lake | " | 36 | " | 83 | 1670 |
| Summit | " | 12 | " | 84 | 1734 |
| Garson lake | " | 13 | " | 84 | 1675 |
| Raft lake | " | 1 | " | 86 | 1717 |
| Summit | " | 25 | " | 86 | 1824 |
| Creek | " | 25 | " | 87 | 1732 |
| Creek | " | 12 | " | 88 | 1731 |
| Summit of valley | " | 1 | " | 89 | 1753 |
| McMurray River | " | 12 | " | 89 | 1145 |
| B. M. on top of iron post 15 feet north of river | " | 12 | " | 89 | 1150 13 |
| Summit of valley north of McMurray river | " | 24 | " | 89 | 1935 |
| Summit | " | 1 | " | 90 | 1984 |
| Sutton creek | " | 25 | " | 90 | 1747 |
| Creek | " | 25 | " | 91 | 1826 |
| Summit | " | 36 | " | 91 | 1934 |
| Creek | " | 1 | " | 92 | 1819 |
| Summit | " | 13 | " | 92 | 1922 |
| Lake | " | 13 | " | 92 | 1878 |
| Summit | " | 24 | " | 92 | 2063 |
| Creek | " | 36 | " | 92 | 1865 |
| Summit | " | 1 | " | 93 | 2046 |
| Lake | " | 1 | " | 94 | 1884 |
| Summit | " | 13 | " | 94 | 1988 |
| Depression | " | 24 | " | 94 | 1887 |
| Summit | " | 25 | " | 94 | 2013 |
| Depression | " | 36 | " | 94 | 1881 |
| Summit of ridge | " | 12 | " | 95 | 2098 |

As many areas of swamp land occur along the line of the fourth meridian a few remarks on such areas may not be out of place. The swamps over this district are not individually extensive. They are nearly all formed by the surface water being unable to get an outlet through the local surrounding ridges, and not because the entire surface of the country is so level that the water cannot drain off in any direction. The standing water over many swamps will frequently be found to be many feet higher than the water in streams within a few hundred yards of them, some intervening ridge cutting off the outlet. Even in the case of an extensive swamp it will often occur that an outlet could be made with little labor at some place around its border, and so the water could drain off the whole swamp.

The general surface of the country is rolling, yet although locally there is ample fall to carry off the surface water there is no continuous connection from one level down to another, which would ultimately discharge the collected surface water into some stream, nor is there even a continuous fall from several different directions into the larger depressions, which would result in a few large lakes being formed, in place of the many local areas of half-flooded swamps, which now exist.

In uninhabited districts, where the contour of the surface is that originally formed by nature, the greater number of the local depressions are not connected, but form a series of basins. The water from rain and melted snow will run down into the lower levels, no matter how little they may be lower than the surrounding lands, so every depression carries more than its own share of surface water. The slowness of the evaporation in these northern latitudes is emphasized by the general growth of timber, which cuts off the sunshine, and also by the absorbent nature of the mossy surface. There is always some substratum, (it may be many feet below the surface), which prevents the water readily draining downwards. The result of all these conditions is that the water lies in these depressions for so long a period each year that the surface becomes soft, and swamps are formed in nearly every depression.

The same natural conditions of surface level occur in many countries, but the unconnected lower depressions will not become swampy without the additional conditions of abundance of rain, some impenetrable substratum, and some impediment to evaporation. It is the combination of all these conditions in the timbered lands of the north, which produces so many areas of swamp.

Not only are these swamps a perfectly natural result, and a result which should reasonably be expected to exist, but their value is altogether greater than is popularly supposed to be the case. In many of the areas over the north, the greater part of the surface of the country appears to have been originally composed of pure, fine yellow sand. This is especially the case where the country is covered with coniferous timber. There are many districts where a person may travel for days, and see only the same succession of jackpine, spruce, and tamarack with practically no other timber. Where poplar is found, the sandy conditions are not as a rule nearly so marked, and birch indicates hard stony soil, but in the coniferous areas, it will be found that fine sand occurs everywhere ,either coming up to the surface, as on the ridges of jackpine, or else existing immediately below the moss and black surface soil of the spruce areas in the lower lands. In such areas almost the only source of fertile soil has been the accumulation of decayed vegetation during past ages. This has been derived from the fallen needles of the pine and spruce trees, and from the growth of moss in the lower lands. Were it not for fires there would now be a great depth of such soil both on the higher and lower lands. But, on account of the prevalence of fire, land free from surface water has been burnt over again and again, with the result that surface conditions on the dry lands in such areas have changed but little from the time when the sand was first left there.

In the lower levels, the slow evaporation has kept the surface wet and has not only fostered the growth of vegetation, especially moss and lichens, but has tended to preserve these areas from fire. The much maligned spruce and tamarack swamps are really about the only features which have saved many large areas in the north from being almost entirely destitute of any available fertile soil.

Were these swamps so level that large expenditures would be necessary to drain them, no doubt it might be urged that, if the surface water has been the cause of preserving the soil, it has done so at the cost of making the soil now unavailable, but areas of swamp land so level as this are not common. The usual swamp has ample fall, even over its own apparently level surface, to allow the water to run off, if the surface were free of the obstruction of moss and sticks, or else it only needs a short outlet cut through some local elevation to drain itself naturally into some neighbouring stream.

Such areas must be drained before being available, but the mere cost of draining will not be great, and so long as the country is uninhabited, and fires continue to run, the want of drainage, whether caused by want of outlet, or by obstruction by the moss, is a blessing in disguise. It is that very surface water, which so many people think makes these swamp areas worthless, which has really been not only the origin, but the means of preserving the greater proportion of the available fertile soil over many large areas in the north.

The contention that in these sandy districts, a natural condition of surface contour which impedes drainage is better than a condition which lends itself to the speedy draining of the surface water into streams and lakes receives support in the conditions, which can be seen to-day, north of McMurray river. Here the land is so rolling that local undrained depressions are very rare, and swamps of a greater area than a few acres are almost unknown. The soil is nearly everywhere pure yellow sand, coming right up to the surface. The surface has been too sandy to allow the growth of vegetation without standing water, and no fertile soil has accumulated. The country has been too well drained. The area is timbered everywhere with small pine, but the fires have continually burned off the fallen needles, before they had time to decay, and there is now nothing left except a surface, which has only a few lichens growing over it.

Were it not for the general growth of jackpine (which appears to be the only thing which will grow in this area), there are many square miles here which would be composed of nothing but wind-swept hills of sand. Had this area been less rolling, and had there been more undrained depressions, which would have shut in the surface water, and have retained it, so as to form swamps, there would to-day be many acres which could be drained, and which would then afford fertile soil, instead of there being nothing now left but well-drained sandy hollows.

North of McMurray river, there are very few areas of swamp, while south of it swamps are common, and there can be no doubt whatever, that the district, which contains the swamps, is much more valuable than the other.

On November 28, the last day's work was done on the meridian, and next day, all the party were moved back southerly to a small lake crossed by the meridian in section 12, township 92 where a supply house had to be built. The sleighs were then sent to McMurray river, to bring up supplies. They reached camp on December 7. The house was by that time finished, and the remainder of the party moved to the river, reaching there on December 9. The sleighs then made a trip to the house at the Cascades, and brought up all the goods remaining there, and these were placed in a cache on the meridian, about two miles north of the north edge of McMurray valley, close to the northeast corner of section 25, township 89.

On December 13, a start was made for Methye portage, and it was reached on the 15th. The distance from the meridian to the road running to the lake from McMurray river is about seven miles. The ice was just strong enough to carry horses, but there was still some open water in places. From the river, it is twelve miles to Methye lake, and then, eight miles southwesterly, across the lake, to the H. B. post. There is a summer trail around the west shore, but it is unfit for use with horses.

We left Methye portage on December 17, and travelling over the ice of Methye lake, and Buffalo lake, reached Isle a la Crosse, on December 23, a distance of one hundred and ten miles. From there we travelled to Green lake, and thence to Big River, and getting a train there, reached Prince Albert on the evening of December 31.

The total distance from Methye portage to Big River is 275 miles. The ice was fairly good throughout.

Photo by C. Engler, D.L.S.

Settlers on road to Athabaska Landing.

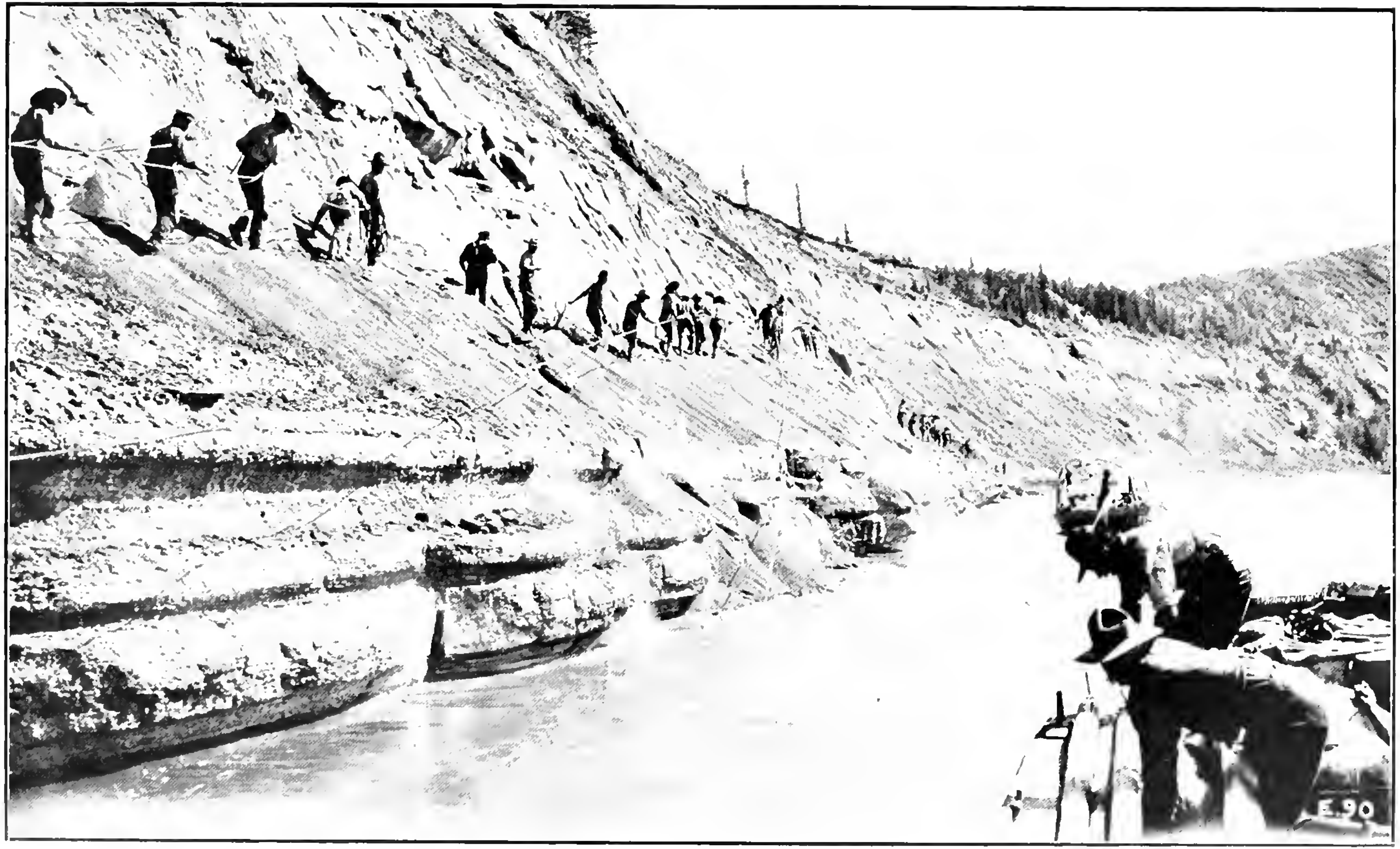


Photo by C. Engler, D. L. S.

Tracking on the Athabaska river

Photo by C. Engler, D.L.S.

The passengers' supper in the cook's scow, Athabaska river.

Photo by C. Engler, D.L.S.

The passengers' supper in the cook's scow, Athabaska river.

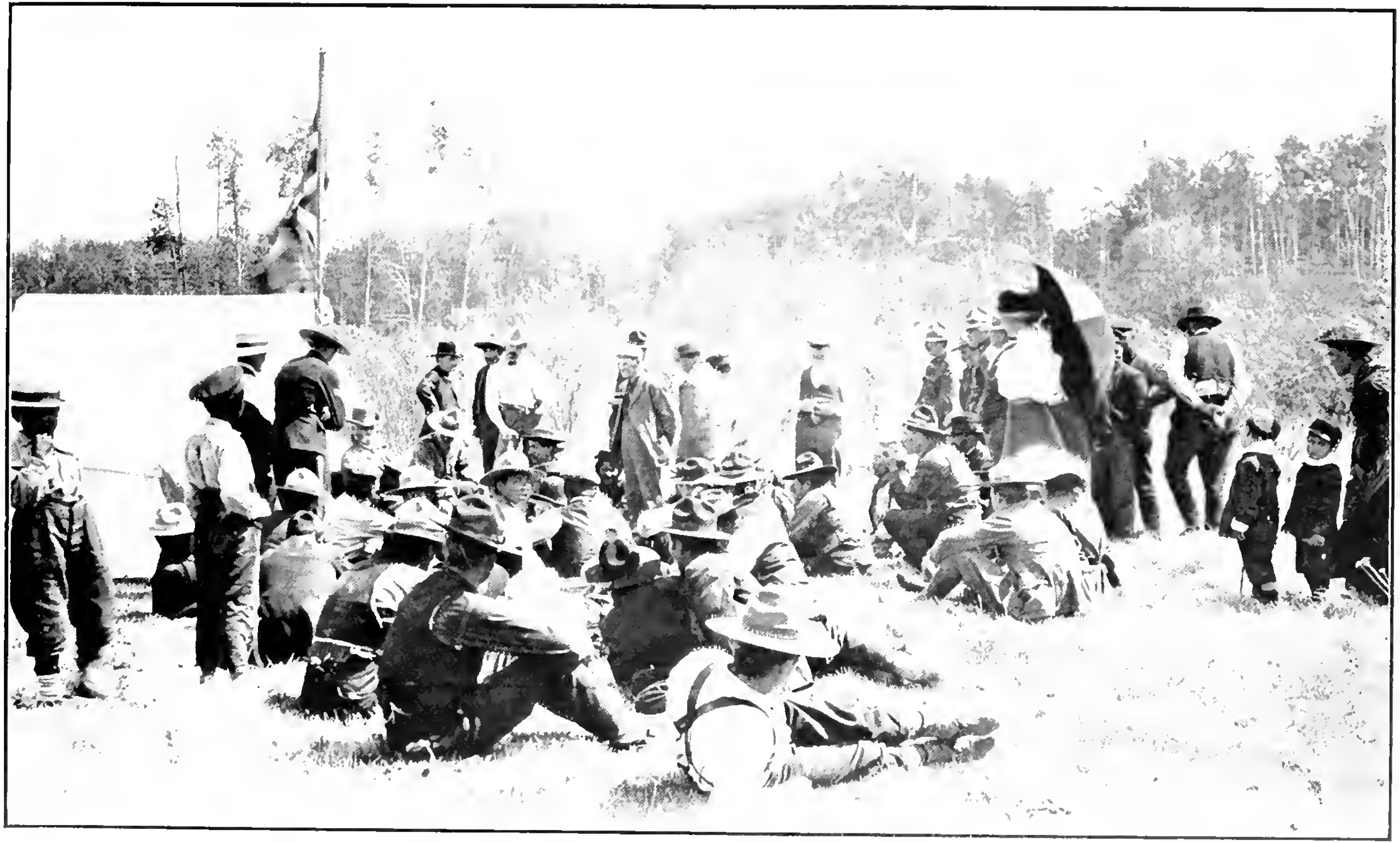

Photo by C. Engler, D.L.S.

Paying annuities to Indians at McMurry.

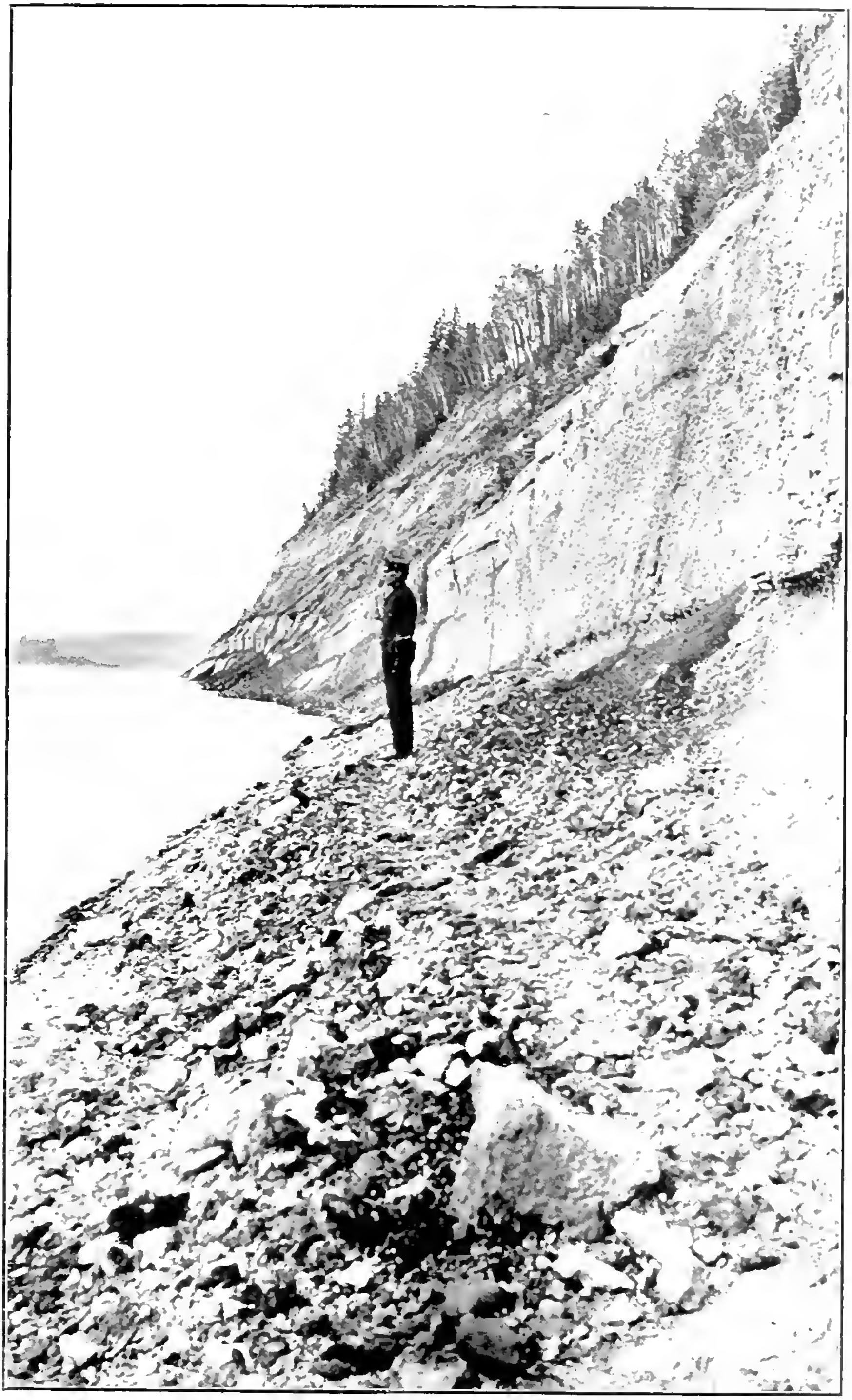

Photo by C. Engler, D.L.S.

The tar sands on the banks of the Athabaska river above McMurray.

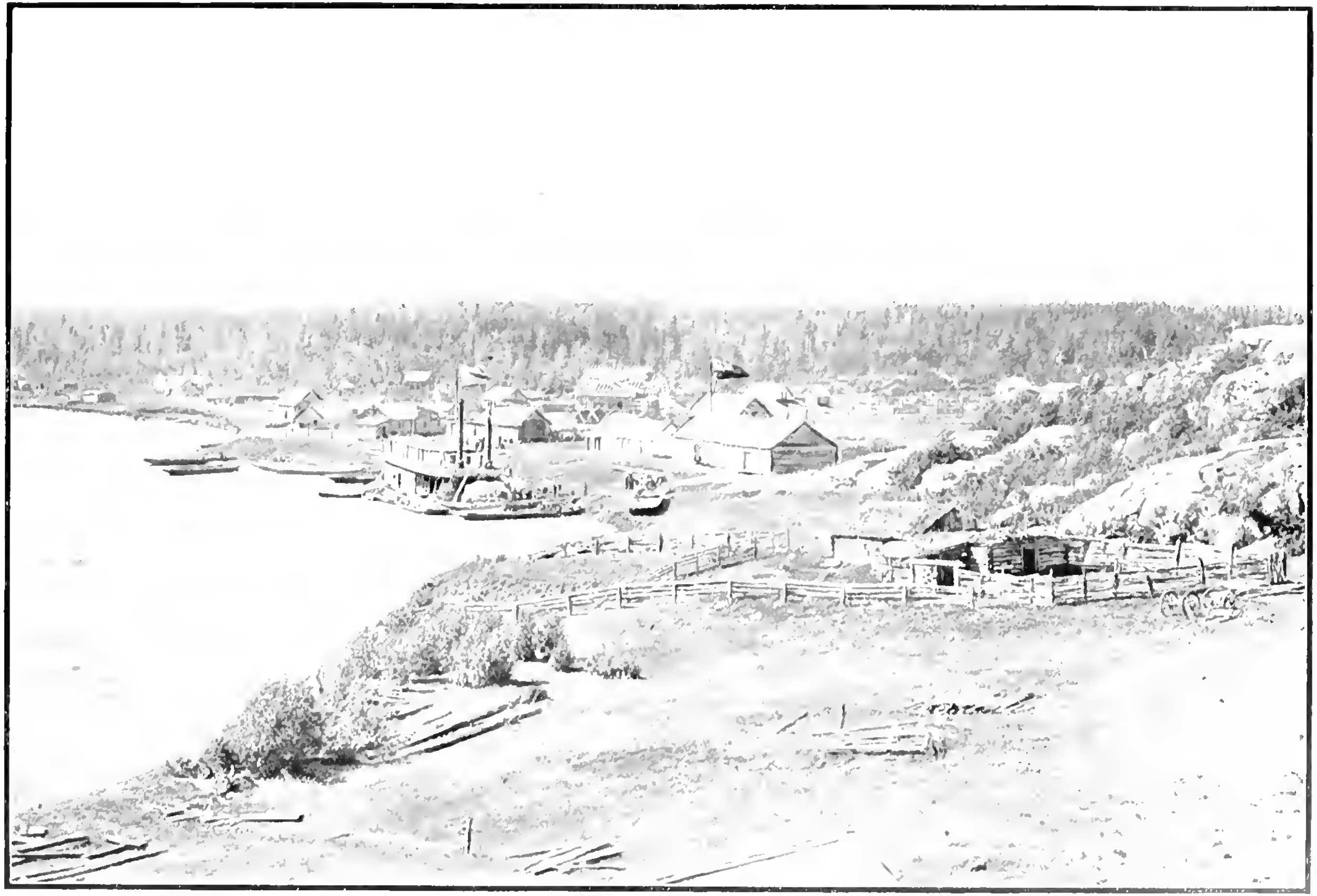

Photo by C. Engler, D.L.S.

Smith Landing.

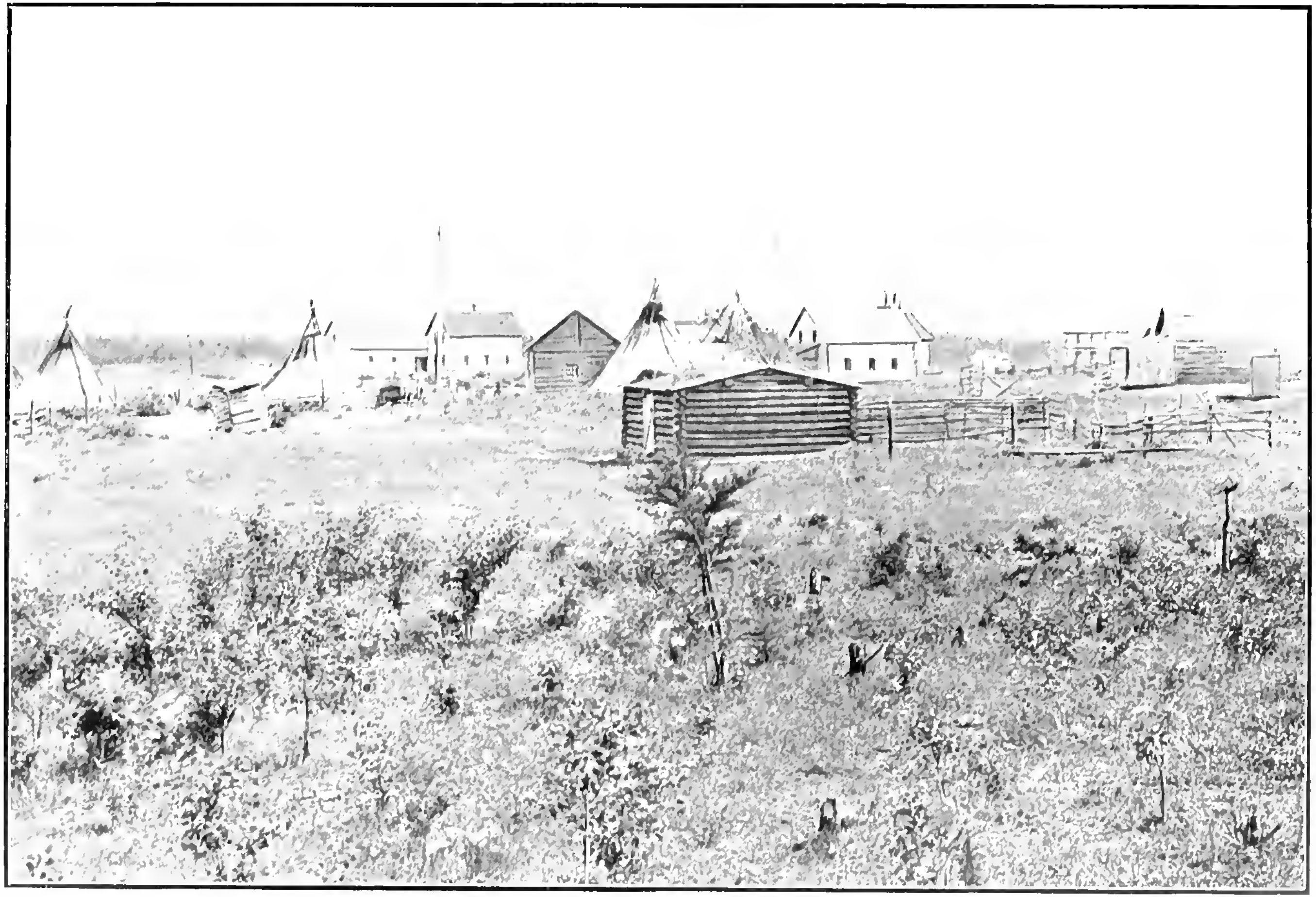

Photo by C. Engler, D. L. S.

Fort Smith.

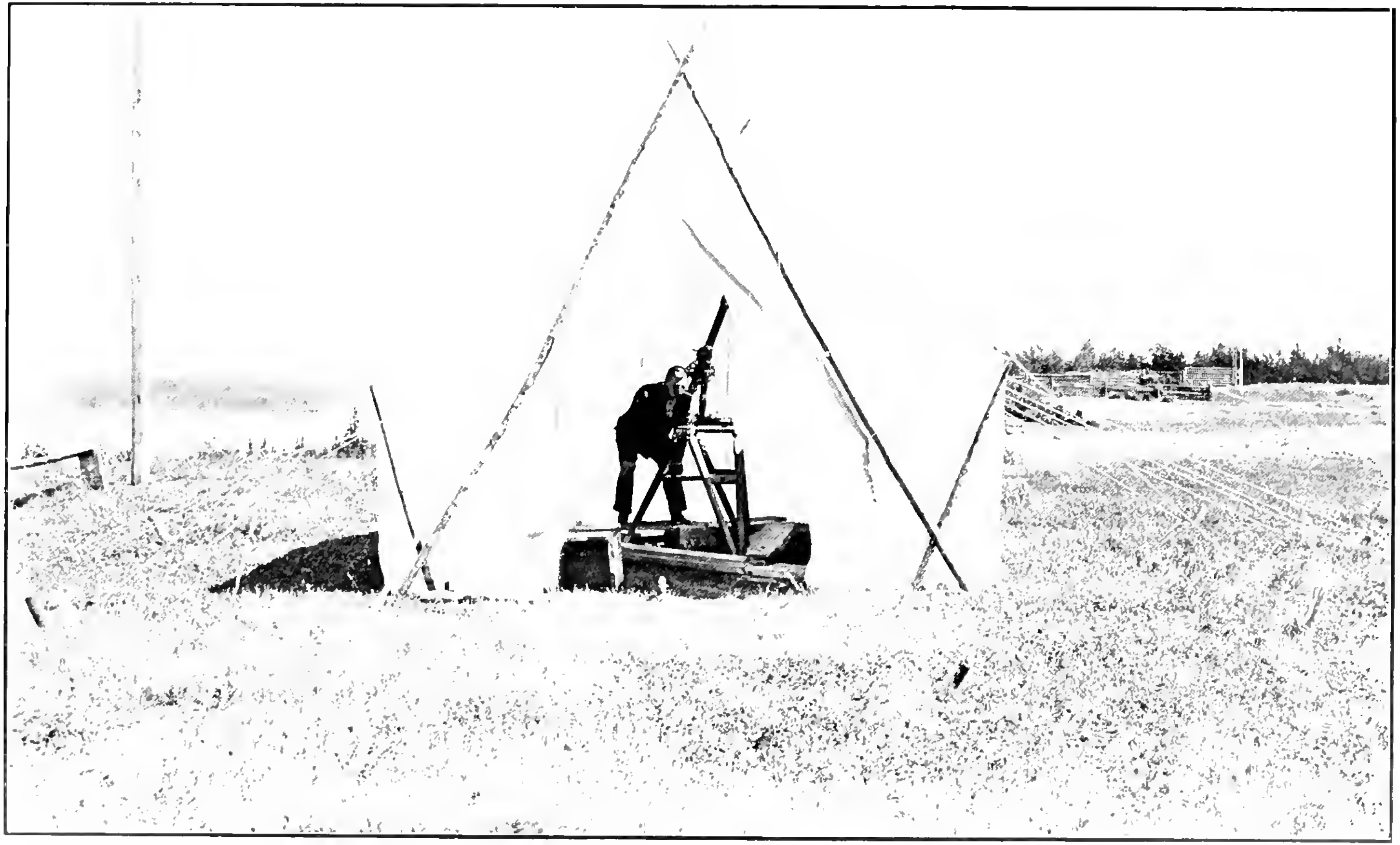

Photo by C. Engler, D.L.S.

Observing tent at Fort Smith.

Photo by C. Engler, D. L. S.

Priest's farm at Fort Smith. Potatoes in foreground. Barley and oats almost ripe in the distance. July 31, 1910.

Photo by A. W. Ponton, D.L.S.

Ferrying across Stinking creek

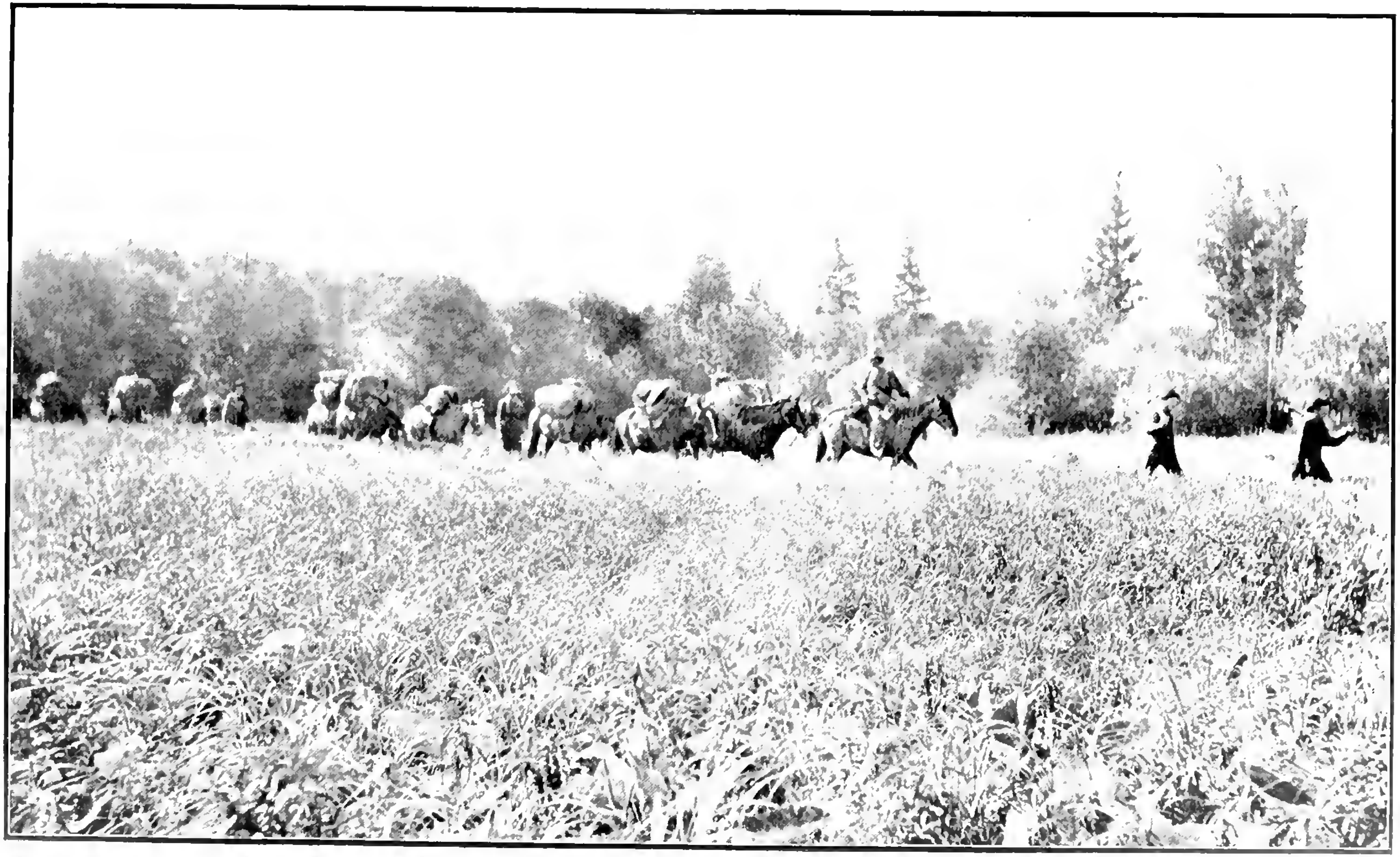

Photo by A. W. Ponton, D.L.S.

Prairie near Burnt river.

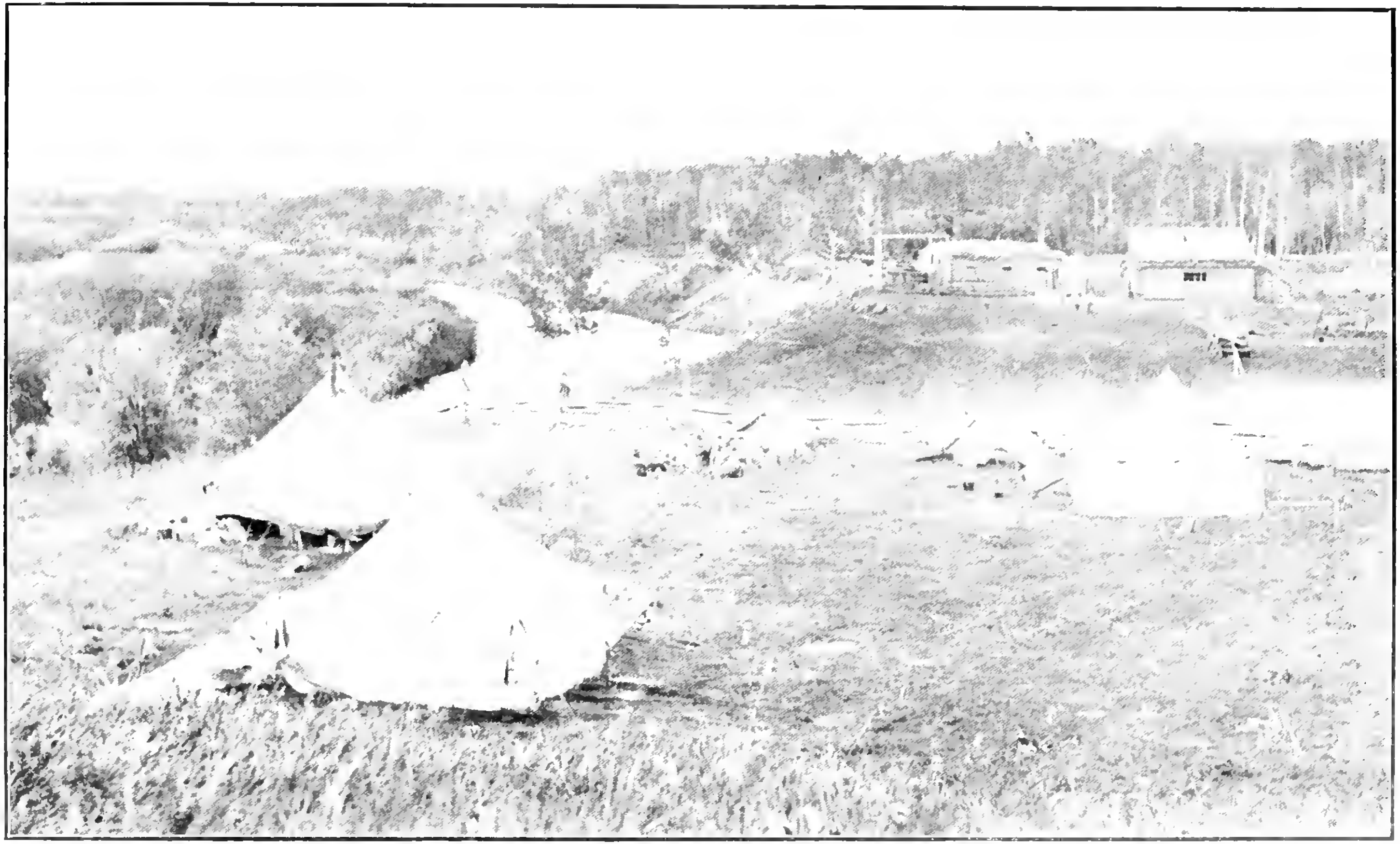

Photo by A. W. Ponton, D. L. S.

Clement Paul's ranch on Boyer river. Survey camp in foreground.

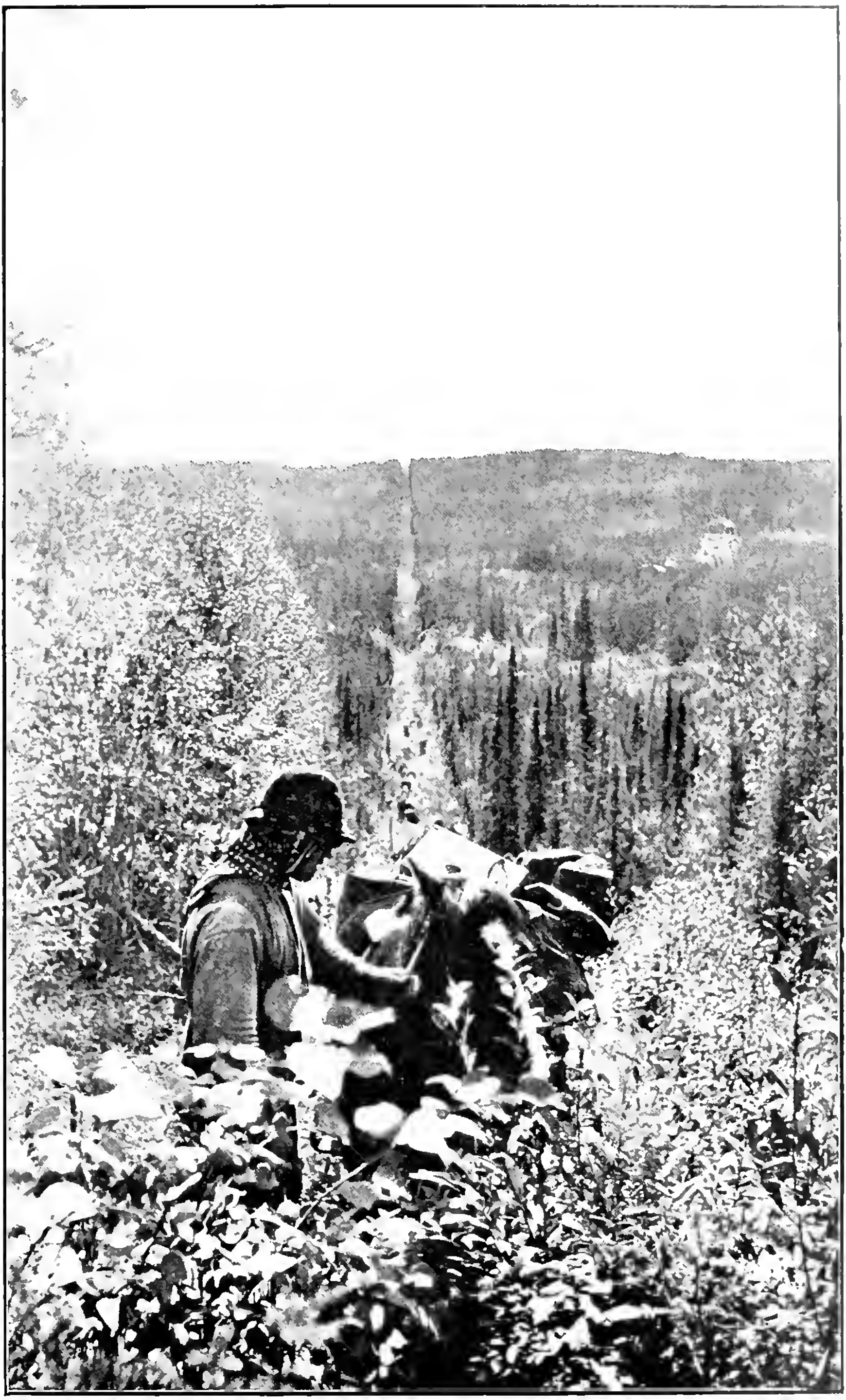

Photo by A. W. Ponton, D.L.S.

Valley of Panny river—looking south

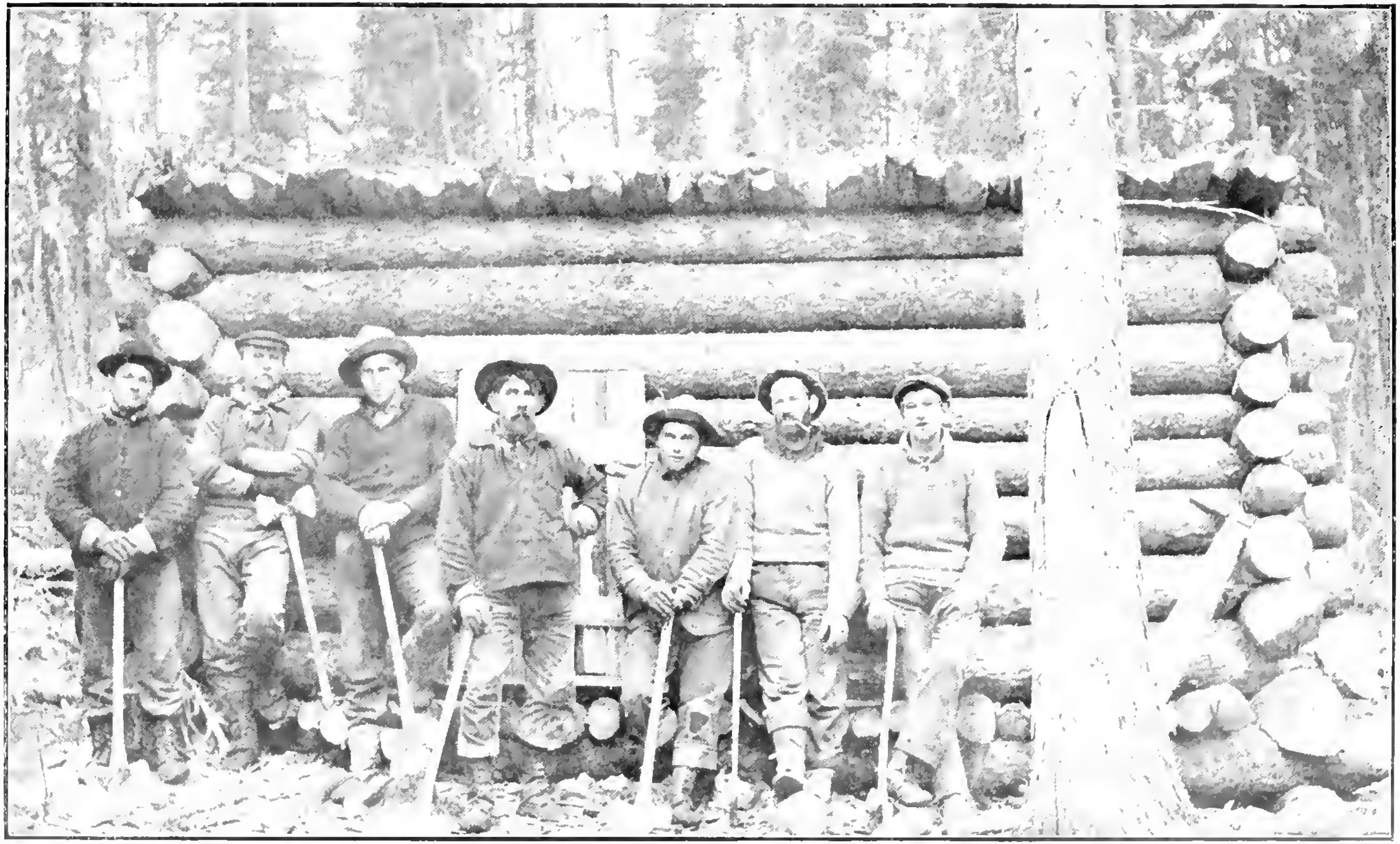

Photo by A. W. Ponton, D.L.S.

Survey cache—Peace River.

Photo by A. W. Ponton, D. L. S.

Prairie country, township 108, range 13, west of 5th meridian

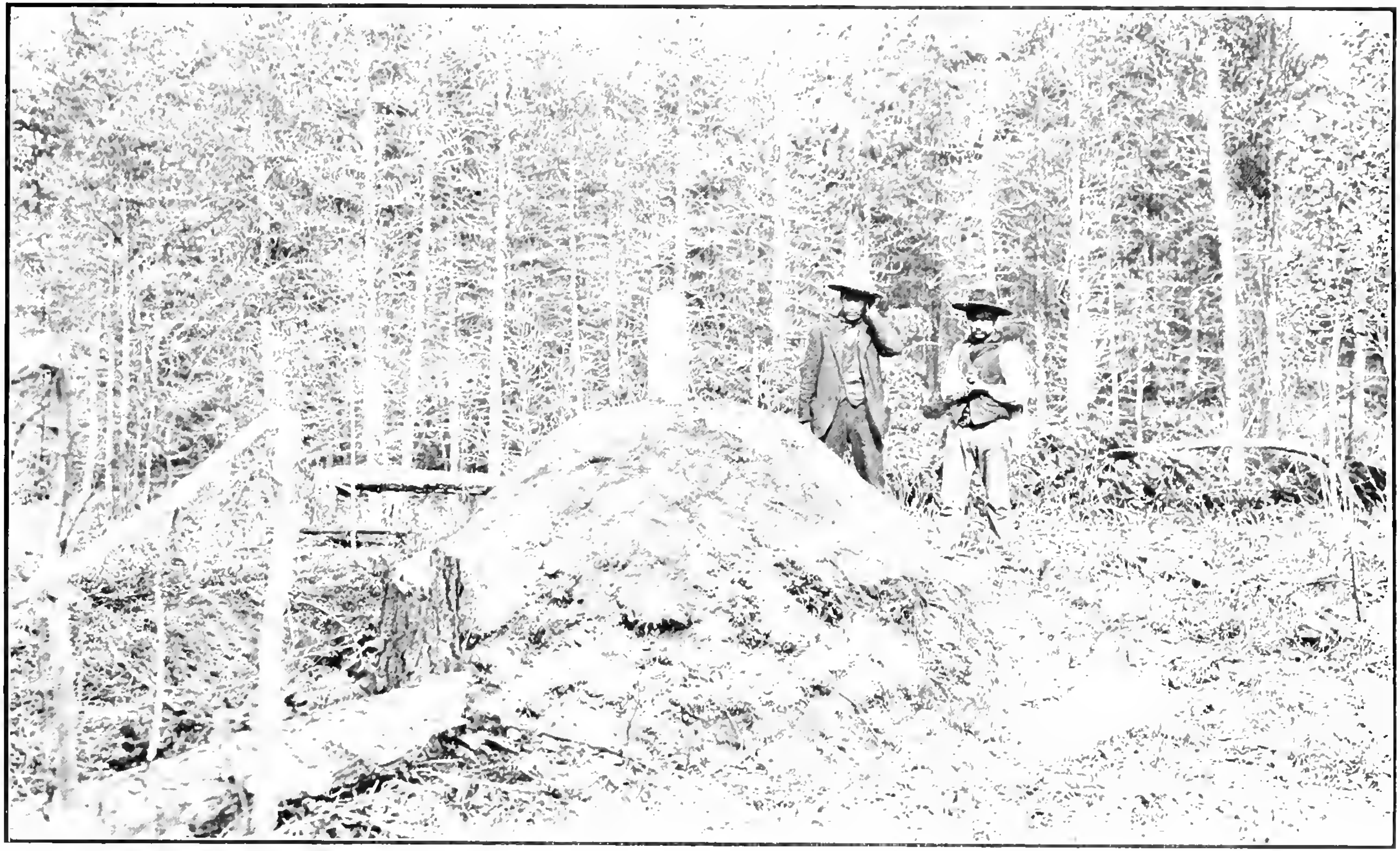

Photo by C. Engler, D. L. S.

Mound and post marking the boundary between Alberta and the Northwest Territory, on the west side of Slave river.

Photo by A. W. Ponton, D.L.S.

Northeast corner township 108, range 18, west of 5th Meridian. Looking east.

Kananaskis Falls on Bow River near Kananaskis, Alta. Taken by P. M. Sauder.

DEPARTMENT OF THE INTERIOR

DOMINION OF CANADA.

# REPORT

OF

# PROGRESS OF STREAM MEASUREMENTS

FOR

## THE CALENDAR YEAR 1911

BY

F. H. PETERS, C. E.,
D. L. S., A. L. S., A. M. Can. Soc. C. E., A. M. Am. Soc. C. E.

*PRINTED BY ORDER OF PARLIAMENT*

**OTTAWA**
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY.
1913

[No. 25d—1912]

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# APPENDICES

# ILLUSTRATIONS

*To His Royal Highness, Field Marshal, Prince Arthur William Patrick Albert, Duke of Connaught and Strathearn, K.G., K.T., etc., etc., etc., Governor General and Commander-in-Chief of the Dominion of Canada.*

MAY IT PLEASE YOUR ROYAL HIGHNESS:

The undersigned has the honour to lay before Your Excellency the report of the progress of Stream Measurements for the year 1911.

Respectfully submitted,

ROBERT ROGERS,
Minister of the Interior.

OTTAWA, Sept. 16, 1912.

DEPARTMENT OF THE INTERIOR,
OTTAWA, Sept. 10, 1912.

The Honourable ROBERT ROGERS,
Minister of the Interior.

SIR:—

I have the honour to submit the report of Stream Measurements for the year 1911, and to recommend that it be published as the third of a series of progress reports.

I have the honour to be, Sir,
Your obedient servant,

W. W. CORY,
*Deputy Minister of the Interior.*

FORESTRY AND IRRIGATION BRANCH,
Department of the Interior,
OTTAWA, Sept. 9, 1912.

W. W. CORY, ESQ., C.M.G.,
Deputy Minister of the Interior.

SIR:—

I beg to submit herewith the progress report of Stream Measurements for the year 1911, submitted by Mr. F. H. Peters, C.E., Commissioner of Irrigation, and would recommend that it be published, and that a sufficient number of copies be printed to permit of its being widely distributed among those interested in the question of the water-supply of Western Canada.

Respectfully submitted,
R. H. CAMPBELL,
*Director of Forestry and Irrigation.*

DEPARTMENT OF THE INTERIOR,
IRRIGATION OFFICE,
CALGARY, ALTA, July 12, 1912.

SIR:—

I have the honour to transmit herewith the manuscript of the Report of Progress of Stream Measurements for the calendar year 1911. This Report has been prepared, under my direction, by Mr. P. M. Sauder, C.E., Chief Hydrographer. I have the honour to request that this manuscript be published as the third of the series of Reports of Progress of Stream Measurements.

I have the honour to be, Sir,
Your obedient servant,
F. H. PETERS,
*Commissioner of Irrigation.*

R. H. CAMPBELL, ESQ.,
*Director of Forestry and Irrigation,*
Department of the Interior,
Ottawa.

DEPARTMENT OF THE INTERIOR,
IRRIGATION OFFICE
CALGARY, ALTA, June 29, 1912.

SIR:—

I have the honour to transmit herewith the manuscript of the Report of Progress of Stream Measurements for the Calendar Year 1911.

In this report is given a brief outline of the methods of obtaining and compiling the data contained therein, but owing to the want of space and time many of the datails had to be omitted. It gives in a tabulated form almost all the records of stream-flow during 1911. As a result of certain unavoidable causes, a few of the records could not be included in this report but will be included in the next report.

I beg to request that this manuscript be published as the third of the series of Reports of Progress of Stream Measurements.

I have the honour to be, Sir,
Your obedient servant,
P. M. SAUDER,
*Chief Hydrographer.*

F. H. PETERS, ESQ.,
*Commissioner of Irrigation,*
Department of the Interior,
Calgary, Alberta.

# REPORT

OF

# PROGRESS OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1911.

By P. M. SAUDER, C.E., Chief Hydrographer.

## INTRODUCTION.

### SCOPE OF WORK

The chief features of the stream-measurement work are the collection of data relating to the flow of the surface waters and a study of the conditions affecting this flow. Information is also collected concerning the river profiles, duration and magnitude of floods, irrigation, water-power, storage, seepage, etc., which may be of use in hydrographic studies.

This information is obtained by a series of observations at regular gauging stations which are established at various points. The selection of sites for these gauging stations and their maintenance depend largely on the physical features and needs of the locality. If water is to be used for irrigation purposes the summer flow receives special attention; where it is required for power purposes, it becomes necessary to determine the minimum flow; if water is to be stored, information is obtained regarding the maximum flow. In all cases the duration of the different stages of the streams is noted. Throughout the country gauging stations are maintained for general statistical purposes, to show the conditions existing through long periods. They are also used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin.

As the result of an increased appropriation the investigations were extended over a much larger territory during the past year. Considerable reconnaissance work was done and a number of new gauging stations were established. In the spring of 1911, field operations were commenced with 98 regular gauging stations and at present the regimen of flow is being studied at 132 regular gauging stations along the various streams in Alberta and Saskatchewan; records of the quantity of water diverted by thirty ditches for irrigation purposes are also being secured. Most of the stations on ditches were established by or at the request of the irrigation inspecting engineers. Winter records which are so valuable for power investigations have been given considerable attention lately and records have been secured on almost all the important streams in the two provinces during the past winter.

### ORGANIZATION

The methods of carrying on the investigations were similar to those of previous years. Local residents were engaged to observe the gauge-height at regular gauging stations. These observations were recorded in a book supplied by the Department, and at the end of each week the observer copied the week's records on a postcard which was sent to the chief hydrographer by the first convenient mail. The district hydrographers made regular visits to the gauging stations usually once in every three weeks. They examined the observers' records, made discharge measurements and collected such information and data as would be of use in making estimates of the daily flow at the station. The results of the gaugings were transmitted by a post card to the chief hydrographer. The records of the gauge-height observers and the hydrographers were copied from the post cards to regular forms in the office at Calgary and filed. At the close of the open-water season, part of the engineers returned to the office and assisted in the final computations and estimates of run-off. Gauge-height-area, gauge-height-mean-velocity, and gauge-height-discharge curves were plotted and rating tables constructed. Tables of discharge measurements, daily gauge-height and discharge, and monthly discharge were also compiled. These records have been re-copied and are embodied in this, the third annual report of Progress of Stream Measurements.

The organization in 1911 was very similar to that of the previous years. The territory covered being very much increased during 1911, the staff was, therefore, increased to include ten assistant engineers, a recorder, a computer and a clerk. The territory was divided, for administrative purposes, into ten districts; viz., Banff, Calgary, Macleod, Cardston, Milk River, Western Cypress Hills, Eastern Cypress Hills, Wood Mountain, Moosejaw, and Battleford. In each district there was a hydrographer, and while in the field he had an assistant and was equipped with the necessary gauging and surveying instruments. In the Banff, Macleod, Moosejaw and Battleford districts the hydrographers travelled by train or by hired livery, and stopped at hotels and stopping houses, while in the other districts each was supplied with a team, light wagon and light camping outfit.

## BANFF DISTRICT

This district includes the following regular gauging stations :—

| Stream | Location | Date Established |
|---|---|---|
| Bow River | S. E. 28–28–16–5 | July 18, 1910 |
| " | N.E. 35–25–12–5 | May 25, 1909 |
| " | Sec. 22–25–7–4 | May 25, 1910 |
| Cascade River | S.E. 19–26–11–5 | Aug. 16, 1911 |
| Devil's Creek | S.E. 29–26–11–5 | June 18, 1910 |
| Ghost River | N.E. 23–26–6–5 | Aug. 17, 1911 |
| Jumpingpound Creek | Sec. 30–24–4–5 | May 7, 1908 |
| Kananaskis River | N.E. 33–24–8–5 | Aug. 31, 1911 |
| Pipestone River | S.W. 27–28–16–5 | Aug. 31, 1911 |
| Spray River | Sec. 25–25–12–5 | July 15, 1910 |

The Bow River, with its many important tributaries, is playing a very important part in the industrial and agricultural development of Alberta. As is well known, large tracts of land lying east of Calgary and also in the vicinity of Medicine Hat are to be irrigated from it. The whole of the normal flow and a large portion of the high water have already been granted for irrigation purposes. The market for power is increasing, and preparations are being made to increase the output of the existing plants and to construct new ones. During 1911, a survey under the direction of the Water-Power Branch of the Department of the Interior made extensive investigations on the upper regions of the Bow and Elbow rivers. With a view to a very comprehensive study of the flow of these streams, several new gauging stations were established, and almost all the stations in this district have been maintained during the whole of the past winter. In a few cases the conditions have been so unfavourable that gauge-heights could not be obtained all winter, but in almost every case discharge measurements have been made regularly at intervals of about two weeks. A large number of miscellaneous measurements at other points and on other streams were also made during the year.

During the months of January, February and March, 1911, H. R. Carscallen, B.A.Sc., was in charge of the field-work in this district. On the first of April, Mr. Carscallen returned to the office and during the months of April and May, H. C. Ritchie, Grad. of *S. P. S.* was in charge. On the first of May, when Mr. Ritchie was placed in charge of the construction of the rating station, Benjamin Russell, B.Sc., was placed in charge. About the middle of July, Mr. Russell was transferred to reservoir site surveys and H. O. Brown was placed in charge of this district. Mr. Brown left the service in September to resume his studies at the University of Toronto, and V. A. Newhall, B.A.Sc., was in charge of the field-work in this district from that time until the end of the year. The final computations for this district were made by H. R. Carscallen.

## CALGARY DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Berry Creek | N.E. 21-23-13-4 | May 30, 1911 |
| Blood Indian Creek | S.W. 10-23-8-4 | June 26, 1911 |
| Bow River | Sec. 13-21-19-4 | Aug. 20, 1909 |
| " | N.E. 15-24-1-5 | Nov. 25, 1910 |
| C.P.R. Canal | N.E. 36-23-1-5 | May 9, 1908 |
| Elbow River | S.W. 14-24-1-5 | May 8, 1908 |
| Findlay and McDougall Ditch | S.W. 31-18-29-4 | June 17, 1911 |
| Fish Creek | S.W. 26-22-3-5 | May 13, 1907 |
| Highwood River | N.W. 6-19-28-4 | May 28, 1908 |
| " | N.W. 17-20-28-4 | Oct. 3, 1911 |
| Little Bow Ditch | S.W. 6-19-28-4 | Aug. 1, 1910 |
| Nose Creek | N.W. 13-24-1-5 | April 24, 1911 |
| Pekisko Creek | N.W. 8-17-2-5 | Oct. 6, 1911 |
| Sheep River | N.W. 22-20-29-4 | May 25, 1908 |
| N.B. Sheep River | S.W. 12-21-3-5 | May 22, 1908 |
| S.B. Sheep River | S.E. 17-20-2-5 | May 23, 1908 |
| Stimson Creek | N.E. 14-17-2-5 | Oct. 6, 1911 |

It will be noted that while the western portion of the old Calgary district has been formed into a separate district, a number of new gauging stations have been established and the territory extended so that this is still a large and important district. Some attention was given to a study of the flow in the tributaries of Red Deer River, but owing to the distance and difficulty of reaching these, the investigations were not as extensive as desired. The data obtained is, however, of considerable value, as previously there were practically no data at all. Regular gauging stations were established on Berry and *Blood Indian* creeks. The gauging station on Highwood River at High River is not very satisfactory, and a new station has been established near Aldersyde. If the observer at the new station proves satisfactory the old station will be abandoned. Stations have also been established on Pekisko and Stimson creeks, tributaries of Highwood River. The station on Bow River near Bassano was established and is maintained by the irrigation department of the Canadian Pacific Railway Company. Mr. A. S. Dawson, Chief Engineer, has very kindly furnished copies of the gauge-height records and the results of their gaugings. The district hydrographer also makes regular measurements at this station.

H. R. Carscallen also included Bow and Elbow rivers at Calgary in his district during the months of January, February and March. H. C. Ritchie was in charge of the field-work in the Calgary district also, during April and May, but when he was placed in charge of the construction of the rating station, L. R. Brereton was placed in charge of the field-work in this district. After he left the service in October to resume his studies at the University of Toronto, gaugings were discontinued at all the stations except those on the Bow and Elbow rivers. These were included in the Macleod district and were looked after during November and December by N. M. Sutherland. The final computations for this district were made by H. R. Carscallen.

## MACLEOD DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Belly River | N.W. 1-19-22-4 | Aug. 31, 1911 |
| Canyon Creek | N.E. 14-6-2-5 | July 6, 1910 |
| Connely Creek | S.E. 36-7-2-5 | July 31, 1909 |
| Cow Creek | N.E. 14-8-2-5 | May 26, 1910 |
| Crowsnest River | N.E. 26-7-2-5 | Sept. 7, 1907 |
| do | N.E. 36-7-4-5 | July 28, 1910 |
| do | S.W. 12-8-5-5 | July 28, 1910 |
| Mill Creek | S.W. 18-6-1-5 | July 7, 1910 |
| Mosquito Creek | N.E. 30-16-28-4 | Aug. 1, 1908 |
| Muddypound Creek | Sec 27-11-28-4 | July 27, 1908 |
| Nanton Creek | Sec. 20-16-28-4 | Aug. 3, 1908 |
| Oldman River | N.E. 34-7-1-5 | Sept. 15, 1908 |
| do | N.W. 10-9-26-4 | July 12, 1910 |
| Pincher Creek | N.E. 22-6-30-4 | Aug. 13, 1906 |
| Southfork River | S.E. 2-7-1-5 | Aug. 5, 1909 |
| St. Mary River | N.E. 26-7-22-4 | Oct. 13, 1911 |
| Todd Creek | S.W. 19-8-1-5 | Aug. 3, 1909 |
| Trout Creek | Sec. 33-11-28-4 | July 7, 1911 |
| Willow Creek | S.W. 25-9-26-4 | July 1, 1909 |

This district was well organised soon after the survey was commenced, and few changes were made and few stations established during the past year. The new stations on Belly and St. Mary rivers will furnish valuable data. The importance of St. Mary River as a source of water-supply for irrigation purposes and its possibilities as a source of power are well known, and the records at the new station will serve to make the data more complete. The discharge of Belly River near Lethbridge is the drainage of practically the whole of the south-western portion of the province of Alberta, and records at this point will be very valuable for general statistical purposes, and in connection with short series of measurements will serve as basis for estimating the flow at other points in the drainage basin. The conditions at the old station on Oldman river near Macleod have very much improved and last year this station was re-established. For some time the Branch was unable to secure an observer at a suitable site on Trout Creek above the intakes of the ditches, but last year one was secured and a new station was established, and the old one abandoned.

Gauge-height observations and discharge measurements have been taken at all the regular gauging stations on all the larger and more important streams throughout the past winter. A large number of miscellaneous discharge measurements, which will be very valuable as general information, were also made during the year.

Owing to the coal-miners' strike, industrial development in the Crowsnest district was slightly retarded during 1911. The water-supply is, however, becoming more important, and, while there is no necessity for establishing any additional gauging stations, there should be no interruption in the records at those already established.

W. H. Greene, Grad. of S. P. S., was in charge of the field-work in this district until the middle of March when he was transferred to the Battleford district. J. E. Degnan was then in charge until the end of April when he was transferred to the Milk River district. A. W. P. Lowrie, Grad. of S. P. S., was in charge from the first of May to the end of September, when he returned to the University of Toronto to resume his studies. N. M. Sutherland, Grad. of the Royal Military College, has been in charge since Mr. Lowrie left. Only part of the final computations for this district have been made. These were made by H. J. Duffield, C.E., and G. H. Whyte.

## CARDSTON DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| A. R. & I. Canal | S. W. 21-2-24-4 | July 26, 1910 |
| Belly River | S.E. 21-6-25-4 | May 27, 1909 |
| do | N.E. 5-2-28-4 | Nov. 1, 1911 |
| Christianson Ditch | S.E. 12-3-28-4 | Sept. 14, 1911 |
| Crooked Creek | S.E. 23-2-29-4 | Sept. 15, 1909 |
| Fidler Ditch | S.E. 19-1-26-4 | Sept. 13, 1911 |
| Lee Creek | N.W. 10-3-25-4 | June 28, 1909 |
| Mami Creek | N.E. 18-2-27-4 | Aug. 13, 1909 |
| N.B. Milk River | N.E. 13-1-23-4 | July 21, 1909 |
| do | Sec. 18-2-20-4 | July 17, 1909 |
| Ralph Creek | S.W. 21-2-24-4 | May 17, 1911 |
| St. Mary River | Sec. 25-1-25-4 | By. A.R. & I Co., 1905 |
| Waterton River | N.E. 8-2-29-4 | Aug. 26, 1908 |

While a station has been maintained on Belly River near Stand Off for some time, the importance of this stream as a possible supplementary supply for the A. R. & I. Canal justified the survey in establishing another station in the vicinity of Mountain View. A cable station was, therefore, established on the N. E. ¼ Sec. 5, Tp. 2, Rge. 28, W. 4th Mer., at West's ranche, last fall, and has been included in this district.

It was impossible to secure an observer for the gauge on the North Branch of Milk River in Sec. 18, Tp. 2, Rge. 20, W. 4th Mer., during 1911, but discharge measurements were made at every opportunity.

For several years past the Water Resources branch of the U. S. Geological Survey has maintained a gauging station on St. Mary River near the International Boundary. The gauging station at Kimball is only a few miles below, and it is thought that a joint station should be maintained. A self-recording water-gauge could be installed, and by making comparisons of the results of the gaugings made by the hydrographers of both countries, records of a high degree of accuracy and results which would be most satisfactory to both countries could be obtained. It is hoped that satisfactory arrangements can be made and a joint station established in the near future.

There are several streams of some importance emptying into the Waterton lakes, but as no observers are available, regular gauging stations have not been established on these. Miscellaneous discharge measurements of these and several other streams in the district were made whenever possible during the past year.

Winter records were taken at the stations on Belly River, Lee Creek, St. Mary River and Waterton River.

L. J. Gleeson, B.Sc., was in charge of the field-work in this district until the end of November, when he returned to the office to make the final computations, and D. D. Macleod, B.A.Sc., was in charge of the field-work during the winter months.

There are only a few irrigation ditches in this district and the hydrographer, therefore, makes the necessary inspections. Unless urgent, these are usually made in the late summer or early fall, when the streams are low and almost stationary and need not be gauged as often as usual.

MILK RIVER DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Deer Creek | S.W. 15-1-12-4 | May 26, 1911 |
| do | N.E. 26-1-12-4 | May 27, 1911 |
| Manyberries Creek | S. E.3-5-6-4 | June 17, 1910 |
| Milk River | N.E. 21-2-16-4 | May 18, 1909 |
| do | S.W. 35-1-13-4 | Aug. 2, 1909 |
| do | S.W. 21-2-8-4 | Aug. 5, 1909 |
| do | S.E. 3-1-5-4 | Aug. 7, 1909 |
| N.B. Milk River | S.W. 19-2-18-4 | July 15, 1909 |
| S.B. do | N.W. 31-1-18-4 | July 14, 1909 |

It was impossible to secure an observer for the gauge on the North Branch of Milk River on the S. W. ¼ Sec. 19, Tp. 2, Rge. 18, W. 4th Mer., during 1911, but discharge measurements were made at every opportunity.

As has been pointed out in former reports, the bed of Milk River is composed almost entirely of sand and loose material, which shifts continually. Discharge measurements had, therefore, to be made at short intervals and even then considerable difficulty was experienced in compiling reliable estimates of the daily discharge.

As there have been several applications for water for irrigation purposes in the vicinity of Pakowki Lake, special attention was given to the records on Manyberries Greek. Not only will these be useful in studying the water-supply in this stream, but by comparing the areas of the watersheds, a fair estimate can be made of the probable run-off in other streams in the Pakowki Lake drainage.

It will be noted that two gauging stations have been established on Deer Creek. This is only a small stream, but a dispute has arisen between two licensees and data are recorded at the two points to determine the seepage. As these stations are close to the regular route of the hydrographer little time is lost in making the gaugings and the results are of general interest.

A large number of miscellaneous discharge measurements of the small streams draining into Milk River were made during the year.

In this district also the hydrographer makes inspections of and reports on the irrigation works.

N. M. Sutherland was in charge of the field-work in this district during the month of April, but for the remainder of the open season J. E. Degnan was in charge. Winter measurements were made during the past winter at the regular station on the N. E. ¼ Sec. 21, Tp. 2, Rge. 16, W. 4th Mer., by D. D. Macleod. The final computations for this district were made by J. E. Degnan.

WESTERN CYPRESS HILLS DISTRICT.

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Anderson Ditch | S.W. 23-6-3-4 | Sept. 23, 1911 |
| Battle Creek | S.W. 2-6-28-3 | July 5, 1910 |
| do | N.E. 33-5-29-3 | June 3, 1909 |
| do | N.E. 3-3-27-3 | May 10, 1910 |
| Bullshead Creek | N.W. 15-9-5-4 | Oct. 9, 1911 |
| Cheeseman Ditch | S.W. 12-8-29-3 | June 24, 1911 |
| Gaff Ditch | Sec. 25-5-29-3 | July 11, 1911 |
| Gap Creek | N.E. 31-11-26-3 | May 3, 1910 |
| " | S.W. 3-10-27-3 | Apr. 25, 1909 |

| | | |
|---|---|---|
| Gilchrist Bros. Ditch | S.W. 11–5–27–3 | Oct. 16, 1911 |
| Grosventre Creek | S.E. 27–9–4–4 | Oct. 10, 1911 |
| Lindner Ditch | Sec. 10–6–29–3 | July 26, 1910 |
| Lodge Creek | Sec. 12–1–29–3 | Aug. 13, 1909 |
| do | S.W. 15–6–3–4 | July 22, 1909 |
| E.B. Lodge Creek | S.E. 1–7–3–4 | Oct. 7, 1911 |
| E.B. Mackay Creek | N.W. 36–10–1–4 | Oct. 13, 1911 |
| W.B. Mackay Creek | S.W. 23–10–2–4 | Oct. 12, 1911 |
| McShane Creek | Sec. 4–10–27–3 | Apr. 23, 1909 |
| McKinnon Ditch | N.W. 20–4–26–3 | Oct. 20, 1911 |
| Maple Creek | N.E. 16–11–26–3 | May 9, 1908 |
| do | S.E. 28–11–26–3 | May 4, 1910 |
| Marshall Ditch | N.E. 33–5–29–3 | July 11, 1911 |
| Marshall and Gaff Ditch | S.W. 25–5–29–3 | July 11, 1911 |
| Middle Creek | S.W. 35–5–1–4 | June 21, 1910 |
| do | S.W. 30–5–29–3 | July 20, 1909 |
| do | N.E. 4–2–29–3 | June 13, 1910 |
| Oxarart Creek | N.E 20–6–27–3 | June 15, 1909 |
| Richardson Ditch | S.E. 2–5–27–3 | Oct. 14, 1911 |
| Ross Ditch | N.W. 24–9–3–4 | Oct. 11, 1911 |
| Sage Creek | Sec. 9–1–2–4 | Aug. 10, 1909 |
| Sixmile Coulee | N.W. 36–6–29–3 | July 4, 1911 |
| do | N.W 29–7–28–3 | July 22, 1909 |
| Spangler Ditch | Sec. 6–7–28–3 | July 10, 1911 |
| Starks and Burton Ditch | S.E. 17–11–5–4 | Oct. 9, 1911 |
| Stirling and Nash Ditch | Sec. 22–3–27–3 | July 11, 1911 |
| Tenmile Creek | S.W. 4–6–29–3 | July 21, 1909 |
| White Ditch | S. W. 1–9–27–3 | June 15, 1911 |

The majority of applications for water for irrigation purposes during the past years have come from the Cypress Hills, and, as apparently almost the total flow of many of the streams has already been granted, the records in this district are very important. It is impossible to obtain records on every stream in the district, but stations have been established and are maintained on all the more important streams and by a careful comparison of watersheds fair estimates of the probable flow can now be made for many of the smaller and less important streams for the same year. There are, however, very big differences in the run-off for different years, and it will be some years before the records will show the extremes of flow and a reliable mean.

During the past year, M. H. French, who was in charge of the field-work in this district, made a reconnaissance of the country surrounding Old Fort Walsh and the heads of Battle, Lodge, Mackay, Ross and Bullshead creeks and established several new stations. W. A. Fletcher, irrigation inspector, established the gauging stations on most of the irrigation ditches in this district, but, as some of the ditches were not used during 1911 and in other cases the gauge was not installed until after the irrigation season, few records of the flow in the ditches have been secured.

A heavy rain and snow storm in September caused an unexpected flood in many of the streams in this district, and the run-off during the fall was higher than the average.

A large number of miscellaneous gaugings which will be valuable as general information were made in this district during 1911. No winter records were taken.

M. H. French was in charge of the field-work and also made the final computations.

### EASTERN CYPRESS HILLS DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Axton Ditch | N.E. 23–7–21–3 | Aug. 12, 1911 |
| Bear Creek | S.E. 18–11–23–3 | June 22, 1908 |
| E. B. Bear Creek | S.E. 21–10–23–3 | Aug. 18, 1909 |
| W. B. Bear Creek | S.W. 32–10–23–3 | Sept. 16, 1909 |
| Belanger Creek | S.W. 18–7–25–3 | June 12, 1909 |
| Beveridge Ditch, West Branch | N.W. 18–10–24–3 | June 5, 1911 |
| do East Branch | N.E. 7–10–24–3 | June 9, 1911 |
| Blacktail Creek | S.W. 31–6–23–3 | Aug. 3, 1909 |
| Bone Creek | N.W. 34–8–22–3 | July 2, 1908 |
| Braniff Ditch | S.E.30–11–23–3 | July 22, 1911 |
| Bridge Creek | N.W. 11–11–22–3 | July 29, 1909 |
| do | S.E. 33–10–22–3 | Apr. 29, 1911 |
| Cross Ditch | N.W. 15–7–22–3 | Sept. 9, 1911 |
| Davis Creek | N.E. 29–6–25–3 | May 24, 1909 |

| | | |
|---|---|---|
| Enright and Strong Ditch | N.E. 25–6–22–3 | July 31, 1908 |
| Fairwell Creek | N.W. 30–6–24–3 | June 10, 1909 |
| Fearon and Moorehead Ditch | N.E. 29–10–22–3 | July 6, 1911 |
| do do | N.E. 33–10–22–3 | July 4, 1911 |
| do do | S.E. 33–10–22–3 | July 6, 1911 |
| N.B. Frenchman River | N.E 16–7–22–3 | July 25, 1908 |
| Frenchman River | N.E 31–6–21–3 | July 31, 1908 |
| Hay Creek | N.E 30–10–25–3 | April 22, 1909 |
| do | S.W. 29–10–25–3 | July 4, 1910 |
| Jones Coulee | N.E. 5–8–10–3 | Sept. 23, 1909 |
| Lonepine Creek | N.W. 27–7–26–3 | July 17, 1909 |
| Moorehead Ditch | N.W. 25–10–25–3 | June 10, 1911 |
| Morrison Ditch | S.W. 26–6–21–3 | Aug. 22, 1911 |
| Needham Ditch | S.W. 30–11–23–3 | June 22, 1911 |
| Piapot Creek | N.E. 18–11–24–3 | June 17, 1908 |
| Pollock Ditch | N.W. 22–7–21–3 | Aug. 10, 1911 |
| Rose Creek | Sec. 26–7–22–3 | May 2, 1911 |
| Skull Creek | N.W. 10–11–22–3 | June 29, 1908 |
| do | N.E. 29–10–22–3 | April 8, 1911 |
| Sucker Creek | N.W. 24–6–26–3 | May 26, 1909 |
| Swiftcurrent Creek | S.W. 22–7–21–3 | May 18, 1909 |
| do do | Sec. 17–10–19–3 | May 27, 1910 |
| do do | Sec. 18–10–19–3 | June 15, 1910 |

The remarks regarding the conditions in the Western Cypress Hills district apply also to this district. The greatest irrigation development has been in the Frenchman River drainage basin, and special efforts are being made to get gaugings in this locality during high-water and flood stages of the streams. This, however, is a large district with many long drives, and it is impossible always to be on hand at a particular station when the stream is high. There has also been difficulty in securing good observers. The records have, however, improved considerably during the past year.

Several gauges were installed on irrigation ditches by F. T. Fletcher, irrigation inspector, but, as some of the ditches in this district were not used during 1911, and most of the gauges were not installed until after the irrigation season, few records of the flow have been secured.

As a large quantity of water is diverted from Frenchman River above the old gauging station, the records have not been altogether satisfactory. It was, therefore, decided to establish two cable stations at points above East End. The cables were stretched late last fall, but owing to bad weather the hydrographer was unable to finish these stations. They will be completed and put in good shape this spring, and it is expected that better and more satisfactory records will be obtained. The records on Bridge and Skull creeks have been much improved by the additional data secured at the new stations above the intakes of Fearon and Moorehead's ditches. A gauge was placed on Mule creek, but, as a satisfactory observer could not be secured, no records except periodic discharge measurements were secured.

The storm in September also raised the streams in this district, but not as much as in the Western Cypress Hills district.

A large number of miscellaneous gaugings which will be valuable as general information were made in this district during 1911. No winter records were taken.

G. H. Whyte was in charge of the field-work and also made the final computations.

### WOOD MOUNTAIN DISTRICT

There is only one regular gauging station in this district, namely:—

| Stream | Location | Date Established |
|---|---|---|
| Frenchman River | Sec. 5–5–14–3 | May 23, 1910 |

During 1911, a study was made of the water-supply and possibilities of irrigation development in a large and partially settled district in the southern part of Saskatchewan, including the drainage basins of Lake Chaplin, Lake Johnston, Big Muddy Lake, Poplar Creek, Rocky Creek and the lower part of Frenchman River. Early in June, N.M. Sutherland and the Chief Hydrographer left Swift Current and made a circuit of the western portion of this district. Mr. Sauder returned to Calgary at the end of June, and the investigations were continued by Mr. Sutherland.

An account of the work done in this district is given in a separate report by Mr. Sutherland. For this work Mr. Sutherland was provided with a light camping outfit, one man and three horses. He travelled about 1,660 miles and reported 109 gaugings. While many of the reports showed that the streams were dry or nearly dry, or that water was standing in pools, it should be remembered that a trip had to be made to the stream to learn the condition. Reports on streams, even when dry, are just as important as when they are running, as they show the actual conditions of the stream at that time.

As a result of the investigations during 1911, it has been decided that the possibilities of irrigation in this district are so limited that there will be no necessity to carry on any further reconnaissance on stream-measurement work for the present.

As suggested by Mr. Sutherland, in a few years the farmers in this locality may wish to use the water from springs for irrigation purposes, and, when such occasions arise, no doubt investigations will have to be made of the schemes.

The records of flow for the regular station on Frenchman River were not very satisfactory. At first an observer could not be secured, and then beavers built a dam below the gauge and caused the water to back up on it. As these difficulties still exist and there will be no hydrographer in the district during 1912, it has been decided to abandon this station.

### MOOSEJAW DISTRICT

This district includes the following regular gauging stations.

| Stream | Location | Date Established |
|---|---|---|
| Boxelder Creek | N.E. 2-12-30-3 | May 24, 1909 |
| Bridge Creek | S.E. 23-13-19-3 | Mar. 29, 1911 |
| Bullshead Creek | Sec. 16-12-5-4 | July 26, 1909 |
| Long Creek | S.E. 10-2-8-2 | June 22, 1911 |
| Mackay Creek | N.W. 26-11-1-4 | July 29, 1909 |
| Moosejaw Creek | N.W. 14-15-25-2 | April 13, 1910 |
| do do | N.W. 16-16-26-2 | April 7, 1910 |
| do do | N.W 19-11-18-2 | June 21, 1911 |
| Qu'Appelle River | S.W. 33-19-21-2 | May 12, 1911 |
| Ross Creek | N.W. 31-11-2-4 | July 28, 1909 |
| S. Saskatchwean River | N.W. 31-12-5-4 | May 31, 1911 |
| Sevenpersons River | N.E. 30-12-5-4 | April 27. 1910 |
| Souris River | N.E 11-2-8-2 | June 23, 1911 |
| do | N.E. 36-2-1-2 | June 26, 1911 |
| do | Sec. 6-4-26-1 | July 20, 1911 |
| Swiftcurrent Creek | S.W. 30-15-13-3 | April 30, 1910 |

It is imperative that records should be continued on Moosejaw Creek for several years, and, as there are a number of important streams crossing and in the vicinity of the railway between Medicine Hat and Broadview, and between Moosejaw and Melita, it was decided to have a hydrographer look after these by train.

Some time was spent in reconnaissance to find the most suitable sites before the new stations were established. Besides those shown above, stations were established on Qu'Appelle River at points north of the towns of Qu'Appelle and Indian Head, but the current was so sluggish at these two points that the records were not satisfactory and the stations have been abandoned.

J. C. Keith, B.A.Sc., was in charge of the field-work in this district. After the stations had been established he did not retain a regular helper but engaged locally any help he required. Mr. Keith made a number of miscellaneous gaugings and inspected several works to divert water for domestic and industrial purposes.

Winter records were taken at the stations on Moosejaw Creek near Moosejaw and Qu'Appelle River at Lumsden during the past winter. They were included in the Battleford district during that period.

Final computations for this district were made by M. H. French and G. H. Whyte.

### BATTLEFORD DISTRICT

This district includes the following regular gauging stations:—

| Stream | Location | Date Established |
|---|---|---|
| Battle River | S.E. 19-43-16-3 | June 17, 1911 |
| Red Deer River | S.E. 20-38-27-4 | Dec. 2, 1911 |
| N. Saskatchewan River | N.W. 33-52-24-4 | May 14, 1911 |
| do | N.E. 29-43-16-3 | May 18, 1911 |
| do | River lot No. 76 | Oct. 2, 1911 |
| S. Saskatchewan River | S.W. 28-36-5-3 | May 27, 1911 |

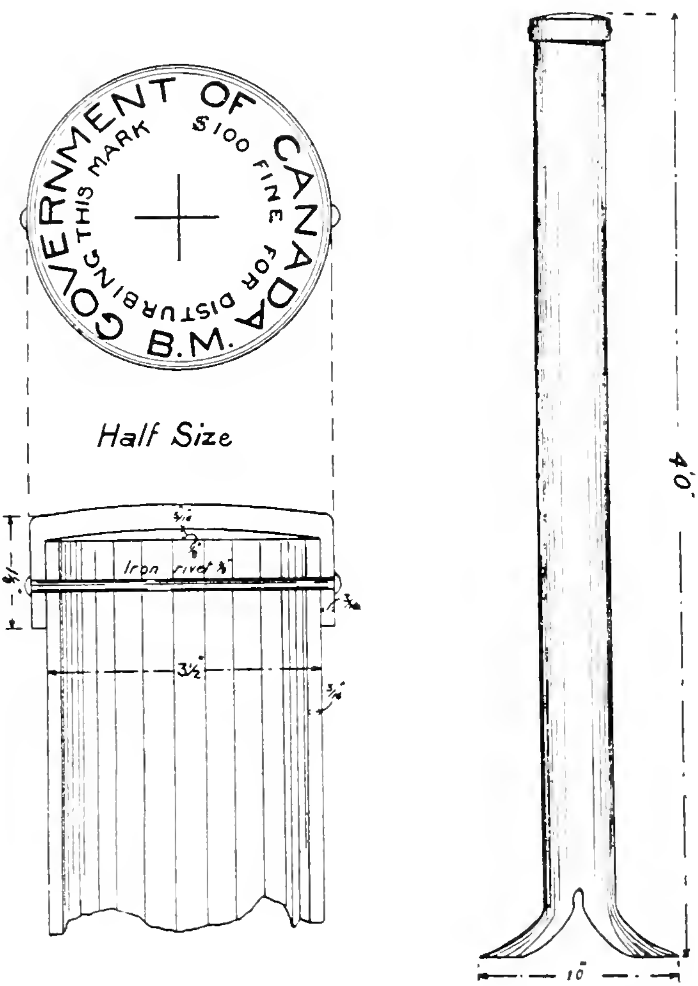
While the North and South Saskatchewan rivers are not likely to be of importance for irrigation purposes, they are large streams and may be utilized for power and irrigation purposes. The watersheds are large, and records on these streams will also be of considerable value for general statistical purposes.

SESSIONAL PAPER No. 25d

DEPT. OF THE INTERIOR

IRRIGATION OFFICE

# PLAN OF PERMANENT IRON BENCH MARK



Investigations in this district were commenced in March, 1911, when miscellaneous gaugings were made on the North Saskatchewan River at Edmonton and Battleford by W. H. Greene.

In May, H. R. Carscallen was placed in charge of this district, and at once established stations at Edmonton, Battleford and Saskatoon. Later a station was established at Prince Albert by J. C. Keith.

In 1910, Mr. Keith reconnoitered Red Deer River in the vicinity of Red Deer and found that the most suitable site for a regular gauging station was at a traffic bridge west of Innisfail. Arrangements were made for an observer, but he failed to perform the duty. Gaugings were made at regular intervals at this station during 1911, but no gauge-height observations were secured. In November, a further reconnaissance was made, and, as the cross-section has improved and conditions are now fairly good, a station was established at the traffic bridge in the town of Red Deer.

Mr. Carscallen had charge of the field-work in this district until the end of July, when he received leave of absence. After that Mr. Keith included this district in his route. Gaugings were continued during the winter at all the stations except the one on Battle River. Different members of the staff have done parts of the final computations for this district, but they are only partly finished.

On account of the distance between the stations the travelling and living expenses of the hydrographer are somewhat higher than in the other districts. For several months the hydrographer worked without a regular helper and hired locally what help he required, but, as the rivers in this district are very large, much skill is required in making accurate measurements, particularly the soundings, and so much time was lost with an inexperienced helper that it was decided that the hydrographer should have a regular helper.

### CURRENT-METER RATING STATION

In 1911, a new and up-to-date current-meter rating station was established at Calgary. The plans, specifications and estimate of cost for the station and equipment were prepared by the Commissioner of Irrigation, and the construction was also carried out under his personal direction. Particulars of the station and a discussion of the methods employed in and the results of ratings are republished from the general report on Irrigation and Canadian Irrigation Surveys as an appendix to this report.

H. C. Ritchie acted as resident engineer on the construction of the rating station, On the completion of this, he was transferred to the National Parks branch of the Department of the Interior, and V. A. Newhall was detailed to rate the meters.

All the meters of the survey except four which were not used during 1911 and one which was badly damaged were rated and tables were carefully compiled for each. Three meters belonging to the British Columbia Railway Belt Hydrographic Survey and one belonging to the Irrigation Department of the Canadian Pacific Railway were also rated. A number of meters were re-rated just before freeze-up in the fall and all the hydrographers are provided with newly rated meters when they start out in 1912. The spare meters will be rated as soon as possible, and whenever a hydrographer has reason to believe that the rating of his meter has changed, a newly rated meter will be sent out to him and he will return the old meter. Every meter which is in use will be rated at regular intervals to test it. In future a hydrographer will be retained at headquarters to rate meters, look after the taking of gravel from Bow and Elbow rivers within the limits of the city of Calgary, and do any special hydrographic work that may arise.

### BENCH-MARKS

In previous years when regular gauging stations were established, the gauge was usually referred to a bench-mark on a wooden stake or the stump of a tree. These were easily shifted or destroyed, and were not satisfactory. During 1911, permanent iron bench-marks were established at 62 regular gauging stations. Except where the gauge can be referred to a bench-mark on a concrete pier or other permanent structure, all the new gauges (and as soon as possible all the old gauges) will be referred to permanent iron bench-marks. An assumed elevation has been given to each bench-mark, but it is expected that the actual elevation above mean sea-level will eventually be determined.

Plate No. 2 shows the type and details of the permanent iron bench-mark which is used. This is the type of bench-mark that has been adopted by the United States Geological Survey, and over 20,000 bench-marks of this type have been used in the United States.

It is made of a piece of three and a half inch wrought-iron pipe, which is split at the bottom and expanded to a width of ten inches in order to anchor the tube solidly in the ground. The top is covered by a cap, cast out of brass or, preferably, aluminum bronze (10 per cent aluminum and 90 per cent copper), which is secured to the top of the pipe by a long iron rivet. All the writing on the cap is cast in sunk-in letters, giving a smooth surface to the cap. All the exposed surfaces of the iron pipe are given a good coat of a first-quality rust-resisting paint, and the bench-mark is set with six inches projecting above the ground.

When extensive levelling operations are commenced it will be necessary to have some form of bench-mark which can be set in solid rock or solid masonry. For such places the brass cap for the iron bench-mark would be modified and have a stem about three inches long projecting on the under side, which would be cemented into a drill hole in the rock or masonry.

## OFFICE-WORK

As above intimated, the reports of the gauge-height observers and the hydrographers are transmitted to the office by post-cards. These are copied to office forms and filed in a cabinet, which is carefully indexed and where they can be referred to at any time without trouble. As the engineers completed their computations the results were entered on convenient forms and filed in the same cabinet.

A cabinet made up of four styles of drawers is used for filing the records. The top section is used for filing the gauge-height books of the observers and the current-meter note-books of the hydrographer. The gauge-height books are filed alphabetically according to the names of the gauging stations, while the current-meter note-books are filed alphabetically according to the names of the hydrographers. The next section contains the post cards sent in by the observers and the hydrographers. Both of these are filed alphabetically according to the names of the gauging stations. The third section is made up of map drawers and contains the gauge-height-area, gauge-height-mean-velocity and gauge-height-discharge curves and plotted cross-sections, which are filed alphabetically according to the names of the gauging stations. The same section contains the maps showing the outline of the drainage basins, filed numerically according to the number of the sectional sheet. The rating curves for the current-meters are also filed in this section, numerically according to the office numbers of the meters. The bottom section of the cabinet consists of letter-size pockets, alphabetically arranged for each gauging station. The tables of gauge-heights, discharge measurements, daily gauge-height and discharge, monthly discharge and a description of the station and memos of any changes are filed in these pockets. The different rating tables for each meter are also filed numerically in this section and another drawer contains the monthly reports of the meteorological service.

The copying and filing of the reports of the gauge-height observers and the hydrographers is entrusted to the office recorder. While doing this, he must carefully examine all records to see that there are no errors or mistakes, and where there are doubtful or impossible records it is his duty to have the data corrected or ascertain the cause of the unusual condition. He also makes out the pay list for the observers and conducts the correspondence relating to the records.

There was no regular recorder until about the end of July, when R. H. Goodchild was engaged. He is to be placed on irrigation inspections, and G. H. Nettleton will be placed in charge of the records.

All computations made by the survey are checked before being used or published. For this reason, as far as possible, men with some technical education or students in science are engaged as helpers. The gaugings are computed by the helper, and his work is checked by the hydrographer. In some instances, where there is a great deal of driving and camping out, the hydrographer cannot secure a helper who can compute discharges, and, in that case, he computes the discharges himself and his computations are checked in the office. Gaugings of the flow under ice are usually made by using the multiple-point method and vertical-velocity curve have to be plotted to determine the mean velocity in the vertical. The computation by this method is long and tedious and cannot be done by the hydrographer in the field. There are therefore, a great many computations to be made in the office and the services of a computer have been required. As a result of not having one, a large amount of checking and computing had to be done by the hydrographers after they returned to the office, and for that reason the computation of daily discharge for 1911 had not been all completed when spring arrived and the hydrographers had to leave for the field. Those that are unfinished are mostly for the months of November and December, when ice conditions prevailed, and considerable time has to be spent in computing the discharge. During the winter months R. J. Srigley, one of the helpers, was utilized as a computer. He is, however, going out in the field again as a helper, and a computer is urgently required.

## FUTURE WORK

Investigations will be continued during the coming year in all the old districts except Wood Mountain, and every effort will be made to extend the territory covered by the survey, but the scope of the work is of course limited by the appropriations and staff available.

There are a number of important streams which rise in the mountains west of the Calgary and Edmonton branch of the Canadian Pacific Railway. With the advent of railways, industries will soon be started in this district and the water-supply will be an important factor. A small party, such as operated in Wood Mountain district during 1911, should be placed in this district in the near future.

An effort will be made during the coming year to collect data regarding the flow in the streams along the Grand Trunk Pacific Railway west of Edmonton. As soon as funds and staff are available, the survey should be extended to include the Athabaska River drainage basin.

It is not necessary to elaborate on the importance of continuing observations during the winter on the more important streams. The minimum flow occurs during that season and should be determined for use in considering power schemes. While it was realized that the streams got very low during the winter, the results of the investigations in many cases show much lower discharge than was expected. An instance of the value of winter records may be cited in the case of Elbow River. Estimates of the possible power development based on records of the flow during the open season were found to be far too high when records of the winter flow were taken.

The survey should be extended eastward to include the streams in the Province of Manitoba. As the market for power is increasing, the time is approaching when every site will be developed. Reliable estimates of the possible power development cannot be made without a knowledge of the water-supply, and as records should extend over a period of several years in order to show the extremes of flow and a reliable mean, it is important that the studies be commenced at the earliest possible date.

The water-supply is one of the most important resources of a country, and an accurate knowledge of the flow of water in nearly all important streams is essential for the solution of many problems in connection with navigation, water-power, irrigation, domestic and industrial water supplies, sewage disposal, mining, bridge-building, river-channel protection, flood prevention, and storage for conservation of flood waters. The records of the survey are being used quite extensively now by engineers and the time is at hand when the field-operations should be extended to include other parts, if not the whole, of the Dominion.

## DEFINITIONS

The volume of water flowing in a stream is known as run-off or discharge. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are 'second-feet,' 'acre-feet,' 'run-off per square mile' and 'run-off in depth in inches' and may be defined as follows:

'Second-foot' is an abbreviation for cubic foot per second. A 'second-foot' is the body of water flowing in a stream one foot wide and one foot deep at the rate of one foot per second.

The 'acre-foot' is the unit capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of one foot.

The expression 'second-feet per square mile' means the average number of cubic feet of water flowing each second from every square mile of drainage area on the assumption that the run-off is uniformly distributed.

'Depth in inches' means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rain-fall, which quantity is usually given in depth in inches.

It should be noticed that 'acre-feet' and 'depth in inches' represent the actual quantities of water which are produced during the periods in question, while 'second-feet,' on the contrary, is merely a rate of flow per second.

## EXPLANATION AND USE OF TABLES

The data obtained and the estimates made therefrom have been compiled in tabulated form and for each regular gauging station are given, as far as available, the following data:—

1. Description of station.
2. List of discharge measurements.
3. Daily gauge-height and discharge table.
4. Table of monthly discharges and run-off.

The description of stations gives such general information about the locality and equipment as would enable the reader to find and use the station. It also gives, as far as possible, a complete history of all the changes that have occurred since the station was established and that might affect the records in any way.

The list of discharge measurements gives the results of all the discharge measurements that have been made at or in the vicinity of the gauging station or have been used in completing the records for the gauging station. It gives the date on which the measurement was made, the name of the hydrographer, the width and area of cross-section, the mean velocity of the current, the gauge-height and the discharge in second feet.

The table of daily gauge-heights and discharges given in this report is a combination of two tables kept in the office of the survey, namely, the table of daily gauge-heights and the station water rating table. The table of daily gauge-heights gives the daily fluctuations of the surface of the above the zero of the gauge, as reported by the observer. During high water, two observations of the gauge were made at some stations, and the gauge-height given in the table is the mean of the observations for the day. The discharge measurements and gauge-heights are the base data from which the other tables are computed. The table of the daily discharges is the discharge in second-feet, corresponding to the stage of the stream, as given by the station rating table.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gauge-height was highest. As the gauge-height is the mean for the day, there might have been short periods when the water and the corresponding discharge were greater than given in this column. Likewise, in the column "Minimum" the quantity given is the mean flow for the day when the mean gauge-height was lowest. The column headed "Mean" is the average flow for each second during the month. The computations for the quantities in the remaining columns have been based upon this mean. The drainage area for each gauging station was marked off on the sectional maps of the Department and the area taken off with a planimeter. In many districts, information regarding topographical features is very incomplete and the computed areas are only approximate. As the surveys of the Department are extended and completed these computations will be checked and, if necessary, corrected.

CONVENIENT EQUIVALENTS

The following is a list of convenient equivalents for use in hydraulic computations:—
1 second-foot equals 35.7 British Columbia miner's inches, or one British Columbia miner's inch equals 1.68 cubic feet per minute.
1 second-foot equals 6.23 British imperial gallons per second; equals 538,272 gallons for one day.
1 second-foot equals 7.48 United States gallons per second; equals 646,272 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet; equals 724 acre-feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one 28-day month covers 1 sqaure mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 British Imperial gallons per min. equals 0.268 second-foot.
100 United States gallons per min. equals 0.223 second-foot.
1,000,000 British Imperial gallons per day equals 1.86 second-feet.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 British Imperial gallons equals 3.68 acre-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 43,560 cubic feet.
1 acre-foot equals 271,472 British Imperial gallons.
1 acre-foot equals 325,850 United States gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 acre equals 43,560 square feet.
1 cubic foot equals 6.23 British Imperial gallons.
1 cubic foot equals 7.48 United States gallons.
1 cubic foot of water weighs 62.5 pounds.
1 foot per second equals 0.682 miles per hour.
1 horse-power equals 550 foot-pounds per second.
1 horse-power equals 746 watts.
1 horse-power equals 1 second-foot falling 8.80 feet.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{Fall in Feet}}{11}$ = Net Horse-power on Water-wheel, realizing 80 per cent of theoretical power.

METHODS OF MEASURING STREAM FLOW

There are three distinct methods of determining the surface flow of streams: (1) By measurements of slope and cross-section and the use of Chezy's and Kutter's formulae; (2) by means of weirs, which include any device or structure that by measuring the depth on a crest or sill of known length and form, the flow of water may be determined; (3) by measuring the velocity of the current and the cross-section. The third method is the one most commonly used by this survey. The second is used when the flow is too small to be accurately determined by the third, while the first is only used in making estimates of the discharge of a stream when the only data available are the cross-section and slope.

*Slope Method of Determining Discharge.*—The slope of a stream, or, rather, of a section of a stream, is the difference in elevation between the upper and lower ends of the section, commonly called the fall, divided by the distance or the length of the section. Slope sections vary in length from two or three hundred feet to several hundred feet, depending largely upon the nature of the stream.

It is difficult to ascertain accurately the slope of the water surface in a stream, since in nearly all streams there are pulsations in the water, causing the surface to rise and fall locally. In most streams the slope of the bottom is far from uniform, and the flow of water in any given section is more or less influenced by the flow in the adjacent section, above or below. For this reason it is a good plan to consider a number of adjacent sections, comprising a considerable length of the stream, in one computation, being careful to take into account the diversity of cross-section at various places in the length.

In determining the slope of the surface of a stream, levels are taken of the water surface at each end of the slope section, and referred to some datum or bench-mark. A good plan is to set firmly a stout wooden stake below the water surface at each end of the slope section, and then to drive a nail into the top of each stake, so that the nail-head will exactly coincide with the water surface. The difference in elevation between the two nails-head, divided by the distance between the stakes, will give the slope.

The wetted perimeter is that portion of a stream channel that is in contact with the water. The form or outline of the wetted perimeter of a stream has an important influence upon the velocity of the current. It is usually determined graphically from the plotted cross-section or may be measured by means of a flexible tape or chain after the flood has subsided.

The hydraulic radius, which is sometimes called the mean radius of the channel below the water surface, is found by dividing the area of the cross-section (in sq. ft.) by the length of the wetted perimeter (in feet).

The Chezy formula, which is the fundamental formula for stream discharge, is:

$$Q=A\,V$$

in which $Q$ = the discharge of the stream in sec.-ft.
$A$ = the area of the cross-section in sq. ft.
$V$ = the mean velocity of flow, in ft. per sec.

In applying this formula to the determination of stream discharge, the mean velocity of a stream is considered a function of the slope and of the wetted perimeter of the stream. This may be expressed by formula as follows:

$$V=C\sqrt{r\,s}$$

in which $r$ = the hydraulic radius of the channel.
$s$ = the surface slope.
and $C$ is a variable coefficient, depending upon the nature of the channel.

In determining the value of $C$ for any given case it is customary to make use of Kutter's formula, which is:—

$$C=\frac{41.6+\frac{.00281}{s}+\frac{1.811}{n}}{1+\left(41.6+\frac{.00281}{s}\right)\frac{n}{\sqrt{r}}}$$

In this formula $r$ and $s$ have the same significance as in the Chezy formula and the new factor $n$ is called the coefficient of roughness. It is a variable coefficient, and its value is dependent upon the size, shape, slope and degree of roughness of the channel. Tables of values of $n$ are given in various text books, but it is difficult to choose the correct value. It is, therefore, advisable whenever possible to compute the value of $n$ from a measured discharge. As the slope method of determining discharge is seldom employed except to estimate flood discharge, a current meter measurement is very often made at the slope section, during low water. Having determined the mean velocity, slope and hydraulic radius at the time of the metering, the value of $C$ may be found from the formula $V=C\sqrt{rs}$ or $C=\frac{V}{\sqrt{rs}}$. Trautwine's Pocket Book for Civil Engineers and other texts contain tables giving the value of $n$ for different values of $r$, $s$, and $c$. From these tables we can interpolate the proper value of $n$ for a particular section of the stream, at low-water stage. In most cases this value of $n$ is applicable to high-water and flood conditions of the stream also and is used with values of $r$ and $s$ for the high-water or flood cross-section to determine the value of $C$ at the higher stage. Having determined the value of $C$ the computation of the discharge is simple.

The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value of $n$ to be used.

*Weir Method of Determining Discharge.*—As yet no permanent weirs have been constructed by this survey, and the only regular weir measurements have been on small streams by means of a temporary weir. The weir used consists of a wooden base of 2-inch plank, to which is bolted a rectangular notch of three-eighths inch steel with bevelled edges.

In making a measurement by means of a temporary weir, the following directions should be followed as far as possible. The weir should be placed perpendicular and at right angles to the bed of the stream with the crest level. The discharge should be free in so much as the *nappe* should have sufficient fall to allow air to have free circulation underneath it, and the head or depth on the crest should not exceed one-third of the length. The channel of approach should be several times as wide as the opening and the depth of water in the bay or pond should be at least twice the head on the weir, so as to eliminate velocity of approach and cross-currents. In choosing a site for a weir, a point should be chosen that will fulfil the above conditions and give a good sized bay or pond.

To set up a temporary weir, a dam of sods and earth are thrown across the stream, the weir set in place and the sods tramped firmly around it to stop all leakage. On a stream with a sandy bed, sods or clay must be placed on the bottom for a few feet upstream to form a mattress to prevent the undermining of the dam.

After the bay has filled up, the head of the water is observed by taking the difference in elevation of the crest of the weir and the elevation of the water surface in the bay at a distance of 4 to 10 feet from the weir, with an engineer's level. Two common methods of getting the elevation of the water surface are (1) hold the levelling rod on a stone or other solid body under water and subtract the depth of water on the rod from the sight on the rod; (2) drive a pin divided into tenths of feet into the bed of the stream so that an even tenth is level with the surface of the water, then hold the levelling rod on the top of the pin and add the length of pin above the water to the sight on the rod.

When the head of water has been determined, the discharge is computed by using one of the standard formulae which will suit the case. Tables giving the discharges for different heads and lengths of crests are published in many engineering texts.

The formula used by this survey for rectangular sharp-crested weirs is:

$Q=3.33\ (L-.2H)\ H^{3/2}$ being a modification of Francis' formula, to allow for end contractions and elimination of velocity of approach.

in which $Q$=discharge in sec. ft.; $L$=length of crest in feet; $H$=head in feet.

Measurements by means of temporary weirs should be made some distance above or below the gauge. If they are made close to a gauge, the gauge must be read before the weir is placed in the stream and the pond must be allowed to run off after the weir is removed before the gauge is re-read.

*Velocity Method of Determining Discharge.*—There are two methods of determining the velocity of flow of a stream, namely, direct and indirect. In the direct method, by which the velocity is determined by means of floats, the liability of error is large, and the results far from satisfactory. This method is seldom used except for very rough estimates or when a current meter cannot be used. There are three common kinds of floats, viz: surface, sub-surface and tube or rod floats. In each the procedure is the same. A straight piece of channel is selected for the run and two cross-sections taken at some convenient distance apart, usually from 100 to 200 feet. They are then divided into strips by means of a tagged wire. The velocity in each strip is then measured by noting the time taken by the float in traversing the run or distance between the two cross-sections. As the time and distance are both known the velocity can easily be computed. The velocity, whether measured by surface, sub-surface or tube floats, must be multiplied by a coefficient less than unity to reduce the mean velocity before being used to compute the discharge.

The indirect, or current-meter, method is the most reliable and most widely used method of determining the velocity of the flow of a stream. The meter used by this survey is the Price Patent, manufactured by W. & L. E. Gurley, Troy, N.Y. It consists of six cups attached to a vertical shaft which revolves on a conical hardened steel point when immersed in moving water. The number of revolutions is indicated electrically. The rating of relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From this data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time-interval.

The accuracy of a discharge measurement taken at a velocity-area station is dependent on two factors, namely, the accuracy with which the area of the cross-section and the mean velocity of the flow normal to that section are measured. There is no special difficulty in measuring the first factor, but the second, the velocity, is very difficult to measure accurately, because it is constantly changing. It varies not only from the surface to the bottom but from one bank of the stream to the other, making it necessary to measure it at a number of points.

In making a measurement with a current meter, a number of points, called measuring points, are measured off above and in the plane of the measuring section, at which observations of depth and velocity are taken. These points are spaced equally for those parts of the section where the flow is uniform and smooth, but should be spaced unequally for other parts according to the discretion and judgment of the engineer. In general, the points should not be spaced farther apart than five per cent. of the distance between piers, nor farther apart than the approximate mean depth of the section at the time of the measurement.

The measuring points divide the total cross-section into elementary strips, at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the ends, the width of the strip, and the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.

## METHODS OF DETERMINING MEAN VELOCITY

There are a number of different methods of determining the mean velocity at the ends of these strips, or, as it is commonly called, the 'mean velocity in a vertical', namely, multiple-point, single-point, and integration. These three principle multiple-point methods in general use are the vertical velocity-curve, three-point, and two-point method.

*Vertical-velocity Curve Method of Determining Mean Velocity.*—In this method the centre of the meter is held as close to the surface of the water as is possible, being careful to keep it out of reach of all surface disturbances, and then at a number of different depths throughout the vertical. The velocity at each position of the meter is recorded. These observations are then plotted with velocities in feet per second as abscissae and their corresponding depths in feet as ordinates and a mean curve is drawn through the points. The mean velocity for the vertical is obtained by dividing the area bounded by the curve and its axis by the depth. In the absence of a planimeter for measuring the area, the depth is divided into 5 to 10 equal parts, and the velocities of the centre ordinates of these parts are noted. The mean of these velocities will very closely approximate the mean in the vertical.

It is often more convenient, when the depth is a number of feet and a fraction, as 7.4, to divide the depth into 7 parts of a foot width, and a part of 0.4 foot width. Then the velocity to enter for the narrow part is 0.4 of the velocity at the centre of it.

The vertical-velocity curve is useful in studying the manner in which velocities occur in a vertical. From a study of a number of these curves the other shorter methods of determining mean velocity are deduced. This method is not used in general routine measurements, except during the winter, on account of the length of time taken to complete a measurement, for a change of stage is almost sure to occur during a measurement on a large stream which counterbalances the increased accuracy. For this reason its use is limited to the determination of the coefficient to be used in the reduction of values obtained by other methods of measuring velocity to the true value, to the measurement of velocities under new and unusual conditions of flow, and for measurements under ice.

*Three-Point Method of Determining Mean Velocity.*—This method gives the greatest accuracy outside of the vertical-velocity curve and is the method most commonly used by this survey during the open season. The meter is held at 0.2 in., 0.6 in., and 0.8 in. depth. The mean velocity is then obtained by dividing by 4 the sum of the velocities at 0.2 and 0.8 depth plus twice the velocity at 0.6 depth. It is the best method to use during low water, or in wide shallow streams having a rough bed, where the thread of mean velocity varies considerably from the 0.6 depth.

*Two-Point Method of Determining Mean Velocity.*—In studying the vertical curves made at a number of different points and under varied conditions it has been found that the mean of the velocities occurring at 0.2 and 0.8 depth gives very nearly the mean velocity in the vertical. Use is made of this fact in the two-point method of determining mean velocity, the meter being held at 0.2 and 0.8 depth in the vertical. This method has been found more accurate than the single point method and the time required for a metering is not very much greater. This method has been found to give, also, a very close approximate to the mean velocity in measurements of ice-covered streams, although these flow under very different conditions from those of open water.

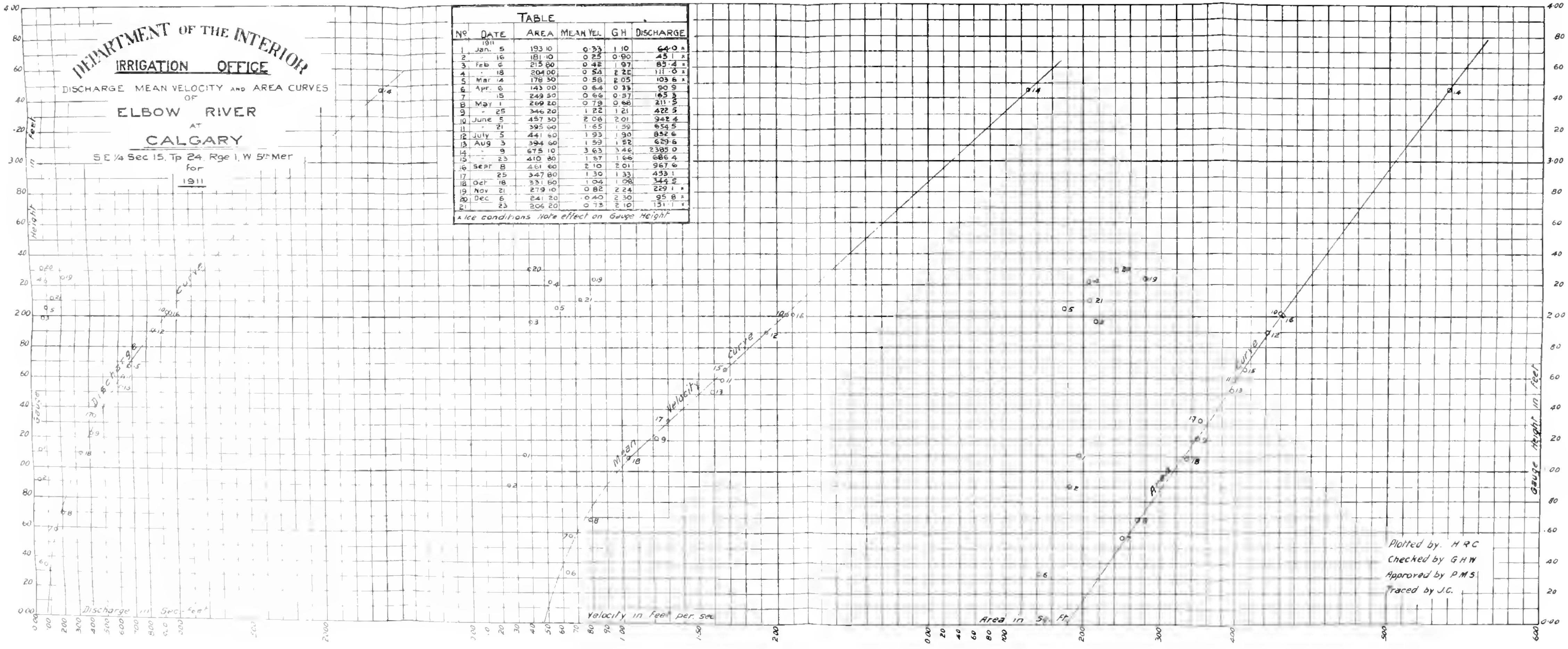
*Single-Point Method of Determining Mean Velocity.*—Experiments made under most favourable conditions and extending over a long period have established the point of mean velocity in a vertical at 0.6 of the depth. Therefore the error resulting from the use of the 0.6 depth as the depth of mean velocity is very small, though in some few cases a study of the vertical-velocity curve will show the need of a coefficient to reduce the observed velocities to the mean. The variation of the coefficient from unity in individual cases is, however, greater than the two- or three-point method and the general results are not as satisfactory. For that reason this method is not employed very extensively by the survey.

In the other principal single-point method the meter is held near the surface, at from 0.5 to 1 foot below the surface, care being taken to sink the instrument below the influence of wind or waves. The resulting velocities must be multiplied by a coefficient to reduce them to mean velocities. This coefficient, as found by a large number of experiments, varies from 0.78 to 0.98, depending upon the depth and speed of the stream. The deeper the stream and the greater the velocity, the larger the coefficient. In flood work coefficients varying from 0.90 to 0.95 should be used. This method is only used when the current is too strong to permit the sinking of the meter to any great depth below the surface of the water. It is often employed at times of flood, or when a stream is carrying a lot of drift wood or ice.

*Integration Method of Determining Mean Velocity.*—This method of determining the mean velocity in a vertical consists in moving the meter at a slow uniform speed from the bed of the stream to the surface and return in a vertical direction, the time and revolutions being observed. In travelling through all parts of the vertical the meter is acted upon by each and every thread of velocity from the bed to the surface of the stream, and the resulting observations determine the mean in that vertical.

This method is very useful in checking the results of other methods. It is, however, seldom used by this survey, as the Price meter is not suited to observations by this method, since the vertical motion of the meter causes the wheel to revolve.

Plate No. 3.




TABLE

| No | Date | Area | Mean Vel. | G.H. | Discharge |
|---|---|---|---|---|---|
| | 1911 | | | | |
| 1 | Jan. 5 | 193.10 | 0.33 | 1.10 | 64.0 x |
| 2 | " 16 | 181.10 | 0.25 | 0.90 | 45.1 x |
| 3 | Feb 6 | 215.80 | 0.42 | 1.97 | 85.4 x |
| 4 | " 18 | 204.00 | 0.54 | 2.25 | 111.0 x |
| 5 | Mar 14 | 178.30 | 0.58 | 2.05 | 103.6 x |
| 6 | Apr. 6 | 143.00 | 0.64 | 0.33 | 90.9 |
| 7 | 15 | 249.50 | 0.66 | 0.57 | 165.3 |
| 8 | May 1 | 269.20 | 0.79 | 0.68 | 211.5 |
| 9 | " 25 | 346.20 | 1.22 | 1.21 | 422.5 |
| 10 | June 5 | 457.30 | 2.06 | 2.01 | 942.4 |
| 11 | " 21 | 395.60 | 1.65 | 1.59 | 654.5 |
| 12 | July 5 | 441.60 | 1.93 | 1.90 | 852.6 |
| 13 | Aug 3 | 394.60 | 1.59 | 1.52 | 629.6 |
| 14 | " 9 | 675.10 | 3.63 | 3.46 | 2385.0 |
| 15 | " 23 | 410.80 | 1.67 | 1.66 | 686.4 |
| 16 | Sept 8 | 461.60 | 2.10 | 2.01 | 967.6 |
| 17 | 25 | 347.80 | 1.30 | 1.33 | 453.1 |
| 18 | Oct 18 | 331.80 | 1.04 | 1.08 | 344.5 |
| 19 | Nov 21 | 279.10 | 0.82 | 2.24 | 229.1 x |
| 20 | Dec 6 | 241.20 | 0.40 | 2.30 | 95.8 x |
| 21 | 23 | 206.20 | 0.73 | 2.10 | 151.1 x |

x Ice conditions Note effect on Gauge Height

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# Department of the Interior

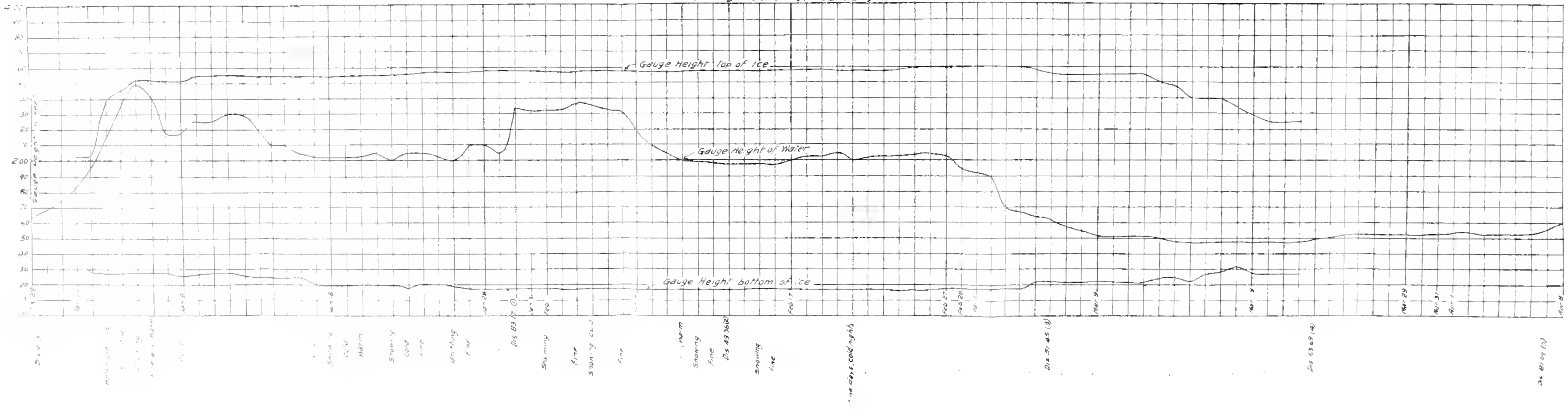
## IRRIGATION OFFICE

DIAGRAM SHOWING

Gauge Height of Top of ice, water surface, and bottom of ice at Gauging Station on

## BOW RIVER AT LAGGAN, ALTA.

during January, February & March - 1911




Note the fluctuation in Gauge Height of water which does not always change in accordance with the weather

Plotted by H.R.C.
Traced by J.C.

## GAUGING STATIONS

The first step is to select a suitable locality for a gauging station. Although apparently simple, this is really a difficult task. Not only must the water be moving in nearly straight lines over a solid bed and between well defined banks, but the place must be accessible at moderate cost, and there must be living near a competent person who can be engaged to serve as observer. Permanent gauging stations should only be selected after a very thorough reconnaissance. In the irrigation districts and in more thickly populated districts there is more or less diversion of water. This is apt to complicate matters for the hydrographer, or a gauging station above all works may not include all the tributaries of the stream and it is often necessary to establish gauging stations at several points along the streams, and on tributaries, canals and pipe lines, in order to obtain complete information regarding the water-supply in a particular stream.

There are three classes of gauging stations, namely, wading, bridge and cable stations. The wading station can, of course, be used only in the case of small streams having a maximum depth at its highest stage of three feet or less. The equipment for a wading station is small, consisting usually of a plain staff gauge, graduated to feet and hundredths, and fixed vertically to one of the banks of the stream. For convenience a measuring line, usually a wire with tags, may be fixed permanently at this section. When taking the reading, the hydrographer should stand below and to one side of the meter, so as to not cause eddies in the water.

Bridge stations, because of their permanency and the freedom of movement allowed the hydrographer, are much preferred. Very often, however, more particularly in swift currents, the piers materially affect the accuracy of the results. When the gauge cannot be attached to a pier, it is often attached horizontally to the guard-rail or floor of the bridge and the height of the stream is found by lowering a weight by a chain over a pulley. It is indicated by a marker on the chain. Distances of three, five, or ten feet, according to the size of the stream, are marked on the lower chord of the downstream side of the bridge, to serve as a measuring line.

Frequently it is impossible to establish a permanent gauging station at a bridge. In that case the wire cable of a ferry can be utilized, or, if that is not available, a permanent wire cable is stretched across the river. For spans of average length a galvanized wire cable three-fourths of an inch in diameter is safe. It is supported at each bank by means of high struts or by passing it through the crotch of a tree. The cable is run into the ground and anchored securely to a 'deadman' buried at least six feet below the surface, or, if convenient, it is anchored to the lower part of the trunk of a tree. A turnbuckle is inserted in the cable between the strut and anchorage to permit tightening the cable when it begins to sag. A permanent measuring line, usually a wire, with tags five or ten feet apart, is stretched across the stream just above the cable. A cage large enough to carry two men and instruments is constructed and suspended from the cable by means of cast-iron pulleys. The cage is moved from point to point by hand. A stay-line, usually quarter-inch guy wire, is stretched across the stream about thirty to forty feet upstream from the cable, and securely fastened. By passing a sash cord through a pulley hung on this stay line the current meter is prevented from being carried down stream.

## LOW-VELOCITY LIMITATIONS

Owing to the presence of a slight amount of friction in the current-meter, a certain definite velocity is required to make the wheel revolve. *i.e.*, to overcome the frictional resistance of the wheel. For this reason the meter is unsuitable for the measurement of low velocities, approaching this value. This velocity, which is required to overcome friction, and which is obtained from the meter-rating curve, is called the velocity of no flow for the particular meter referred to. It varies in different types of meters, and also slightly in meters of the same type, according to the time the meter is in use, but very seldom exceeds 0.2 foot per second in any meter. From a number of observations the low-velocity limit, below which values of velocity are unreliable, is found to be 0.5 foot per second. In many cases at low stages the gauging station on a stream becomes unsuitable for a discharge measurement, owing to the mean velocity in the section falling below the safe limit. In such instances, where it is possible to wade the stream, a suitable gauging section may be located within a reasonable distance of the regular station and the discharge measurements made at this point. When a gauging is made at a cross-section other than the regular station, sufficient soundings should be made at the latter at the time of the gauging to develop the cross-section and compute the area. The measurement is thus referred to the regular gauging station and the mean velocity and area at the regular section is reported and used in the office computations.

## WINTER MEASUREMENTS

The laws governing the flow of streams in open channels have, through extensive investigations, become well defined, but the flow under an ice-cover has been but little investigated. In winter, as in summer, the daily discharge of a stream is computed from frequent discharge measurements and daily gauge-height observations. In most cases, however, the vertical-velocity curve method is used for the determination of the mean velocity in the vertical, as the mean velocity varies considerably. In fact, there are usually two points in the vertical at which the thread of mean velocity occurs under an ice cover. These points are near 0.2 and 0.8 depths and the two-point method will give fairly accurate results, but in this report all discharges are based on computations from vertical-velocity curves.

The discharge measurements are made through holes in the ice from five to ten feet apart, and large enough to allow the meter to pass through freely. The measurement is then taken in the same manner as at open sections, except that the depth of the stream is taken at the distance from the bottom of the ice to the bed of the stream. The soundings, however, are always referred to the surface of the water in the holes, the distance from the surface of the water to the bottom of the ice being measured and subtracted from the sounding to obtain the depth. The meter should be kept in the water continuously to prevent the wheel from freezing and sticking.

The gauge is read once a day, the observer noting the elevation of the water as it rises in a hole cut through the ice, the height of the top of the ice, the thickness of the ice, presence of needle or slush ice, snow on top of ice, ice-jams, and also any sudden changes in temperature. To do this the observers are provided with an ice chisel for chopping holes, and a square to measure the thickness of the ice. Any form of gauge may be used but the chain gauge is the most satisfactory, as the staff gauge, being frozen to the ice, heaves with it.

Some of the cross-sections used in the summer were found to be unsuitable for winter measurements. This was usually caused by the cross-section filling up with slush, needle or anchor ice. There is a flow through this ice, and it is impossible to measure it. The most suitable stations for winter measurements are those where there is a long stretch of very smooth sluggish water above the station and a rapid fall below.

There are certain conditions in Western Canada which make it exceptionally difficult to make estimates of the daily discharge during the winter. The gauge-height in many cases fluctuates very much, and often sudden rises or drops occur. The rises are often explained by the fact that during very cold spells a great deal of slush, frazil and anchor ice is formed and chokes up the channel. thus raising the surface of the water, when in reality the discharge is decreasing. Then, again, a 'Chinook' causes a sudden rise in temperature, and the discharge is often increased, while at the same time the gauge-height gradually lowers, evidently because the warmer water and weather has melted out a lot of the ice from the channel and given it a greater carrying capacity. So far the investigations have proved that, in order to make reliable estimates of the daily discharge, gaugings must be made at short intervals and the weather conditions and temperature must be very carefully noted. There is under the present methods a great deal of work in calculating the discharge by the vertical-velocity curve method and in estimating the daily discharge during the winter months, but as yet no improved or shorter methods have been discovered. It is hoped, however, that, in the near future, the laws governing the flow under ice will be better understood and shorter and easier methods evolved.

A report on the winter conditions in the Banff district during the winter of 1911-12, by V. A. Newhall, district hydrographer, which is appended, explains more fully the difficulties experienced in the field-work during the winter.

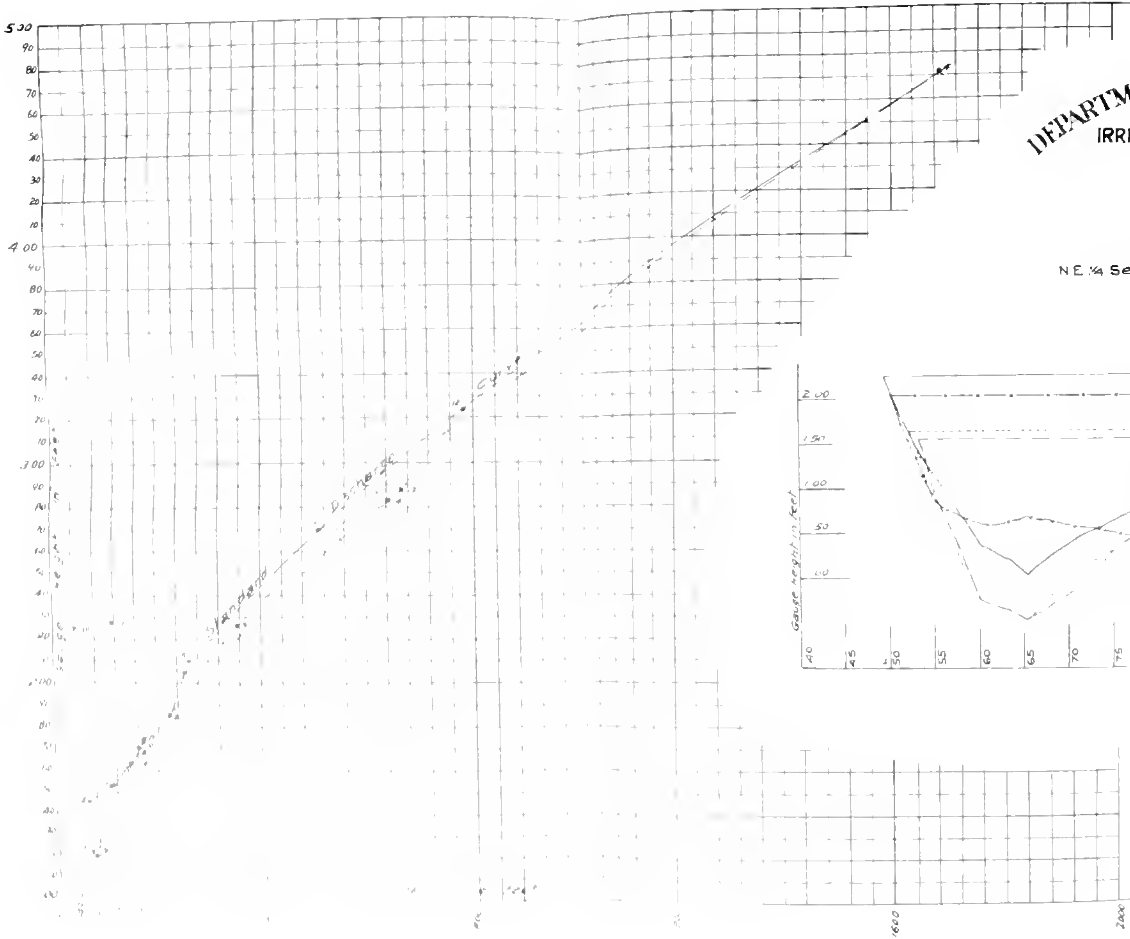
### RE-RATING OF CURRENT METERS

Each meter is rated before being used, in order to determine the relation between the revolutions of the wheel and the velocity of the water. The meter is driven at a uniform rate of speed through still water for a given distance, and the number of revolutions of the wheel and the time are recorded. From this data the number of revolutions per second and the corresponding velocity per second are computed. Tests are made for speeds varying from the slowest which will cause the wheel to revolve to several feet per second. The results of these runs, when plotted with revolutions per second as abscissae and velocity in feet per second as ordinates, locate points that define the meter-rating curve, which for all meters is practically a straight line. From this curve a meter-rating table is prepared. Theoretically, the rating for all meters of the same make and type should be the same, but as a result of slight variations in construction, and in bearing of the wheel on the axis at different velocities, the ratings differ. After a meter has been in use for some time the cups may have received small injuries, or the bearing of the wheel on the axis may have changed owing to unavoidable rough usage. These changes will affect the running of the meter and change its rating. As a consequence each meter is re-rated at regular intervals and a new rating curve and table prepared.

Particulars of the rating station and a discussion of the methods employed in, and the results of, ratings are republished from the report on Irrigation and Canadian Irrigation Surveys as an appendix to this report.

### OFFICE COMPUTATIONS

*Rating Curves and Tables.*—When a series of discharge measurements has been made at a gauging station a rating curve is constructed for that station, showing graphically the discharge corresponding to any stage of the stream within the limits covered by the gaugings. This curve, as it is usually drawn, has an abscissae, the discharges in second-feet and as ordinates, the corresponding gauge heights at which the discharges were made. A smooth curve is drawn through the resulting set of points and from this curve the discharges at any stage within the limits of the curve are taken. Some measurements may be more reliable than others, owing to more or less favourable conditions at different times of gauging, or to other causes. In order to obtain the weight of the different measurements, curves with area and mean velocity, as abscissae, and gauge heights as ordinates, are also drawn. From a study of these curves any discrepancies




# DEPARTMENT OF THE INTERIOR

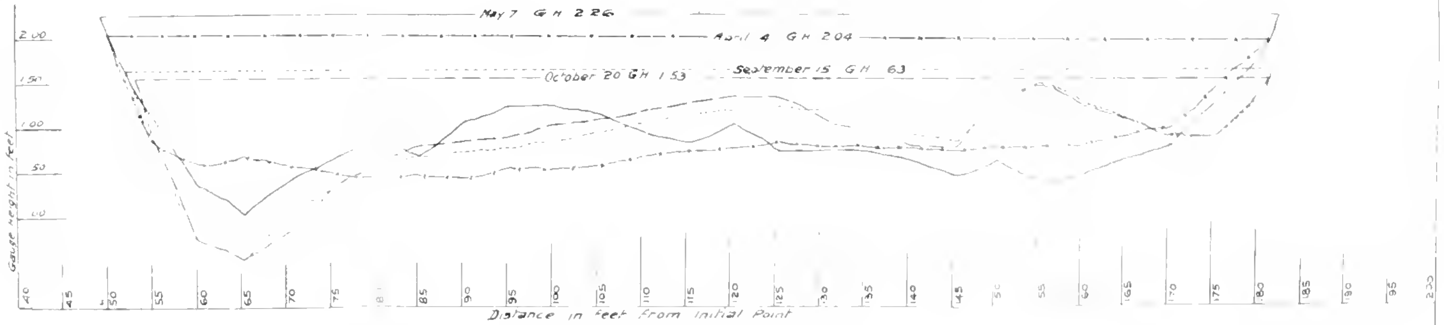
## IRRIGATION OFFICE

DISCHARGE CURVE
OF
MILK RIVER
AT
MILK RIVER
N.E. ¼ Sec 21, Tp 2, Rge 16 W 4th Mer
for
1911.

TABLE

| No | Date | Area | Mean Vel | G H | Discharge |
|---|---|---|---|---|---|
| | 1911 | | | | |
| 1 | Apr 14 | 160 51 | 1 61 | 2 04 | 258 60 |
| 2 | May 2 | 141·08 | 1 59 | 1 85 | 223 81 |
| 3 | " 7 | 186 30 | 1 92 | 2 26 | 358 65 |
| 4 | " 17 | 484 14 | 3 50 | 4 72 | 1692 23 |
| 5 | 22 | 157 40 | 1 68 | 2 10 | 263 82 |
| 6 | June 13 | 113 83 | 1 42 | 1·70 | 162 00 |
| 7 | " 28 | 245 10 | 2 09 | 2 70 | 512 00 |
| 8 | July 5 | 120 80 | 1 45 | 1·74 | 175 45 |
| 9 | " 29 | 69 82 | 1 08 | 1 20 | 75 12 |
| 10 | Aug 10 | 128 58 | 1 34 | 1 73 | 172 60 |
| 11 | " 30 | 67 47 | 99 | 1 22 | 66 78 |
| 12 | Sept 7 | 294 50 | 2 66 | 3 24 | 783 46 |
| 13 | " 8 | 269 11 | 2 48 | 2 88 | 667 15 |
| 14 | " 9 | 259 15 | 2 48 | 2 83 | 643 38 |
| 15 | " 15 | 102 04 | 1·45 | 1 63 | 147 70 |
| 16 | Oct 14 | 83 75 | 1 36 | 1 53 | 113 58 |
| 17 | " 20 | 85 82 | 1 32 | 1 53 | 112 48 |
| 18 | Nov 10 | 45 19 | 1 52 | 1 45 | 68 55* |
| 19 | Dec 7 | 101 67 | 1 18 | 2 28 | 119 80* |
| 20 | 29 | 53 35 | 0 90 | 2 25 | 47·97* |

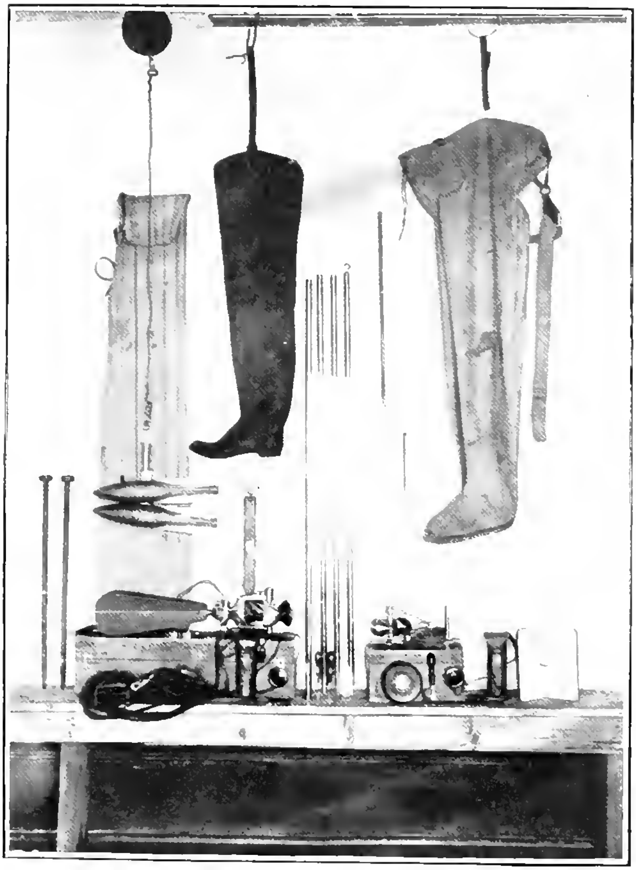
* Ice conditions. Note effect on Gauge height




Sections showing changes in River Bed

Note – Bolster Method used in estimating the daily discharge during periods of changing conditions

Plotted by E.D.
Checked by L.J.G.
Approved by H.R.C.
Traced by J.C.



Meters and Equipment for Measuring the Discharge of a Stream by the Velocity Method. Photo by F. H. Peters.

PLATE No. 7.

Gauging a Small Creek with a 15-inch Weir. Photo by R. J. Burley.

in a measurement, either in its area or mean velocity, may be detected. Should it be necessary to extend the rating curve beyond the limits of actual discharge measurements the area and mean velocity curves may be constructed to the stages for which the discharge curve is desired and the latter found by taking the product of the two curves. The discharge curve under natural conditions of flow is always convex to the gauge height axis. The area curve is either a straight line or is convex to the gauge height axis, except in the case of overhanging banks when it becomes concave to the axis. The mean velocity curve is always concave to the gauge height axis, except in cases where standing water occurs below the stage of no-flow. In this case the curve will assume a reverse form, starting from the gauge height of zero flow with a curve convex to the gauge height axis and gradually reversing to a curve concave to this axis. In plotting all three curves the horizontal and vertical scales should be so chosen that the curves may be used within the limits of accuracy for the work, and in their critical position will make, as nearly as possible, angles of 45 degrees with each axis.

The rating curve being constructed it becomes necessary to prepare a station rating table, giving the discharge at any stage of the stream within the limits of the daily gauge height observations on record. From this rating table the daily discharges corresponding to the daily gauge heights are read and tabulated. The rating table is constructed for tenths, half-tenths, or hundreds of feet, according to the readings of the gauge to which it is to be applied. The discharges for this table are read directly from the rating curve and are then adjusted so that the differences for successive stages shall be either constant or gradually increasing, but never decreasing, unless the station is affected by backwater.

*Daily Discharge, Monthly Mean and Run-Off.*—The rating table being made to cover the range of daily gauge height observations, the next procedure in the computations is to make out a table of daily discharges from this rating table. The daily gauge heights are copied as they were sent in by the observer and opposite each the corresponding discharge is filled in from the rating table. The monthly discharge is found by totalling the daily discharges for the month in question and the monthly mean is obtained by dividing this total by the number of days in the month.

The run-off is computed with two different sets of units, depending upon the kind of work for which the data is intended, as follows: (1) Run-off in inches is the depth to which a plane surface equal in extent to the drainage area would be covered if all the water flowing from it in a given time were conserved and uniformly distributed thereon; it is used for comparing run-off with rain-fall, which is usually expressed in depth in inches. The mean run-off in second-feet per square mile for each month is used. The monthly mean run-off in second-feet is divided by the area of the drainage basin in square miles to find the monthly mean run-off per square mile. This result, reduced to run-off in depth in inches for the monthly period, is in the form required.

(2) The run-off in acre-feet is the form of most use in connection with storage. An acre-foot is equivalent to 43,560 cubic feet, and is the quantity of water required to cover an acre to the depth of one foot. The monthly mean run-off in second-feet is used for the computation of run-off in acre-feet. The monthly mean is reduced to cubic feet per month and this quantity divided by 43,560 gives the run-off in acre-feet.

The run-off of the stream being computed both in depth, in inches and in acre-feet for each month, the run-off for the period, during which observations of run-off were made, is found by the summation of the amounts of run-off for the several months making up this period.

*Changing Conditions of Channel.*—On streams such as Milk River, whose bed is in a constant state of motion, measurements of discharge should be made every few days, otherwise considerable data relating to changes cannot be obtained. For discharges on days other than those on which measurements are taken, the interpolation method is used. The two methods of interpolation in general use are the Stout and Bolster methods.

The Stout method deals with the correction of the gauge heights. A curve is drawn, using the difference between the actual gauge heights at the time of measurement and the gauge height corresponding to the measured discharge as ordinates and the corresponding days of the month as abscissae. From an irregular curve drawn through these points corrections for gauge heights can be made for days on which there was no discharge measurement. When the discharge is greater than that given by the curve the correction is positive and vice-versa. Each daily gauge height is corrected by the amount shown on the correction curve, and the corresponding discharge taken from an approximate rating curve for the station.

The Bolster method deals more particularly with the modification of the discharge. Results of discharge measurements covering a whole year or season are plotted, and though considerably scattered, will define one or more regular curves, called standard curves, the number and position of each indicating the radical changes. Where the river bed changes from day to day, the position of the standard curve also varies and must pass through the points indicating the different days. The points indicating two successive measurements are joined by a line, which for short distances on the cross-section paper is a straight line and otherwise a curve. This line is divided into a number of equal parts, each indicating an intervening day, the assumption being that as the change during this period is gradual the daily rating must pass through each point, or day, as represented by the divisions. A simple and convenient way of making these interpolations and moving the daily rating curve is to make a tracing of the standard curve with a vertical line of reference. By keeping the lines of reference coincident this curve can be shifted into any desired position and the discharge read for any gauge height.

## NORTH SASKATCHEWAN RIVER DRAINAGE BASIN

*General Description*

The North Saskatchewan River draws its water-supply from the eastern slope of the Rocky mountains. The basin is bounded on the south by that of the Red Deer River and on the north by that of the Athabaska River. Its principal tributaries in the mountain district are the Clearwater and Brazeau Rivers. In addition to these there are a great number of smaller streams draining into the river. From the City of Edmonton the river takes a north and easterly course for about forty or fifty miles, and then flows in an easterly direction to its junction with the South Saskatchewan River, a few miles east of the city of Prince Albert, Saskatchewan. From this point it is known as the Saskatchewan River. The greater part of the drainage basin in the prairie section lies to the south of the river and the principal tributaries are the Vermilion and Battle rivers, the former emptying into the main stream north and a little west of the town of Lloydminster, and the latter in the town of Battleford.

In the mountain section the North Saskatchewan River and its tributaries have well defined rocky valleys with a large amount of fall, and the whole drainage basin is well wooded. The valley of the stream widens out as it gets out to the prairies, and gives rise to large fertile flats. The timber in this part of the drainage basin is confined mostly to the river valley. The stream-bed changes from a rocky and fairly solid formation in the mountain district to a gravelly, sandy and very unstable bed as the river comes out on the prairies.

The stream receives the greater part of its water-supply from the mountains. In consequence, the high water occurs in the hot months of summer, caused by the melting snow from the mountains. The low-water period occurs in the winter months, when there is a minimum amount of drainage from the snow fields.

Three stations were established on the main stream in 1911, and daily records of gauge-height were taken at these stations during the season, as well as discharge measurements at regular intervals. These three stations were located at Edmonton, Battleford and Prince Albert. The only tributary touched upon as yet is Battle River, a gauging station having been established on it at Battleford in 1911.

### NORTH SASKATCHEWAN RIVER AT PRINCE ALBERT, SASK.

This station was established October 2, 1911, by J. C. Keith. It is located at the Canadian Northern railway and traffic bridge in the town of Prince Albert on River Lot No. 76, Prince Albert Settlement.

Discharge measurements are made from the downstream side of the bridge, which is a seven-span steel structure on cement piers and abutments. The initial point for soundings is 25 feet north of the iron post at the end of the hand-rail of the bridge, and is suitably marked on the guard-rail of the bridge.

The channel is straight for about one mile above and 300 feet below the station. Both banks are high and will not overflow. The bed is composed of coarse gravel and boulders with a silting of sand near the piers.

The gauge is a plain staff, graduated to feet and hundredths, attached to the shore face of the concrete pier close to the right bank of the stream. It is referred to a Public Works Department bench-mark on a brass bolt on the top of the right abutment at its downstream side, marked 'P.W.D. B.M.47'; the elevation of this bench-mark is 1489.202 feet above mean sea-level. The elevation of the gauge datum is 1456.097 feet.

The gauge was read once daily by L. Murray, of Prince Albert.

As only a few discharge measurements were made during 1911, there are not sufficient data to make accurate estimates of the daily discharge. Tables of daily gauge-heights. daily discharge, and monthly discharge, for 1911, will be prepared during 1912 and published with the records for that year.

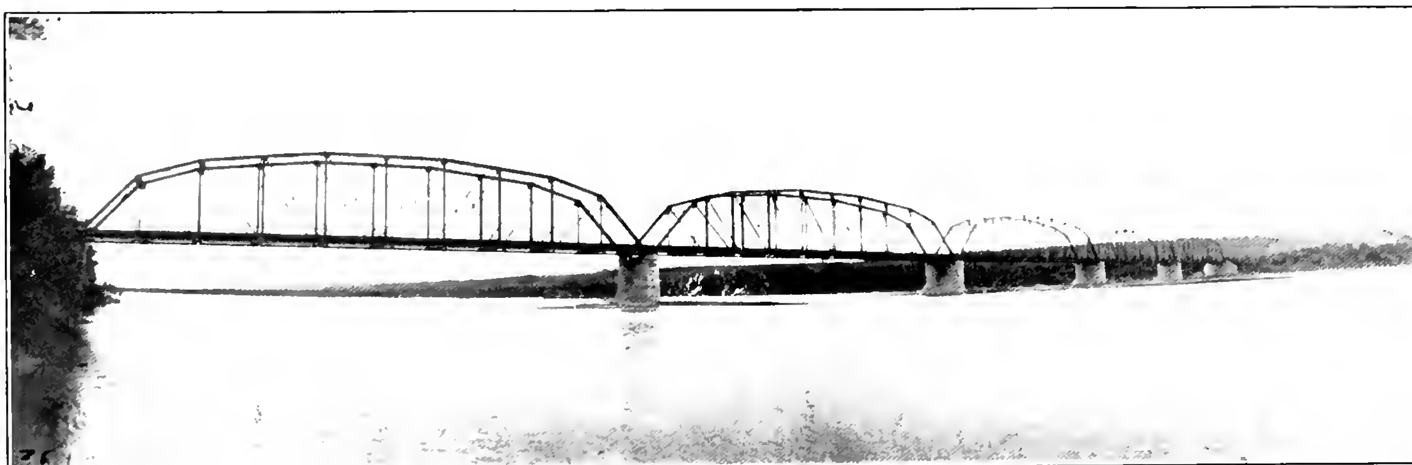
DISCHARGE MEASUREMENTS OF NORTH SASKATCHEWAN RIVER AT PRINCE ALBERT, SASK., in 1911

| Date | Hydrographer. | Width | Area of Section. | Mean Velocity. | Guage Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec. ft. |
| Oct. 2 and 3 | J. C. Keith | 794 | 4874.8 | 2.14 | 6.286 | 10,449 |
| Nov. 24 and 25 | do | 800 | 2463.5 | 1.11 | 4.265 | 2,757† |
| Dec. 14 and 15 | do | ... | 2345.2 | 1.13 | 4.586 | 2,671† |

† Ice conditions.

PLATE No. 8.

Railway and Highway Bridge at Prince Albert. Used as a Gauging Station. Taken by F. H. Peters.



Traffic Bridge over the North Channel of North Saskatchewan River at Battleford, Sask. Used as a Gauging Station. Taken by F. H. Peters.

### NORTH SASKATCHEWAN RIVER AT BATTLEFORD, SASK.

This station was established May 16, 1911, by H. R. Carscallen. It is located at the traffic bridge in the town of Battleford on the northeast quarter of Section 29, and the southwest quarter of Section 33, Tp. 43, Rge. 16, west of the 3rd Mer. A large island in the river at this point divides the stream into two channels and the river is spanned by two steel bridges, one over each channel. The bridge over the north channel is a five-span steel structure on cement piers and abutments; the south bridge is a three-span steel structure on cement piers and abutments. The two channels necessitate the existence of two gauges, one in each channel.

Discharge measurements are made from the downstream side of the bridges. The initial point for soundings for each channel is the north end of the hand-rail on the downstream side of the bridge, and distances are marked at every ten feet on the hand-rails.

The north channel is straight for about 1500 feet above and 1200 feet below the station. The right bank is high, gravelly and free from brush. The left bank is comparatively low, wooded and will overflow at high stages. The bed of the stream is very sandy and shifts continually. Numerous sand-bars appear in the channel at low stages of the stream.

The south channel is straight for about 1500 feet above and 500 feet below the station. The left bank is comparatively low, wooded and will overflow at high stages. The right bank is higher, wooded and not liable to overflow. The bed of the stream is composed of sand and gravel and will shift.

The gauge in the north channel is a plain staff, graduated to feet and hundredths, spiked inside a stilling-box sunk in the bed of the stream at the right bank. The zero (elev., 74.37) is referred to a bench-mark (assumed elev., 100.00) on the top of the downstream end of the left abutment.

The gauge in the south channel is a plain staff graduated to feet and hundredths, spiked to the stream face of the cribbing around the right abutment at its upstream end. The zero (elev., 74.28) is referred to the bench-mark described above.

On November 16, 1911, the above gauges were replaced by chain gauges of the standard type, one in each channel. The gauge in the north channel is located on the floor of the bridge, near the left side of the centre span, The zero of the gauge (elev., 71.87) is referred to the same bench-mark as the staffs. The gauge in the south channel is located on the floor of the bridge at the centre of the right span. The zero of this gauge (elev., 71.02) is also referred to the bench-mark described above.

The gauges were read once each day by George Bond, of Battleford, who lives within half a mile of the bridge on the north side of the river. In his absence the readings were taken by Robert Campbell, who is in the employ of Mr. Bond.

As only a few discharge measurements were made during 1911, there are not sufficient data to make accurate estimates of the daily discharge. Tables of daily gauge-height, daily discharge and monthly discharge for 1911 will be prepared during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS OF NORTH SASKATCHEWAN RIVER AT BATTLEFORD, SASK., in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec. ft. |
| April 3 | W. H. Greene | 624 | 1,848 | 1 29 | . | 2,395 |
| May 18 | H. R. Carscallen | 606 | 1,807 5 | 1 83 | 1 60 | 3,317 |
| May 19 | do | 324 | 2,156 | 2 63 | 1 405 | 5,665 |
| May 18, 19 | do | 930 | 3,963 | | | 8,982 |
| June 15 | do | 805 5 | 2,539 | 2 10 | 2 23 | 5,322 |
| June 16 | do | 457 2 | 3,059 | 2 46 | 2 28 | 7,540 |
| June 15, 16 | do | 12,627 | 5,598 | | | 12,862 |
| July 14, 15 | do | 10,778 | 4,924 | 2 69 | 4 41 | 13,248 |
| July 17, 18 | do | 4,999 | 4,174 | 2 56 | 3 67 | 10,673 |
| July 14-18 | do | 15,777 | 9,098 | . . | . . . . | 23,922 |
| Aug. 9, 10 | J. C. Keith | 1,076 6 | 4,531 | 2 59 | 4 07 | 11,776 |
| Aug. 10, 11 | do | 509 2 | 4,639 | 2 55 | 4 186 | 11,851 |
| Aug. 9-11 | do | 1,585 8 | 9,170 | | . | 23,627 |
| Sept. 25 | do | 807 0 | 2,065 | 2 07 | 1 98 | 4,099 |
| Sept. 26 | do | 442 5 | 2,632 | 2 29 | 1 83 | 6,026 |
| Sept. 25, 26 | do | 1,249 5 | 4,697 | . | . | 10,125 |
| Nov. 13, 14 | do | . . . | 1,078 | 1 17 | 3 21 | 1,266 |
| Nov. 15, 16 | do | . . . | 560 9 | 1 21 | 3 00 | 679 |
| Nov 13-16 | do | . . . | 1,639 | . . | | 1,945 |
| Dec. 7, 8 | do | . . . | 511 | 1.45 | 3 52 | 738 |
| Dec. 8, 9 | do | . . . | 1,085 | 1 83 | 4 065 | 1,988 |
| Dec. 7-9 | do | . . . | 1,596 | . . . . | . . . . | 2,726 |

N.B. —Measurements on and after Nov. 13 were made under ice conditions.

### NORTH SASKATCHEWAN RIVER AT EDMONTON, ALTA.

This station is located at the low-level traffic and railway bridge in the city of Edmonton, on the N.W. quarter Sec. 33, Tp. 52, Rge. 24, W. 4th Mer. The bridge is a four-span steel structure supported by concrete piers and abutments. Between the right pier and the shore, and extending for some distance above and below the bridge, there is a row of timber piers with a long string of booms anchored to them. This boom is for the purpose of conducting logs to the Edmonton Lumber Company's mill, a short distance below the bridge. The boom is sometimes full of logs and at such times it becomes very hard to obtain velocity observations in this span.

The channel is straight for about 700 feet above and 200 feet below the station. Both banks are high, of an earth formation and sparsely covered with brush. The bed of the stream is composed of sand and gravel, and is liable to shift. The three piers of the bridge divide the stream into four channels.

Discharge measurements are made from the donwstream side of the bridge. The initial point for soundings is the stream face of the left or north abutment and is suitably marked on the hand-rail of the bridge.

There are two gauges at this station known as (1) the high-level gauge and (2) the low-level gauge. The high-level gauge is spiked perpendicularly to a high timber pier which is a short distance above the saw-mill, close to the right bank of the river and about 300 yards below the bridge. The gauge consists of two 1 in. x 6 in. x 12 ft. boards faced with tin, stencilled off into feet and tenths and is spiked to the pier in such a manner that the twelve-foot mark on the lower gauge coincides with the zero of the upper gauge. The low-level gauge is spiked to a low pier about 200 feet from the right bank and about 75 feet upstream from the pier to which the high-level gauge is attached. This gauge consists of one 1 in. x 6 in. x 10S board marked in the same way as the high-level gauge. Both gauges are referred to a bench-mark on the down-stream face of the left abutment of the bridge marked "D.P.W." This bench-mark was established by the River Surveys Branch of the Department of Public Works, and their elevation for it is 2025.00 feet above mean sea-level. The elevation of the datum of the high-level gauge is 1995.668 feet; that of the low-level gauge is 1991.728 feet.

This station was first made use of by this survey during the season of 1911. The gauge was read twice daily by an employee of the Edmonton Lumber Company, and the observations were supplied to this office by that Company, but, as only a few discharge measurements were made, there is not sufficient data to compute daily and monthly discharges. The records for this station for 1911 will be completed during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS OF NORTH SASKATCHEWAN RIVER AT EDMONTON, ALTA., in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| Mar. 22, 23 | W. H. Greene | 400 1 | 1,500 | 1 518 | *None.* | 2,278 |
| May 11, 12 | H. R. Carscallen | 431.6 | 3,628 5 | 2 61 | 6.89 | 9,465 |
| June 12, 13 | do | 504.6 | 3,940 2 | 2 93 | 7.61 | 11,550 |
| July 12, 13 | do | 578 0 | 5,790 2 | 3.52 | 10 34 | 20,402 |
| Aug. 4 and 5 | J. C. Keith | 577 9 | 5,639 0 | 3 67 | 10 33 | 20,720 |
| Sept. 19 and 20 | do | 542 3 | 3,908 5 | 2 44 | 7 32 | 9,534 |
| Dec. 22, 26 | do | ... | 1,418 4 | 1 09 | 3 67 | 1,540† |
| Dec. 29, 30 | do | ... | 1,606 | 1 04 | 3 81 | 1,699† |

Note:—Gauge-heights referred to high-water gauge.
Zero of datum, 1995 668.
†Ice Conditions.

### BATTLE RIVER AT BATTLEFORD, SASK.

This station was established June 17, 1911, by H. R. Carscallen. It is located at the traffic bridge about one and one-quarter miles south of the town of Battleford on the S.E. quarter Sec. 19, Tp. 43, Rge. 16, W. 3rd Mer. The station is about three miles above the junction of the Battle River with the North Saskatchewan River. Owing to the station being so close to the mouth of the river, extreme high water in the North Saskatchewan River may cause water to back up on this gauge.

Discharge measurements are made from the downstream side of the bridge which is a three-span steel structure supported by concrete piers and abutments. Remains of old timber piers close to the new ones affect velocity observations in their vicinity. The initial point for soundings is a mark on the hand-rail opposite the stream face of the left abutment.

The channel is straight for about 300 yards above and one-half mile below the station. Both banks are high, sandy and clear of brush. Both banks are riprapped with boulders near each abutment. The bed is sandy and liable to shift.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the downstream face of a short pile near the right bank and about forty feet upstream from the bridge. The zero (elev., 71.95) is referred to a bench-mark (assumed elev., 100.00) on the top of the downstream corner of the left abutment.

During 1911, the gauge was read once daily by C. J. Johnson, who lives within 200 yards of the bridge.

As only a few discharge measurements were made during 1911, there are not sufficient data to make accurate estimates of the daily discharge, tables of daily gauge-height daily discharge and monthly discharge for 1911 will be prepared during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS OF BATTLE RIVER AT BATTLEFORD, SASK., in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| May 29 | H. R. Carscallen | 160.5 | 295.12 | 1.642 | . | 484.70 |
| June 17 | do | 153.3 | 237.26 | 1.38 | 4.00 | 327.67 |
| July 18 | do | 170.3 | 405.16 | 1.85 | 5.05 | 751.13 |
| Aug. 12 | J. C. Keith | 187.2 | 478.98 | 2.13 | 5.55 | 1022.85 |
| Sept. 27 | do | 165.0 | 375.45 | 2.09 | 5.14 | 784.64 |

MISCELLANEOUS DISCHARGE MEASUREMENTS IN NORTH SASKATCHEWAN RIVER DRAINAGE BASIN, in 1911.

| DATE. | Hydrographer | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet* | *Sq. Feet* | *Ft. per sec.* | *Sec.-ft.* |
| Oct. 20 | P. J. Jennings | Ribstone Creek | N.W. 35-43-4-4 | 20.0 | 15.4 | 0.90 | 11.08x |

x Slope measurement.

## SOUTH SASKATCHEWAN RIVER DRAINAGE BASIN

*General Description.*

The upper portion of this drainage basin will be dealt with in the descriptions of the drainage basins of the Bow, Little Bow, Oldman, Waterton, Belly and St. Mary rivers. These streams are all conjoined at a point known as the Grand Forks, to form the South Saskatchewan River. From the Grand Forks the river flows in a north and easterly direction to its junction with the North Saskatchewan river a short distance east of the city of Prince Albert. From this point onward the stream takes the name of the Saskatchewan River.

After the confluence of the Bow and Belly rivers the stream receives comparatively little drainage, the principal tributaries being the Red Deer river, draining that portion of the basin between the North and the South Saskatchewan river, and Sevenpersons river and Swift-current creek emptying into the main stream from the south. Descriptions of the drainage basins of all these streams are given elsewhere in this report.

The drainage basin of this stream is quite similar to that of all such streams as have their source in the mountains and flow across the prairies. The upper part of the basin has a good fall, with rock and gravel formation and a good growth of timber. In contrast to this, the prairie section of the basin is sparsely wooded, except along the banks of the stream, the rock formation changes to earth and the stream is more apt to change its channel, especially in times of flood. The high water, futhermore, occurs in the hot months of summer and is caused by the melting of the snow-fields in the mountains. In consequence, the low water occurs in the winter months, when there is no melting snow to augment the stream flow.

In addition to the gauging station on the tributaries, which are taken up in detail elsewhere in this report, there were two stations established on the main stream during the season of 1911, and daily gauge-height observations and discharge measurements at regular intervals were taken at these stations. These stations are located at the cities of Medicine Hat and Saskatoon.

### SOUTH SASKATCHEWAN RIVER AT SASKATOON, SASK.

This station was established May 27, 1911, by H. R. Carscallen. It is located at the Canadian Northern Railway bridge in the city of Saskatoon, on the S.W. quarter Sec. 28, Tp. 36, Rge. 5, W. 3rd. Mer.

The bridge is a six-span timber structure supported by cement piers and abutments. It was originally set upon timber piers and abutments. Parts of these old piers still remain in the stream close to the new cement ones, and affect velocity observations in their vicinity. There is a foot-bridge on the downstream side of the bridge which facilitates gauging. Discharge measurements are made from the downstream side.

The channel is straight for about 500 feet above and 800 feet below the station. Both banks are high and sandy. The right bank is covered with a dense growth of trees and brush above and below the station. The left bank is clear of brush. The bed of the stream is sandy and shifts.

The gauge is a plain staff, graduated to feet and hundredths, spiked to a pile at the left side of the old timber pier near the left bank of the river. The zero (elev., 63.80) is referred to a bench-mark (assumed elev., 100.00 ) on the top of the downstream end of the left abutment.

The gauge was read once each day by N. M. McDonald, a book-keeper, living within 200 yards of the bridge.

As only a few discharge measurements were made during 1911, there are not sufficient data to make accurate estimates of the daily discharge. Tables of daily gauge-height, daily discharge and monthly discharge for 1911 will be prepared during 1912 and published with the records for that year.

Discharge Measurements of South Saskatchewan River, at Saskatoon, in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| May 27 | H. R. Carscallen | 744 2 | 5,916 | 4.48 | 5.30 | 26,535 |
| June 20 | do | 788 7 | 7,688 | 5.34 | 7 39 | 41,054 |
| July 20, 21 | do | 716 7 | 5,451 | 3.88 | 4 66 | 21,192 |
| Aug. 16, 17 | J. C. Keith | 795.7 | 7,830 | 5.38 | 7 75 | 42,162 |
| Sept. 28, 29 | do | 640.8 | 4,317 | 3.24 | 3.15 | 13,953 |
| Nov. 22 | do | ... | 2,095 | 1.40 | 2 772 | 2,942† |
| Dec. 12, 13 | do | ... | 2,098 | 2 19 | 3.44 | 4,598† |

† Ice Conditions.

SOUTH SASKATCHEWAN RIVER AT MEDICINE HAT, ALTA.

This station was established May 31, 1911, by H. R. Carscallen. It is located at the traffic bridge in the city of Medicine Hat on the N.W. quarter Sec. 31, Tp. 12, Rge. 5, W. 4th Mer.

The bridge is a five-span structure supported by concrete abutments and piers. Discharge measurements are made from the downstream side. The initial point for soundings is the stream face of the left, or west, abutment and is suitably marked on the hand-rail of the bridge.

The channel is straight for about 600 yards above and below the station. The current is moderate and uniform, except in the vicinity of the piers, At these points eddies, and, in some cases, stretches of backwater occur, making it difficult to obtain the mean velocity. The banks are high and sandy and clear of undergrowth. The bed is composed of sand and gravel and is liable to shift at high stages of the stream.

There are two gauges, graduated to feet and hundredths, fixed to the upper pier of the swing span of the C.P.R. bridge about 200 yards below the traffic bridge. The gauges are spiked to the shore face of the pier and are so placed that the datum of the lower gauge is exactly five feet below the datum of the higher gauge. The gauges are referred to a bench-mark (assumed elev., 100.00) on top of the downstream end of the left, or west, abutment of the traffic bridge. The elevation of the datum of the lower gauge is 64.85; that of the upper gauge 69.85.

The gauge was read once daily during the summer by John M. Fleager, a blacksmith, working within fifty feet of the bridge. The observations during the frozen season were made by Alfred Webber.

As only a few discharge measurements were made during 1911, there are not sufficient data to make accurate estimates of the daily discharge. Tables of daily gauge-height, daily discharge and monthly discharge for 1911 will be prepared during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS OF SOUTH SASKATCHEWAN RIVER AT MEDICINE HAT, ALTA., in 1911.

| Date | Hydrographer. | Width | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Feb. 25 | H. R. Carscallen | 314 4 | 2,046 | 0 77 | | 1,574 |
| May 31 | do | 643 3 | 4,969 | 2 94 | 5 11 | 14,629 |
| June 26 | do | 782 6 | 6,870 | 4 27 | 8 35 | 29,343 |
| July 25 | do | 621 2 | 4,822 | 2 76 | 4 97 | 13,322* |
| Sept. 9 | J. C. Keith | 773 4 | 6,649 | 4 04 | 7 72 | 26,899‡ |
| Oct. 31 | do | 475.7 | 3,198 | 1.46 | 2 48 | 4,660‡ |

* New gauge established.
‡ New gauge placed.

MISCELLANEOUS DISCHARGE MEASUREMENT South Saskatchewan River in 1911.

| DATE. | Hydrographer. | Stream. | Location. | Width | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet* | *Sq. Feet* | *Ft. per sec.* | *Sec.-ft.* |
| Mar. 11-12 & 13. | W. H. Greene | S. Saskatchewan River (near Bow Island) | Sec. 15-11-11-4 | 671 80 | 1737 71 | 1 43 | 2477.17 |

## RED DEER RIVER DRAINAGE BASIN

### *General Description.*

The Red Deer River rises in the Sawback range of the Rockies, in the northern portion of the Rocky Mountain Park, near the boundary between the provinces of Alberta and British Columbia. It flows eastward for about forty miles, then northeastward for seventy or eighty miles to a point near Red Deer, Alberta. From here the river flows in a southeasterly and easterly direction to its junction with the South Saskatchewan river, just east of the fourth meridian, in Tp. 22, Rge. 28, W. 3rd Mer. It has a length of approximately 400 miles.

The valley of the Red Deer is wide and deep, the banks being very rough and cut up with a large number of deep coulees, draining into the river. Near its source the basin is well timbered and a good growth of timber is found along its banks for some distance out into the prairie. Seams of coal, well suited for domestic use, are found in the valley and form the principal source of fuel supply for the settlers along the stream in the prairie section.

The river carries a considerable supply of water at all times of the year, but the volume is subject to sudden variations, due to the melting of snow in the mountains and heavy summer rains.

Of the tributaries of the Red Deer, the most important are Panther river near its head, Little Red Deer river entering in Tp. 36, Rge. 1, W. 5th Mer., and Rosebud river emptying into it in Tp. 28, Rge. 19, W. 4th Mer. In addition there are innumerable small streams draining into the main river in the western portion of the basin. From the mouth of the Rosebud River eastward there is very little drainage into the river.

Irrigation on the Red Deer and its branches is practically unknown. There are only a few small schemes on some of the smaller tributaries. The land along the valley, though lacking moisture, is extremely fertile, and with the help of irrigation much of it might be cultivated and fine crops produced. The irrigation of the bench-land from the river would be difficult on account of the small fall in the river, the depth of the valley, and the rolling nature of the lands in the drainage basin.

Very little hydrographic work has been done in this basin as yet. A gauging station was established on the Red Deer river near Innisfail, in 1910, but an observer could not be secured and only periodic discharge measurements have been secured at this station. In the fall of 1911, another gauging station was established at the town of Red Deer. It is expected that continuous records will be obtained at this point.

Of the tributaries of Red Deer river, Berry and Blood Indian creeks are the only ones that have been given any attention. These small creeks, which drain into the river in the prairie section, have a few small irrigation rights registered against them, and gauging stations were established on them in 1911.

## RED DEER RIVER NEAR INNISFAIL, ALTA.

This station was established Sept. 28, 1910, by H. R. Carscallen, It is located at the traffic bridge on the N.E. quater Sec. 6, Tp. 36, Rge. 28, W. 4th Mer. The bridge is about four miles northwest of Innisfail. It is a three-span steel structure supported by timber, rock-filled piers and abutments, with a short approach at the south end of the bridge.

The channel is straight for about 600 yards above the station. An island divides the stream into two channels, and extends to within about 300 yards of the station. The channel is straight for about 400 yards downstream. The current is moderate over most of the cross-section, although fairly swift in the right channel. The current is moderate upstream becoming more swift below the station.

The right bank is high and sandy. The left bank is comparatively low and may overflow at very high stages of the stream. Both banks are covered with a dense growth of timber and brush. The bed of the stream is composed of sand and gravel. There is a gravel bar between the two centre piers, and in low water there is no flow in this channel. At high-water stages of the stream there are three channels, caused by the piers of the bridge.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the right face of the left abutment. and distances are marked with red paint every five feet along the bottom chord of the bridge.

The gauge which is a plain staff graduated to feet and hundredths, is spiked to the right abutment on the downstream side of the bridge. It is referred to bench-marks as follows: (1) three spike heads in the cribbing of the right abutment (elevation, 14.25); (2) two spikes in side of large poplar tree on right bank about fifty feet below the bridge; (elevation, 12.50).

Arrangements were made with Mr. F. F. Malcolm, a building contractor living within 300 yards of the bridge, to take daily gauge-height observations. Mr. Malcolm, was, however, away from home so much he was unable to take any records, and as no other observer is at present available at this point a new station was established in the town of Red Deer in the fall of 1911.

DISCHARGE MEASUREMENTS OF RED DEER RIVER AT INNISFAIL, ALTA., in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 9 | H. R. Carscallen | 303 6 | 696 59 | 2 94 | 1 50 | 2,045.93 |
| June 9 | do | 342 0 | 1,138 54 | 4 70 | 2 775 | 5,347.90 |
| July 10 | do | 325 5 | 947 26 | 4 53 | 2.32 | 4,293.34 |
| Aug. 2 | J. C. Keith | 341 0 | 841 35 | 3 77 | 1 97 | 3,168 79 |
| Sept. 15 | do | 342 0 | 875 72 | 2 61 | 1 70 | 2,270.11 |

## RED DEER RIVER AT RED DEER, ALTA.

This station was established on December 2, 1911, by J. E. Degnan. It is located on the S. E. quarter Sec. 20, Tp. 38, Rge. 27, W. 4th Mer., at the traffic bridge in the town of Red Deer.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the downstream face of the cribbing around the center pier. It is referred to the top of a pile on the right bank (elev., 15.50 feet above the datum of the gauge).

The stream flows in one channel, which is straight for about 600 feet above and 1300 feet below the gauge. The right bank may overflow in very high stages of the stream. The left bank is high and cannot overflow. The bed of the stream is composed of gravel, but is not liable to shift.

Discharge measurements are made from the downstream side of the bridge during open water. The initial point for soundings is a point near the north end of the bridge and is marked on the hand-rail of the bridge.

The gauge is read by Mr. Leo B. Brown.

As only two discharge measurements were made, there are not sufficient data to compute daily discharges. The tables of daily and monthly discharges for December, 1911, will be completed during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS OF RED DEER RIVER AT RED DEER, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Dec. 2 | J. E. Degnan | 309.5 | 438 31 | 1 455 | 4 11 | 637 95 |
| Dec. 14 and 15 | do | 240 65 | 404 67 | 1 34 | 4 105 | 544.64 |

## BERRY CREEK AT FORSTER'S RANCHE, ALTA.

This station was established on May 30, 1911, by R. T. Sailman. It is located on the N.E. quarter Sec. 21, Tp. 23, Rge. 13. W. 4th Mer., about ten miles east of the village of Hutton.

The channel is straight for 100 feet above and 30 feet below the station. The right bank is low, covered with scrub and will overflow in high water, the left bank is high and sparsely covered with brush. The bed of the stream is soft and may shift in high stages. The current is sluggish.

Discharge measurements are made at a wading section some distance downstream from the gauge.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post driven into the bed of the stream at the right bank. It is referred to a bench-mark on a nail in the side of a tree on the right bank near the gauge (elevation, 5.37 feet above the zero of the gauge).

The gauge was read once each day by Miss L. Forster.

### Discharge Measurements of Berry Creek at Forster's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 30 | R. T. Sailman | 15.0 | 4.51 | 0.52 | 1.56 | 2.34 |
| June 23 | do | 8.4 | 1.66 | 0.32 | 1.46 | 0.54 |
| July 29 | L. R. Brereton | 19.0 | 12.4 | 1.36 | 2.16 | 16.8 |
| Sept. 7 | do | 17.5 | 7.56 | 0.64 | 1.79 | 4.84 |
| Oct. 13 | do | 13.5 | 4.40 | 0.70 | 1.67 | 3.08 |

### Daily Gauge-height and Discharge of Berry Creek at Forster's Ranche, Alta., for 1911.

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | | | 5.39 | 290 | 2.14 | 16 | 1.85 | 7.0 | 1.70 | 3.7 |
| 2 | | | 5.34 | 280 | 2.13 | 16 | 1.85 | 7.0 | 1.70 | 3.7 |
| 3 | | | 5.15 | 246 | 2.13 | 16 | 1.85 | 7.0 | 1.69 | 3.6 |
| 4 | | | 4.82 | 202 | 2.13 | 16 | 1.85 | 7.0 | 1.69 | 3.6 |
| 5 | | | 4.18 | 137 | 2.12 | 15 | 1.84 | 6.7 | 1.68 | 3.4 |
| 6 | | | 3.70 | 100 | 2.12 | 15 | 1.84 | 6.7 | 1.67 | 3.2 |
| 7 | | | 3.42 | 81 | 2.11 | 15 | 1.81 | 6.0 | 1.67 | 3.2 |
| 8 | | | 3.32 | 75 | 2.11 | 15 | 1.79 | 5.5 | 1.67 | 3.2 |
| 9 | | | 3.24 | 70 | 2.11 | 15 | 1.78 | 5.3 | 1.67 | 3.2 |
| 10 | | | 3.18 | 67 | 2.10 | 15 | 1.77 | 5.1 | 1.67 | 3.2 |
| 11 | | | 2.98 | 55 | 2.10 | 15 | 1.76 | 4.9 | 1.66 | 3.1 |
| 12 | | | 2.86 | 48 | 2.09 | 14 | 1.76 | 4.9 | 1.66 | 3.1 |
| 13 | | | 2.81 | 46 | 2.08 | 14 | 1.76 | 4.9 | 1.66 | 3.1 |
| 14 | | | 2.78 | 44 | 2.06 | 13 | 1.75 | 4.7 | 1.66 | 3.1 |
| 15 | | | 2.74 | 42 | 2.05 | 13 | 1.75 | 4.7 | 1.66 | 3.1 |
| 16 | | | 2.70 | 40 | 2.05 | 13 | 1.74 | 4.5 | 1.66 | 3.1 |
| 17 | | | 2.66 | 38 | 2.02 | 12 | 1.74 | 4.5 | 1.65 | 3.0 |
| 18 | | | 2.58 | 34 | 1.95 | 9.8 | 1.74 | 4.5 | 1.65 | 3.0 |
| 19 | | | 2.51 | 30 | 1.95 | 9.8 | 1.74 | 4.5 | 1.65 | 3.0 |
| 20 | | | 2.46 | 28 | 1.95 | 9.8 | 1.73 | 4.3 | 1.64 | 2.8 |
| 21 | | | 2.42 | 27 | 1.94 | 9.5 | 1.73 | 4.3 | 1.63 | 2.6 |
| 22 | | | 2.37 | 25 | 1.93 | 9.2 | 1.73 | 4.3 | 1.63 | 2.6 |
| 23 | 1.46 | 0.7 | 2.33 | 23 | 1.93 | 9.2 | 1.73 | 4.3 | 1.62 | 2.5 |
| 24 | 1.62 | 2.5 | 2.29 | 22 | 1.92 | 8.9 | 1.72 | 4.1 | 1.61 | 2.4 |
| 25 | 1.76 | 4.9 | 2.26 | 20 | 1.92 | 8.9 | 1.72 | 4.1 | 1.60 | 2.2 |
| 26 | * | | 2.25 | 20 | 1.91 | 8.6 | 1.72 | 4.1 | | |
| 27 | * | | 2.24 | 20 | 1.90 | 8.3 | 1.72 | 4.1 | | |
| 28 | * | | 2.21 | 19 | 1.89 | 8.0 | 1.72 | 4.1 | | |
| 29 | * | | 2.17 | 17 | 1.88 | 7.8 | 1.71 | 3.9 | | |
| 30 | * | | 2.16 | 17 | 1.87 | 7.5 | 1.70 | 3.7 | | |
| 31 | | | 2.15 | 16 | 1.86 | 7.3 | | | | |

* Above top of gauge.

Note:—Daily discharges for gauge-heights above 2.50 are only approximate.

Monthly Discharge of Berry Creek at Forster's Ranche, Alta., for 1911.

(Drainage area, 1060 square miles.)

| Month. | Discharge in Second-Feet | | | | Run-Off | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| June (23-25) | 4 9 | 0 7 | 2 7 | 0 002 | 0 00 | 16 |
| July | 290 0 | 16 0 | 70 3 | 0 066 | 0 08 | 4,323 |
| August | 16 0 | 7 3 | 12 0 | 0 011 | 0 01 | 738 |
| September | 7 0 | 3 7 | 5 02 | 0 005 | 0 01 | 299 |
| October (1-25) | 3 7 | 2 2 | 3 07 | 0 003 | 0 00 | 152 |
| The Period | | | | | 0 10 | 5,528 |

BLOOD INDIAN CREEK AT HALLAM'S RANCHE, ALTA.

This station was established on June 26, 1911, by R. T. Sailman. It is located on the S.W. ¼ Sec. 10, Tp. 23, Reg. 8, W. 4th Mer., about one and one half miles above J. R. Hallam's house and 800 feet downstream from his irrigation dam.

The channel is straight for fifty feet above and forty feet below the station. Both banks are high, fairly clear of brush and of clay formation. The bed of the stream is soft, with considerable vegetation and may shift in high stages. The current is sluggish.

Discharge measurements are made a short distance downstream from the station by wading, a weir being used at low stages of the stream.

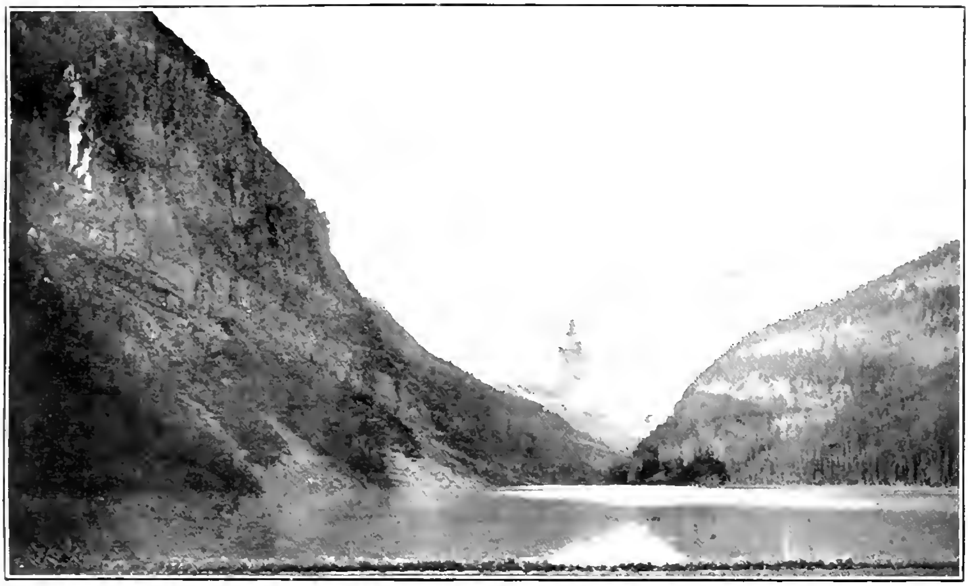
The gauge which is a plain staff graduated to feet and hundredths, is spiked to a post sunk in the bed of the stream at the left bank and securely stayed to the bank. It is referred to a bench-mark on a large stone 107 feet northeast of the gauge (elevation, 9.00 feet above the zero of the gauge).

The gauge was read once each day by J. R. Hallam.

Discharge Measurements of Blood Indian Creek at Hallam's Ranche, Alta., in 1911.

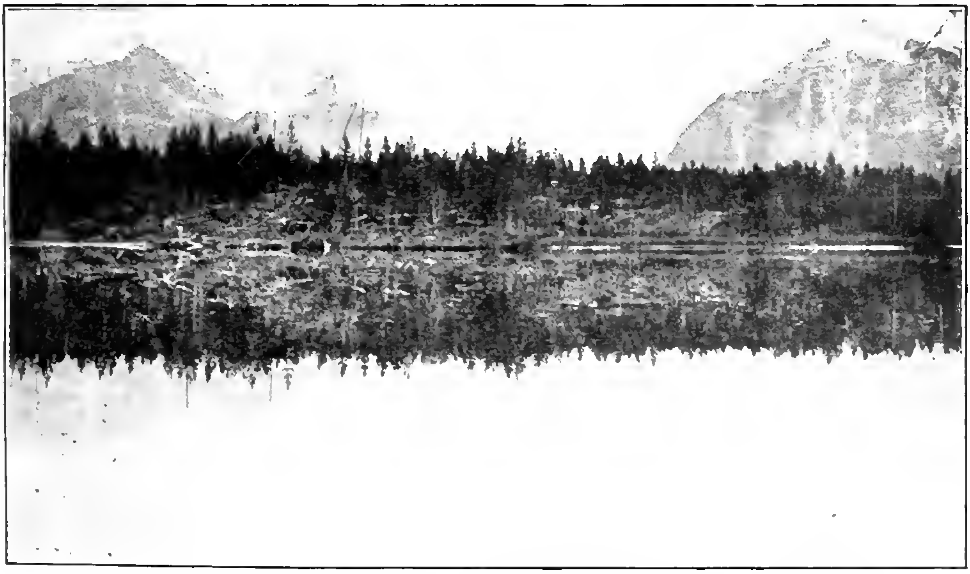
| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. Ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 26 | R. T. Sailman | 3 8 | 1 49 | 0 58 | .... | 0.87 |
| June 26 | do | 8 5 | 1 71 | 0.88 | 2 25 | 1.51 |
| Aug. 9 | L. R. Brereton | 7 2 | 1 92 | 0 72 | 2 20 | 1.39 |
| Sept. 8 | do | 7 0 | 1 48 | 0 63 | 2 18 | 0 93 |
| Oct. 16 | do | 6.3 | 1 33 | 0.75 | 2 18 | 1.00 |

PLATE NO. 10.



Lake Louise and Victoria Glacier looking from Lake Louise Chalet. Taken by P. M. Sauder.

PLATE NO. 11.



A Small Lake near Laggan where Nature Multiplies her Charms, looking southwest to Victoria Glacier, four miles away. Taken by P. M. Sauder.

### Daily Gauge Height and Discharge of Blood Indian Creek at Hallam's Ranche, Alta., for 1911.

| Day. | June. | | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | 2.39 | 3.4 | 2.18 | 1.0 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 |
| 2 | .... | .... | 2.29 | 1.9 | 2.18 | 1.0 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 |
| 3 | .... | .... | 2.28 | 1.8 | 2.17 | 0.9 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 |
| 4 | .... | .... | 2.35 | 2.6 | 2.17 | 0.9 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 |
| 5 | .... | .... | 2.34 | 2.5 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 |
| 6 | .... | .... | 2.30 | 2.0 | 2.20 | 1.1 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 |
| 7 | .... | .... | 2.30 | 2.0 | 2.20 | 1.1 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 |
| 8 | .... | .... | 2.34 | 2.5 | 2.19 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.19 | 1.0 |
| 9 | .... | .... | 2.35 | 2.6 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.19 | 1.0 |
| 10 | .... | .... | 2.39 | 3.4 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.19 | 1.0 |
| 11 | .... | .... | 2.30 | 2.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | †2.19 | 1.0 |
| 12 | .... | .... | 2.35 | 2.6 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | 2.20 | 1.1 |
| 13 | .... | .... | 2.35 | 2.6 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | 2.23 | 1.3 |
| 14 | .... | .... | 2.36 | 2.8 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | 2.23 | 1.3 |
| 15 | .... | .... | 2.36 | 2.8 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | 2.30 | 2.0 |
| 16 | .... | .... | 2.39 | 3.4 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 17 | .... | .... | 2.39 | 3.4 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 18 | .... | .... | 2.28 | 1.8 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 19 | .... | .... | 2.28 | 1.8 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 20 | .... | .... | 2.20 | 1.1 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 21 | .... | .... | 2.20 | 1.1 | 2.15 | 0.8 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 22 | .... | .... | 2.19 | 1.0 | 2.15 | 0.8 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 23 | .... | .... | 2.19 | 1.0 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 24 | .... | .... | 2.19 | 1.0 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 25 | .... | .... | 2.19 | 1.0 | 2.16 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 26 | 2.25 | 1.5 | 2.19 | 1.0 | 2.15 | 0.8 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 27 | 2.32 | 2.3 | 2.19 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 28 | 2.29 | 1.9 | 2.19 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 29 | 2.26 | 1.6 | 2.19 | 1.0 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 30 | 2.21 | 1.2 | 2.19 | 1.0 | 2.17 | 0.9 | 2.18 | 1.0 | 2.18 | 1.0 | .... | .... |
| 31 | ... | .... | 2.18 | 1.0 | 2.16 | 0.9 | .... | .... | 2.18 | 1.0 | .... | .... |

†No observation, gauge height interpolated.
Note:—Data insufficient for computation of discharges corresponding to gauge heights over 2.30.

### Monthly Discharge of Blood Indian Creek at Hallam's Ranche, Alta., for 1911.

(Drainage area, 322 square miles.)

| Month. | Discharge in Second-feet | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| June (26-30) | 2.3 | 1.2 | 1.70 | 0.005 | 0.001 | 17 |
| July | 3.4 | 1.0 | 1.94 | 0.006 | 0.006 | 119 |
| August | 1.1 | .8 | 0.932 | 0.003 | 0.003 | 57 |
| September | 1.0 | .9 | 0.987 | 0.003 | 0.003 | 59 |
| October | 1.0 | 1.0 | 1.0 | 0.003 | 0.003 | 61 |
| November (1-15) | 2.0 | 1.0 | 1.11 | 0.003 | 0.002 | 33 |
| The period | ...... | ...... | ...... | ........ | ........ | 346 |

MISCELLANEOUS DISCHARGE MEASUREMENTS IN RED DEER RIVER Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | Feet | Sq. feet | Ft. per sec. | Sec. feet |
| July 29. | L. R. Brereton | Bullpound Creek | N.W. 9-25-14-4. | 20 5 | 12 41 | 0 40 | 4 95 |
| Sept. 7 | do | do | N E 25-24-15-4 | 9 9 | 2 42 | 0 77 | 1 86 |
| Oct. 12 | do | do | do | No Flow, | water in | pools. | |
| Aug. 3 | J. C. Keith | Blindman River | Sec. 15-39-27-4 | 98 0 | 352 90 | 0 78 | 278 |
| Sept 18 | do | do | do | 96 0 | 330 30 | 0 745 | 246 05 |
| July 31. | L. R. Brereton. | Dead Fish Creek.... | N.E. 21-23-13-4 | 1 0 | 0 10 | 0 40 | 0 04 |
| Sept. 7 | do | do | do | 1 0 | | | nil. |
| Oct. 13 | do | do | do | 1 50 | 0 16 | 0 38 | 0 06 |
| July 31. | do | Est Br. Berry Crk | Sec. 35-22-12-4 | | | | Dry. |
| Sept. 8 | do | do | do | | | | Dry. |
| Oct. 14 | do | do | do | No flow, | water in | pools. | |

## BOW RIVER DRAINAGE BASIN.

### *General Description*

The Bow River heads in lakes Bow and Hector, which lie north of the Canadian Pacific Railway and just east of the Great Divide, in the Rocky Mountain Park, whose elevations are 6420 and 5694 feet, respectively, above mean sea-level. The river flows in a southeasterly direction to the city of Calgary, where it takes a big bend to the south, then continues in a southeasterly course to its junction with Belly River at the Grand Forks. From the confluence of these two streams it is known as the South Saskatchewan River.

The Bow River has a large number of streams draining into it in the western portion of the basin, Of these, the principal tributaries are Cascade and Ghost rivers, draining the northern portion of the basin, and Spray, Kananaskis, Elbow, Sheep and Highwood rivers, draining the southern portion. Beyond the mouth of Highwood river very little drainage reaches Bow river and, in consequence, the stream depends for its supply almost wholly upon the run-off from the mountains and foothills. As a result, Bow River possesses a normally steady flow throughout the year, but is subject to sudden freshets caused by melting snow and heavy rains in the mountains. The minimum flow, therefore, occurs in the frozen season, when there is little run-off from the snow fields in the western part of the drainage basin.

The valley of the Bow is deep and well defined throughout its course. In the mountain section it is, naturally, comparatively narrow and very heavily timbered, and the stream flows over a stony bed and between high rocky banks. The nature of the valley changes gradually until, when it reaches the prairie, it is wide, of a clay formation and devoid of trees and the stream flows over a bed consisting mainly of gravel and sand. The water is clear and pure.

Considerable water is being diverted from Bow River for irrigation purposes and more will be used in the near future. The Natural Resources Branch of the Canadian Pacific Railway are preparing to irrigate about 3,000,000 acres of land lying north of their main line and between Calgary and the eastern boundary of Range 11, W. 4th Mer. The water is being diverted about two miles east of Calgary and also at Bassano. The western section of the tract is now supplied with water and the works to supply the Central and Eastern sections are being rushed to completion. The Southern Alberta Land Company has been granted water rights and works are being constructed to irrigate about 380,000 acres of land lying to the west of Medicine Hat. The head-gates of their canal and their reservoir are near Gleichen. In addition to these large projects, there are a number of small schemes on Highwood and Sheep rivers and their branches.

Many favourable sites for power development are located on the Bow and its tributaries, but up to the present only one of any importance has been developed. This belongs to the Calgary Power and Transmission Company, and is for the purpose of supplying Calgary with electric power. Their dam and power-house is just below Kananaskis falls, their transmission line running a distance of fifty miles to Calgary. At present only 12,000 horse-power is to be developed, but ultimately this will be raised to 30,000 horse-power, their power plant being designed to accommodate this increase.

In addition to these projects the city of Calgary draws its domestic water-supply from Elbow River. The intake is about twelve miles southwest of Calgary, above which point the course of the river is through a wild and unsettled country, thus insuring the purity of the water-supply.

#### BOW RIVER AT LAGGAN, ALTA.

This station was established on July 18, 1910, by J.C. Keith. It was at first located at an old traffic bridge on the N.E ¼ Sec. 28, Tp. 28, Rge. 16, W. 5th Mer., about one third of a mile west of Laggan. This site did not prove satisfactory, and a cable station was, therefore, established by H. C. Ritchie near the east boundary of the S. E. ¼ Sec. 28, Tp. 28, Rge. 16, W. 5th Mer., on August 30, 1911. The new station is about half a mile southeast of Laggan and about 300 feet above the mouth of Pipestone river.

The river flows in one channel at all stages. It is straight for 75 feet above and 200 feet below the station. Both banks are high and not liable to overflow. The right bank is covered with a good growth of spruce, but the left is almost clear. The bed of the stream is composed of gravel and boulders, but is not liable to shift. The current has a good velocity.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the centre of the tower on the left bank, and distances are marked on the measuring wire by tags at every five feet.

The gauge, which is of the standard chain type, is situated at the left bank, about 8 feet downstream from the cable. The zero (elev., 89.14) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated about 11 feet southeast of the cable tower on the left bank.

Arrangements were made to secure records at this station continuously during the whole year, but an ice-jam formed a short distance below the station causing back-water on the gauge, and made it impossible to compute the daily discharge after November 9th.

During 1911, the gauge was read from January 1 to April 30 by W. F. Fraser, from May 1 to October 15 by F. A. Kerr, and from October 16 to the end of the year by E. Braund.

Discharge Measurements of Bow River at Laggan, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| Jan. 30 | H. R. Carscallen | 40.5 | 55.9 | 1.49 | 2.68 | 83.2x |
| Feb. 13 | do | 35.5 | 45.1 | 1.10 | 1.94 | 49.4x |
| Mar. 6 | do | 35.5 | 36.8 | 1.48 | 1.30 | 51.4x |
| Mar. 23 | do | 42 | 45.2 | 1.41 | 1.02 | 63.7z |
| Apr. 7 | H. C. Ritchie | 43.5 | 53.4 | 1.52 | 1.04 | 81.1x |
| Apr. 27 | do | 43.5 | 58.8 | 1.88 | 1.25 | 110.7x |
| May 11 | do | 62.5 | 93.4 | 2.85 | 1.85 | 265.9x |
| June 1 | B. Russell | 103.8 | 184.6 | 3.50 | 2.47 | 647.6x |
| June 16 | do | 111.8 | 310.6 | 5.77 | 3.32 | 1793.0x |
| July 1 | do | 110.0 | 277.6 | 5.71 | 3.17 | 1585.0x |
| July 14 | do | 86.3 | 232.8 | 4.54 | 2.84 | 1058.0x |
| July 27 | H. C. Ritchie | 111.5 | 259.6 | 5.24 | 3.11 | 1360.0x |
| Aug. 18 | H. Rrown | 108.3 | 200.0 | 3.99 | 2.59 | 798.7x |
| Sept. 5 | do | 69.5 | 157.9 | 4.90 | 6.38 | 774.2* |
| Sept. 21 | do | 61.5 | 98.3 | 3.43 | 5.48 | 336.7* |
| Oct. 17 | V. A. Newhall | 47.7 | 46.1 | 2.79 | 4.64 | 128.5* |
| Nov. 2 | do | 34.5 | 29.0 | 1.95 | 4.37 | 56.8* |
| Nov. 29 | do | 61.5 | 289.5 | 0.23 | † | 65.5*‡ |
| Dec. 4 | do | 61 | 196.0 | 0.62 | † | 121.7*▲ |
| Dec. 6 | do | 42 | 38.2 | 1.65 | † | 63.2■ |
| Dec. 18 | do | 45 | 42.2 | 1.43 | † | 60.2■ |

xDischarge measured at old station. *Discharge measured at new station.
†Gauge not read owing to backwater caused by ice jam. ‡May be slightly inaccurate owing to slush ice.
▲Accuracy affected by great amount of frozen slush ice causing cross-currents.
■Gauging made at an open water section west of Laggan. Probable error small.

## Daily Gauge-height and Discharge of Bow River at Laggan, Alta., for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.65 | 114 | 2.65 | 80 | 1.85 | 53 | 1.10 | 90 | 1.33 | 125 | 2.42 | 617 |
| 2 | 1.90 | 130 | 2.65 | 80 | 1.80 | 53 | 1.08 | 87.6 | 1.35 | 129 | 2.66 | 850 |
| 3 | 2.80 | 210 | 2.75 | 90 | 1.40 | 46 | 1.05 | 84 | 1.53 | 167 | 2.82 | 1,035 |
| 4 | 2.90 | 216 | 2.70 | 85 | 1.38 | 48 | 1.05 | 84 | 1.60 | 185 | 2.80 | 1,010 |
| 5 | 3.00 | 216 | 2.65 | 80 | 1.30 | 48 | 1.05 | 84 | 1.75 | 230 | 2.63 | 818 |
| 6 | 2.85 | 195 | 2.65 | 80 | 1.25 | 48 | 1.05 | 84 | 1.85 | 266 | 2.64 | 828 |
| 7 | 2.35 | 140 | 2.40 | 65 | 1.15 | 48 | 1.10 | 90 | 1.80 | 247 | 2.65 | 839 |
| 8 | 2.35 | 135 | 2.20 | 57 | 1.10 | 48 | 1.20 | 103 | 1.78 | 240 | 2.60 | 786 |
| 9 | 2.50 | 140 | 2.10 | 53 | 1.03 | 47 | 1.30 | 120 | 1.80 | 247 | 2.60 | 786 |
| 10 | 2.50 | 130 | 2.00 | 49 | 1.03 | 48 | 1.40 | 139 | 1.80 | 247 | 2.70 | 894 |
| 11 | 2.60 | 130 | 2.00 | 49 | 1.03 | 49 | 1.45 | 149 | 1.85 | 266 | 2.76 | 963 |
| 12 | 2.60 | 121 | 1.98 | 48.2 | 1.03 | 51 | 1.15 | 96 | 1.85 | 266 | 3.05 | 1,349 |
| 13 | 2.40 | 95 | 1.96 | 47.4 | 1.00 | 51 | 1.10 | 90 | 1.85 | 266 | 3.12 | 1,456 |
| 14 | 2.20 | 72 | 1.95 | 47 | 0.95 | 50 | 1.05 | 84 | 1.76 | 233 | 3.27 | 1,697 |
| 15 | 2.20 | 66 | 1.95 | 47 | 0.95 | 52 | 1.05 | 84 | 1.89 | 283 | 3.35 | 1,832 |
| 16 | 2.10 | 59 | 1.98 | 48.2 | 0.95 | 53 | 1.03 | 81.6 | 2.07 | 371 | 3.32 | 1,781 |
| 17 | 2.05 | 51 | 2.00 | 49 | 0.95 | 54 | 1.05 | 84 | 2.25 | 484 | 3.33 | 1,798 |
| 18 | 2.05 | 51 | 2.05 | 51 | 0.95 | 55 | 1.05 | 84 | 2.20 | 450 | 3.34 | 1,815 |
| 19 | 2.05 | 51 | 2.05 | 51 | 0.95 | 56 | 1.05 | 84 | 2.25 | 484 | 3.30 | 1,747 |
| 20 | 2.05 | 51 | 2.10 | 53 | 0.95 | 57 | 1.03 | 81.6 | 2.25 | 484 | 3.16 | 1,519 |
| 21 | 2.10 | 53 | 2.00 | 49 | 0.95 | 58 | 1.08 | 87.6 | 2.30 | 520 | 3.12 | 1,456 |
| 22 | 2.00 | 49 | 2.03 | 50.2 | 0.95 | 59 | 1.08 | 87.6 | 2.28 | 506 | 3.45 | 2,008 |
| 23 | 2.10 | 53 | 2.05 | 51 | 1.00 | 62 | 1.12 | 92.4 | 2.16 | 424 | 3.40 | 1,919 |
| 24 | 2.10 | 53 | 2.05 | 51 | 1.02 | 66 | 1.15 | 96 | 2.09 | 382 | 3.48 | 2,063 |
| 25 | †2.05 | 51 | 2.08 | 52.2 | 1.05 | 70 | 1.20 | 103 | 2.03 | 350 | 3.40 | 1,919 |
| 26 | 2.00 | 49 | 2.10 | 53 | 1.05 | 71 | 1.20 | 103 | 1.95 | 310 | 3.32 | 1,781 |
| 27 | 2.20 | 57 | 2.05 | 51 | 1.05 | 74 | 1.25 | 111 | 1.86 | 270 | 3.25 | 1,664 |
| 28 | 2.20 | 57 | 1.90 | 51 | 1.05 | 77 | 1.30 | 120 | 1.91 | 292 | 3.24 | 1,648 |
| 29 | 2.10 | 53 | .... | .... | 1.06 | 89 | 1.40 | 139 | 1.96 | 315 | 3.20 | 1,583 |
| 30 | 2.68 | 83 | .... | .... | 1.06 | 82 | 1.45 | 149 | 2.06 | 366 | 3.22 | 1,615 |
| 31 | 2.65 | 80 | .... | .... | 1.06 | 85 | ... | ... | 2.18 | 437 | .... | .... |

Note:—Gauge height observations were made at the old gauging station until the end of August. After that they were taken at the cable station. An ice jam a short distance below the station caused backwater on the gauge and made it impossible to compute daily discharges after November 9th.

DAILY GAUGE-HEIGHT AND DISCHARGE OF BOW RIVER AT LAGGAN, ALTA., for 1911 —*Continued.*

| Day. | July. | | August | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | 3.19 | 1567 | 2.98 | 1248 | 6.56 | 870 | 4.95 | 169 | 4.31 | 50.2 |
| 2 | 3.18 | 1551 | 2.93 | 1178 | 6.65 | 919 | 4.92 | 162 | 4.47 | 71.2 |
| 3 | 3.17 | 1535 | 2.96 | 1219 | 6.67 | 930 | 4.90 | 157 | 4.53 | 81.4 |
| 4 | 3.09 | 1410 | 3.00 | 1276 | 6.55 | 865 | 4.87 | 150 | 4.53 | 81.4 |
| 5 | 3.06 | 1364 | 3.01 | 1291 | 6.38 | 773 | 4.85 | 145 | 4.55 | 85 |
| 6 | 3.05 | 1349 | 2.99 | 1262 | 6.25 | 703 | 4.82 | 138 | 4.56 | 86.8 |
| 7 | 3.03 | 1320 | 2.93 | 1178 | 6.08 | 613 | 4.79 | 132 | 4.53 | 81.4 |
| 8 | 3.00 | 1276 | 2.82 | 1035 | 5.99 | 568 | 4.76 | 125 | 4.37 | 57.4 |
| 9 | 2.92 | 1164 | 2.75 | 951 | 5.90 | 523 | 4.76 | 125 | 4.30 | 49 |
| 10 | 2.89 | 1124 | 2.68 | 872 | 5.90 | 523 | 4.75 | 123 | .... | ...... |
| 11 | 2.85 | 1072 | 2.63 | 818 | 5.94 | 543 | 4.75 | 123 | .... | ...... |
| 12 | 2.80 | 1010 | 2.65 | 839 | 6.01 | 578 | 4.75 | 123 | .... | ...... |
| 13 | 2.81 | 1022 | 2.65 | 839 | 6.11 | 628 | 4.75 | 123 | .... | ...... |
| 14 | 2.82 | 1035 | 2.63 | 818 | 6.05 | 598 | 4.75 | 123 | .... | ...... |
| 15 | 2.82 | 1035 | 2.60 | 786 | 5.95 | 548 | 4.73 | 119 | .... | ...... |
| 16 | 3.03 | 1320 | 2.58 | 766 | 5.80 | 475 | 4.66 | 105 | .... | ...... |
| 17 | 3.02 | 1305 | 2.62 | 807 | 5.70 | 430 | 4.66 | 105 | .... | ...... |
| 18 | 3.02 | 1305 | 2.65 | 839 | 5.60 | 386 | 4.67 | 107 | .... | ...... |
| 19 | 3.00 | 1276 | 2.65 | 839 | 5.50 | 345 | 4.64 | 101 | .... | ...... |
| 20 | 2.96 | 1219 | 2.65 | 839 | 5.50 | 345 | 4.57 | 88.6 | .... | ...... |
| 21 | 2.98 | 1248 | 2.63 | 818 | 5.48 | 337 | 4.70 | 113 | .... | ...... |
| 22 | 3.02 | 1305 | 2.59 | 776 | 5.40 | 307 | 4.58 | 90.4 | .... | ...... |
| 23 | 3.03 | 1320 | 2.57 | 756 | 5.32 | 279 | 4.54 | 83.2 | .... | ...... |
| 24 | 3.10 | 1425 | 2.57 | 756 | 5.22 | 246 | 4.52 | 79.6 | .... | ...... |
| 25 | 3.20 | 1583 | 2.58 | 766 | 5.18 | 234 | 4.53 | 81.4 | .... | ...... |
| 26 | 3.19 | 1567 | 2.57 | 756 | 5.14 | 222 | 4.35 | 55 | .... | ...... |
| 27 | 3.11 | 1441 | 2.47 | 661 | 5.08 | 204 | 4.33 | 52.6 | .... | ...... |
| 28 | 3.09 | 1410 | 2.45 | 643 | 5.04 | 193 | 4.41 | 62.4 | .... | ...... |
| 29 | 3.08 | 1395 | 2.50 | 688 | 5.00 | 182 | 4.28 | 46.6 | .... | ...... |
| 30 | 3.05 | 1349 | 2.55 | 736 | 4.97 | 171 | 4.40 | 61 | .... | ...... |
| 31 | 3.01 | 1291 | 2.55 | 736 | | | 4.42 | 63.8 | .... | ...... |

MONTHLY DISCHARGE OF BOW RIVER AT LAGGAN, ALTA., for 1911.

Drainage area, 166 sqaure miles.

| Month. | Discharge in Second-Feet. | | | | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area | Total in acre-feet. |
| January | 216 | 49 | 97.1 | 0.585 | 0.67 | 5,970 |
| February | 90 | 47 | 57.8 | 0.348 | 0.36 | 3,210 |
| March | 89 | 46 | 58.3 | 0.351 | 0.40 | 3,585 |
| April | 149 | 81.6 | 99.1 | 0.597 | 0.67 | 5,897 |
| May | 520 | 125 | 317 | 1.91 | 2.20 | 19,492 |
| June | 2,063 | 617 | 1,403 | 8.45 | 9.43 | 83,484 |
| July | 1,583 | 1,010 | 1,309 | 7.89 | 9.10 | 80,488 |
| August | 1,291 | 643 | 897 | 5.40 | 6.23 | 55,154 |
| September | 930 | 174 | 485 | 2.92 | 3.26 | 28,860 |
| October | 169 | 46.6 | 108 | 0.651 | 0.75 | 6,641 |
| November (1-9) | 86.8 | 49 | 71.5 | 0.431 | 0.14 | 1,276 |
| The period | ...... | ...... | ...... | ...... | 33.21 | 294,057 |

PIPESTONE RIVER NEAR LAGGAN, ALTA.

This station was established August 31,1911, by H. C. Ritchie. It is located on the S. W. ¼ Sec. 27, Tp. 28, Rge. 16, W. 5th Mer., about seven eighths of a mile east of Laggan station and about 350 yards below the Canadian Pacific Railway bridge spanning the stream.

The channel is straight for 60 feet above and 100 feet below the station. Both banks are low, but are not liable to overflow. They are covered with low scrub and a sparse growth of spruce. The bed is rocky, but fairly smooth at the cross-section. The fall of the stream is considerable, and the current is swift.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is a point, suitably marked, on the centre of the left tower, supporting the cable, and distances are marked at every five feet.

The gauge is of the standard chain type, supported over the water by two posts set upright in the left bank of the stream, twelve feet south or downstream from the cable. The zero (elev., 91.54) is referred to a bench mark (assumed elev., 100.00) on an iron spike driven into the side of a spruce tree on the left bank, 22 feet north of the cable.

During 1911, the gauge was read from September 1 to October 14, by F. A. Kerr, and from October 15 to October 31, by E. Braund.

DISCHARGE MEASUREMENTS OF PIPESTONE RIVER, NEAR LAGGAN, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Sept. 5 | H. Brown | 64 5 | 99 1 | 2 71 | 4 95 | 268.5 |
| Sept. 21 | do | 58 5 | 74 9 | 2 13 | 4 54 | 159 8 |
| Oct. 17 | V. A. Newhall | 52 2 | 50 2 | 1 74 | 4 24 | 87 2 |
| Nov. 2 | do | 27 5 | 36 0 | 0 98 | 4 19 | 35 4 |
| Dec. 19 | do | 14 2 | 31 3 | 1 38 | .... | 43 3 |

DAILY GAUGE HEIGHT AND DISCHARGE OF PIPESTONE RIVER, NEAR LAGGAN, ALTA., for 1911.

| Day. | September. | | October. | |
|---|---|---|---|---|
| | Gauge Height | Dis-charge. | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5 12 | 316 | 4 40 | 123 |
| 2 | 5 15 | 324 | 4 40 | 123 |
| 3 | 5.17 | 330 | 4 40 | 123 |
| 4 | 5 08 | 304 | 4 39 | 121 |
| 5 | 4 95 | 268 | 4 38 | 118 |
| 6 | 4 90 | 254 | 4 37 | 116 |
| 7 | 4 80 | 227 | 4 36 | 113 |
| 8 | 4 75 | 214 | 4 35 | 111 |
| 9 | 4 70 | 201 | 4 35 | 111 |
| 10 | 4 70 | 201 | 4 34 | 109 |
| 11 | 4 72 | 206 | 4 33 | 106 |
| 12 | 4 80 | 227 | 4 33 | 106 |
| 13 | 4 90 | 254 | 4 33 | 106 |
| 14 | 4 76 | 217 | 4 33 | 106 |
| 15 | 4 75 | 214 | 4 33 | 106 |
| 16 | 4 68 | 196 | 4 30 | 99 |
| 17 | 4 65 | 188 | 4 33 | 106 |
| 18 | 4 60 | 175 | 4 33 | 106 |
| 19 | 4 56 | 165 | 4 27 | 92.4 |
| 20 | 4 55 | 162 | 4 15 | 69 |
| 21 | 4 55 | 162 | 4 10 | 60 |
| 22 | 4 52 | 154 | 4 10 | 60 |
| 23 | 4 52 | 154 | 4 26 | 90.2 |
| 24 | 4 40 | 123 | 4 15 | 69 |
| 25 | 4 40 | 123 | 4 00 | 46 |
| 26 | 4 45 | 136 | 3 98 | 43.6 |
| 27 | 4 47 | 128 | 4 05 | 52 |
| 28 | 4 42 | 128 | 4 00 | 46 |
| 29 | 4.42 | 128 | 3 98 | 43.6 |
| 30 | 4 41 | 126 | 4 10 | 60 |
| 31 | ..... | ...... | 3.98 | 43.6 |

NOTE.—An ice jam formed below the station during the cold spell in the early part of November and caused the banks of the stream to overflow. Gauge height observations could not be applied and were therefore discontinued.

MONTHLY DISCHARGE OF PIPESTONE RIVER NEAR LAGGAN, ALTA., for 1911.

Drainage area, 122 square miles

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total acre-feet. |
| September | 330 | 123 | 200 | 1.639 | 1.83 | 11,901 |
| October | 123 | 43.6 | 89.8 | 0.739 | 0.85 | 5,522 |
| The period | | | | | 2.68 | 17,423 |

BOW RIVER AT BANFF, ALTA.

This station was established May 25, 1909, by P. M. Sauder. It is located at the highway bridge in the village of Banff, about one mile from the Canadian Pacific Railway station. It is on the quartering line in the S. ½ Sec. 35, Tp. 25, Rge. 12, W. 5th Mer., and is about a mile above the mouth of Spray River, and a short distance below the Vermilion lakes.

The channel is straight for about 300 feet above and 400 feet below the station. Both banks are low and are partly covered with brush and timber, but are not liable to overflow. The bed of the stream is composed of gravel and boulders, the latter making it difficult to obtain accurate soundings at some points. There is a deep hole near the right bank, but the greater part of the cross-section is uniform. The current is sluggish above the station, but the stream becomes swifter as it approaches the bridge, and breaking into rapids a short distance downstream, reaches the Spray Falls about half a mile below. The stream is divided into four channels by the piers supporting the bridge.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is one and a half feet from the north end of the bridge, and distances are marked on the bottom chord of the downstream side of the bridge at every five feet.

The gauge, which is a plain staff, graduated to feet and tenths, is attached to the downstream side of the centre pier. The zero (elev., 92.36) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the right bank about forty feet east of the southern extremity of the bridge.

During 1911, the gauge was read by N. B. Sanson, Meteorological Observer at Banff.

DISCHARGE MEASUREMENTS OF BOW RIVER AT BANFF, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| Jan. 23 | H. R. Carscallen | 50 | 151.6 | 2.58 | 0.84 | 390.6x |
| Feb. 15 | do | 51 | 140.6 | 2.17 | 0.71 | 305.5x |
| Mar. 8 | do | 52 | 151.4 | 2.26 | 0.06 | 341.4x |
| Mar. 24 | do | 82.5 | 172.5 | 1.97 | 0.16 | 340.2† |
| Apr. 6 | H. C. Ritchie | 58 | 118.8 | 1.89 | *0.04 | 281.3† |
| Apr. 25 | do | 161.5 | 586.9 | 1.01 | 0.65 | 592.7 |
| May 10 | do | 240 | 739.6 | 1.51 | 1.24 | 1,114 |
| May 31 | B. Russell | 284.5 | 957.5 | 1.93 | 1.90 | 1,852 |
| June 15 | do | 320 | 1709 | 4.62 | 4.35 | 7,908 |
| June 29 | do | 322 | 1566 | 4.03 | 3.90 | 6,309 |
| July 13 | do | 320 | 1305 | 3.01 | 2.98 | 3,928 |
| July 26 | H. C. Ritchie | 319 | 1376 | 3.25 | 3.50 | 4,465 |
| Aug. 17 | H. Brown | 305 | 1092 | 2.25 | 2.49 | 2,456 |
| Aug. 31 | do | 297 | 1042 | 1.98 | 2.26 | 2,066 |
| Sept. 18 | do | 279 | 872.1 | 1.56 | 1.73 | 1,365 |
| Oct. 18 | V. A. Newhall | 199.5 | 655.8 | 1.03 | 1.09 | 673.8 |
| Nov. 4 | do | 130.5 | 556.3 | 0.99 | 0.85 | 553.0 |
| Nov. 24 | do | 114 | 473.7 | 1.00 | 0.76 | 474.0† |
| Dec. 21 | do | 54.5 | 173.0 | 1.89 | 0.41 | 327.4† |

*Negative gauge height.
xIce conditions.
†Partly frozen over.

## Daily Gauge-heights and Discharge of Bow River, at Banff, Alta., for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.25 | 280 | 0.76 | 336 | 0.40 | 240 | 0.06 | 313 | 0.76 | 669 | 2.35 | 2,595 |
| 2 | 0.23 | 260 | 0.81 | 367 | 0.44 | 270 | †*0.01 | 292 | 0.90 | 795 | 3.10 | 4,210 |
| 3 | 0.41 | 345 | 0.88 | 416 | 0.41 | 285 | *0.08 | 274 | 0.94 | 831 | 3.50 | 5,200 |
| 4 | 0.47 | 345 | 0.92 | 444 | 0.20 | 255 | *0.11 | 268 | 1.04 | 921 | 3.50 | 5,200 |
| 5 | 0.54 | 375 | 1.04 | 537 | †0.16 | 265 | *0.04 | 283 | 1.23 | 1,100 | 3.15 | 4,330 |
| 6 | 0.58 | 375 | 0.92 | 444 | 0.11 | 280 | 0.04 | 307 | 1.42 | 1,290 | 3.00 | 3,970 |
| 7 | 0.59 | 375 | 0.91 | 437 | 0.10 | 300 | *0.01 | 292 | 1.38 | 1,250 | 2.90 | 3,735 |
| 8 | 0.55 | 320 | 0.89 | 423 | 0.04 | 307 | *0.02 | 289 | 1.31 | 1,180 | 2.90 | 3,735 |
| 9 | 0.29 | 210 | 0.91 | 437 | 0.04 | 307 | †0.00 | 295 | 1.27 | 1,140 | 2.90 | 3,735 |
| 10 | 0.41 | 240 | 0.91 | 437 | 0.02 | 301 | 0.01 | 298 | 1.23 | 1,100 | 2.95 | 3,850 |
| 11 | 0.48 | 255 | 0.89 | 423 | *0.02 | 289 | *0.01 | 292 | 1.22 | 1,090 | 3.35 | 4,815 |
| 12 | 0.60 | 300 | 0.87 | 409 | †*0.02 | 289 | *0.05 | 280 | 1.21 | 1,080 | 3.98 | 6,572 |
| 13 | 0.59 | 280 | 0.73 | 318 | *0.03 | 286 | *0.05 | 280 | 1.20 | 1,070 | 4.35 | 7,900 |
| 14 | 0.65 | 295 | 0.71 | 306 | 0.03 | 304 | *0.04 | 283 | 1.20 | 1,070 | 4.70 | 9,310 |
| 15 | 0.70 | 300 | 0.67 | 285 | *0.02 | 289 | *0.04 | 283 | 1.25 | 1,120 | 4.40 | 8,095 |
| 16 | 0.72 | 312 | 0.71 | 306 | *0.01 | 292 | †0.00 | 295 | 1.35 | 1,220 | 4.35 | 7,900 |
| 17 | 0.76 | 336 | 0.71 | 306 | *0.01 | 292 | 0.04 | 307 | 1.57 | 1,452 | 4.30 | 7,710 |
| 18 | 0.78 | 348 | 0.59 | 251 | *0.01 | 292 | 0.03 | 304 | 1.70 | 1,595 | 4.32 | 7,786 |
| 19 | 0.82 | 374 | †0.58 | 247 | †0.06 | 313 | 0.07 | 316 | 1.67 | 1,562 | 4.15 | 7,155 |
| 20 | 0.90 | 430 | 0.57 | 243 | 0.13 | 334 | 0.13 | 334 | 1.66 | 1,551 | 4.00 | 6,640 |
| 21 | 0.88 | 416 | 0.49 | 211 | 0.16 | 344 | 0.30 | 400 | 1.65 | 1,540 | 3.98 | 6,572 |
| 22 | 0.84 | 388 | 0.49 | 211 | 0.13 | 334 | 0.30 | 400 | 1.72 | 1,619 | 4.38 | 8,017 |
| 23 | 0.82 | 374 | 0.50 | 215 | 0.16 | 344 | 0.30 | 400 | 1.64 | 1,529 | 4.60 | 8,900 |
| 24 | 0.82 | 374 | 0.52 | 223 | 0.13 | 334 | 0.42 | 460 | 1.55 | 1,430 | 4.40 | 8,095 |
| 25 | 0.74 | 324 | 0.62 | 263 | 0.06 | 313 | 0.60 | 555 | 1.48 | 1,353 | 4.53 | 8,613 |
| 26 | 0.76 | 336 | †0.55 | 235 | †0.06 | 313 | 0.65 | 590 | 1.41 | 1,280 | 3.98 | 6,572 |
| 27 | 0.85 | 395 | 0.47 | 203 | 0.06 | 313 | 0.64 | 583 | 1.36 | 1,230 | 3.98 | 6,572 |
| 28 | 0.93 | 451 | 0.41 | 210 | 0.05 | 310 | 0.64 | 583 | 1.32 | 1,190 | 4.00 | 6,640 |
| 29 | 0.95 | 465 | .. | . | 0.09 | 322 | 0.62 | 569 | 1.36 | 1,230 | 4.00 | 6,640 |
| 30 | 0.92 | 444 | . | ... | 0.12 | 331 | 0.64 | 583 | 1.44 | 1,310 | 3.95 | 6,470 |
| 31 | 0.88 | 416 | .... | ... | 0.09 | 322 | .. | ... | 1.73 | 1,631 | .... | ..... |

† No observations, gauge height interpolated.
* Negative gauge height.
NOTE.—Very good winter Station

DAILY GAUGE-HEIGHTS AND DISCHARGE OF BOW RIVER, AT BANFF, ALTA., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.88 | 6,252 | 2.78 | 3,079 | 2.30 | 2,120 | 1.32 | 885 | 0.65 | 425 | 0.69 | 445 |
| 2 | 3.88 | 6,252 | 2.84 | 3,225 | 2.32 | 2,154 | 1.32 | 885 | 0.67 | 435 | 0.72 | 460 |
| 3 | 3.80 | 6,025 | 2.86 | 3,275 | 2.38 | 2,259 | 1.32 | 885 | 0.76 | 480 | 0.67 | 435 |
| 4 | 3.55 | 5,330 | 2.88 | 3,325 | 2.38 | 2,259 | 1.28 | 845 | 0.83 | 518 | 0.63 | 415 |
| 5 | 3.27 | 4,618 | 2.88 | 3,325 | 2.28 | 2,088 | 1.27 | 835 | 0.80 | 500 | 0.58 | 392 |
| 6 | 3.20 | 4,450 | 2.88 | 3,325 | 2.18 | 1,930 | 1.22 | 788 | 0.80 | 500 | 0.58 | 392 |
| 7 | 3.61 | 5,493 | 2.85 | 3,250 | 2.07 | 1,773 | 1.20 | 770 | †0.71 | 455 | 0.60 | 400 |
| 8 | 3.50 | 5,200 | 2.86 | 3,275 | 2.00 | 1,675 | 1.21 | 779 | †0.62 | 410 | 0.60 | 400 |
| 9 | 3.25 | 4,570 | 2.75 | 3,010 | 1.98 | 1,649 | 1.19 | 761 | †0.51 | 364 | 0.60 | 400 |
| 10 | 3.20 | 4,450 | 2.65 | 2,790 | 1.92 | 1,574 | 1.18 | 752 | †0.38 | 319 | 0.59 | 396 |
| 11 | 3.12 | 4,258 | 2.58 | 2,643 | 1.91 | 1,562 | 1.18 | 752 | 0.23 | 276 | 0.51 | 364 |
| 12 | 3.05 | 4,090 | 2.50 | 2,480 | 1.91 | 1,562 | 1.18 | 752 | 0.20 | 270 | 0.57 | 388 |
| 13 | 2.98 | 3,922 | 2.55 | 2,580 | 2.10 | 1,815 | 1.17 | 743 | 0.21 | 278 | 0.55 | 380 |
| 14 | 3.00 | 3,945 | 2.48 | 2,442 | 1.99 | 1,662 | 1.18 | 752 | 0.39 | 322 | 0.55 | 380 |
| 15 | 3.22 | 4,545 | 2.48 | 2,442 | 1.93 | 1,586 | 1.18 | 752 | 0.56 | 384 | 0.51 | 364 |
| 16 | 3.28 | 4,700 | 2.52 | 2,520 | 1.89 | 1,538 | 1.13 | 709 | 0.66 | 430 | 0.51 | 364 |
| 17 | 3.38 | 4,965 | 2.45 | 2,385 | 1.81 | 1,442 | 1.08 | 671 | 0.74 | 470 | †0.47 | 348 |
| 18 | 3.38 | 4,940 | 2.48 | 2,442 | 1.73 | 1,346 | 1.08 | 671 | 0.81 | 506 | 0.44 | 337 |
| 19 | 3.14 | 4,200 | 2.48 | 2,442 | 1.69 | 1,298 | 1.04 | 641 | 0.80 | 500 | 0.49 | 356 |
| 20 | 3.05 | 3,915 | 2.52 | 2,520 | 1.62 | 1,214 | 1.02 | 632 | 0.79 | 495 | 0.51 | 364 |
| 21 | 2.97 | 3,660 | 2.44 | 2,367 | 1.62 | 1,214 | 1.00 | 620 | 0.79 | 495 | 0.41 | 328 |
| 22 | 3.10 | 3,990 | 2.39 | 2,277 | 1.61 | 1,202 | 0.99 | 614 | 0.63 | 415 | 0.51 | 364 |
| 23 | 3.05 | 3,840 | 2.30 | 2,120 | 1.59 | 1,178 | 0.97 | 602 | 0.62 | 410 | 0.52 | 368 |
| 24 | 3.00 | 3,670 | 2.27 | 2,072 | 1.54 | 1,119 | 0.98 | 608 | 0.60 | 400 | †0.50 | 360 |
| 25 | 3.17 | 4,095 | 2.28 | 2,088 | 1.48 | 1,053 | 0.87 | 542 | 0.65 | 425 | 0.48 | 352 |
| 26 | 3.29 | 4,436 | 2.30 | 2,120 | 1.46 | 1,031 | 0.75 | 475 | 0.62 | 410 | 0.41 | 328 |
| 27 | 3.20 | 4,180 | 2.21 | 1,976 | 1.41 | 976 | 0.79 | 495 | 0.52 | 368 | 0.40 | 325 |
| 28 | 2.94 | 3,475 | 2.17 | 1,915 | 1.40 | 965 | 0.76 | 480 | 0.53 | 372 | 0.41 | 328 |
| 29 | 2.92 | 3,425 | 2.14 | 1,871 | 1.38 | 945 | 0.72 | 460 | 0.55 | 380 | 0.61 | 405 |
| 30 | 2.93 | 3,450 | 2.18 | 1,930 | 1.37 | 935 | 0.72 | 460 | 0.67 | 435 | 0.66 | 430 |
| 31 | 2.85 | 3,250 | 2.23 | 2,008 | .... | ... | 0.70 | 450 | .... | ... | †0.64 | 420 |

MONTHLY DISCHARGE OF BOW RIVER AT BANFF, ALTA., for 1911.

(Drainage area, 857 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area | Total in acre-feet. |
| January | 465 | 210 | 347 | 0.405 | 0.47 | 21,336 |
| February | 537 | 203 | 327 | 0.382 | 0.40 | 18,161 |
| March | 344 | 240 | 302 | 0.352 | 0.41 | 18,569 |
| April | 590 | 268 | 367 | 0.428 | 0.48 | 21,838 |
| May | 1,631 | 669 | 1,240 | 1.45 | 1.67 | 76,240 |
| June | 9,310 | 2,595 | 6,251 | 7.30 | 8.14 | 371,960 |
| July | 6,252 | 3,250 | 4,438 | 5.18 | 5.97 | 272,878 |
| August | 3,325 | 1,871 | 2,565 | 2.99 | 3.45 | 157,715 |
| September | 2,259 | 935 | 1,504 | 1.75 | 1.95 | 89,494 |
| October | 885 | 450 | 680 | 0.794 | 0.92 | 41,812 |
| November | 518 | 270 | 415 | 0.484 | 0.54 | 24,694 |
| December | 460 | 325 | 380 | 0.443 | 0.51 | 23,365 |
| The year | ... | . | .... | | 24.91 | 1,138,062 |

### SPRAY RIVER NEAR BANFF, ALTA.

This station was established July 15, 1910, by J. C. Keith. It is located at a traffic bridge about one mile southeast of the village of Banff, on the N.W. 1/4 Sec, 25, Tp. 25, Rge. 12, W. 5th Mer., and about 100 yards above the junction with Bow River.

The channel is straight for 75 feet above and 100 feet below the station. The right bank is low, and may overflow at high stages of the stream. The left bank is steep and high. The bed is composed of coarse gravel, and is not liable to shift. The current is swift, but the surface is free from ripples at the station. A quantity of rock has been dumped into the channel at the left abutment of the bridge and affects the accuracy of the results.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the extreme west end of the bottom chord of the bridge.

The gauge, which is a plain staff, graduated to feet and hundredths is nailed to the downstream end of the left abutment. The zero (elev., 93.29) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the left bank about fifty feet downstream from the bridge. On Novemebr 3, V. A. Newhall established a chain gauge on the downstream end of the left or west abutment, projecting about five feet over the water. The zero of this gauge (elev., 88.71) is also referred to the above mentioned bench-mark. The length of the chain from the bottom of the weight to the marker is 14.67 feet. Observations were made with the chain gauge after November 11, but for this report have been reduced to the same datum as the staff gauge.

During 1911, the gauge was read by N. B. Sanson, Meteorological Observer, at Banff.

### Discharge Measurements of Spray River, near Banff, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| Jan. 25 | H. R. Carscallen | 33.5 | 104.8 | 1.62 | *3.30 | 170.3 |
| Feb. 15 | do | 22.5 | 61.2 | 2.34 | *2.05 | 143.4 |
| Mar. 8 | do | 27.5 | 50.8 | 2.76 | *1.89 | 140.2 |
| Apr. 8 | do | 37.5 | 59.5 | 1.99 | *0.75 | 118.6 |
| Apr. 28 | H. C. Ritchie | 60.5 | 83.7 | 2.68 | *1.02 | 224.5 |
| May 12 | do | 71.5 | 109.8 | 3.51 | *1.35 | 385.0 |
| June 17 | B. Russell | 129 | 356.3 | 7.05 | 2.70 | 2,511 |
| July 3 | do | 119 | 315.1 | 6.98 | 2.22 | 2,200 |
| July 15 | do | 118.5 | 255.3 | 5.85 | 1.80 | 1,494 |
| July 28 | H. C. Ritchie | 117.5 | 303.6 | 3.48 | 1.60 | 1,058 |
| Aug. 19 | H. Brown | 111 | 168.7 | 4.42 | 1.36 | 745.8 |
| Sept. 2 | do | 92.5 | 148.7 | 4.45 | 1.18 | 661.3 |
| Sept. 22 | do | 74.5 | 119.0 | 3.91 | 0.89 | 466.3 |
| Oct. 14 | V. A. Newhall | 62.5 | 86.0 | 3.61 | 0.70 | 310.5 |
| Oct. 31 | do | 40 | 83.6 | 3.07 | 0.36 | 256.7 |
| Nov. 22 | do | 35.5 | 87.4 | 2.19 | 0.58 | 191.1 |
| Dec. 7 | do | 32.5 | 85.6 | 2.40 | 0.75 | 201.4 |

*Auxiliary gauge.

DAILY GAUGE HEIGHT AND DISCHARGE OF SPRAY RIVER NEAR BANFF, for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.58 | 200 | 2.47 | 152 | 1.94 | 140 | 0.85 | 158 | 1.07 | 246 | 1.90 | 815 |
| 2 | 1.29 | 195 | 2.48 | 152 | 1.98 | 141 | †0.80 | 140 | 1.10 | 260 | 2.20 | 1,190 |
| 3 | 1.76 | 198 | 2.50 | 153 | 1.72 | 135 | 0.75 | 122 | 1.14 | 278 | 2.56 | 1,852 |
| 4 | 2.11 | 200 | 2.44 | 151 | 1.82 | 137 | 0.73 | 116 | 1.17 | 292 | 2.55 | 1,830 |
| 5 | 2.07 | 195 | 2.45 | 152 | †1.92 | 140 | 0.74 | 119 | 1.26 | 335 | 2.38 | 1,484 |
| 6 | 2.02 | 192 | 2.36 | 149 | 2.03 | 143 | 0.75 | 122 | 1.36 | 388 | 2.40 | 1,520 |
| 7 | 1.78 | 188 | 2.25 | 147 | 1.93 | 140 | 0.77 | 130 | †1.35 | 382 | *1.54 | 1,520 |
| 8 | 1.82 | 186 | 2.30 | 148 | 1.99 | 142 | 0.77 | 130 | 1.35 | 382 | 1.53 | 1,502 |
| 9 | 2.10 | 188 | 2.46 | 152 | 1.88 | 139 | †0.77 | 130 | 1.37 | 394 | 1.48 | 1,412 |
| 10 | 3.92 | 228 | 2.36 | 149 | 1.88 | 139 | 0.78 | 133 | 1.36 | 388 | 1.52 | 1,484 |
| 11 | 5.22 | 255 | 2.23 | 147 | 1.89 | 139 | 0.77 | 130 | 1.36 | 388 | 1.88 | 1,476 |
| 12 | 4.63 | 240 | 2.20 | 146 | †1.94 | 140 | 0.77 | 130 | 1.35 | 382 | 2.26 | 1,920 |
| 13 | 5.10 | 246 | 2.14 | 145 | 2.00 | 142 | 0.77 | 130 | 1.35 | 382 | 2.65 | 2,390 |
| 14 | 5.12 | 245 | 2.16 | 145 | 1.77 | 136 | 0.78 | 133 | †1.35 | 382 | 2.45 | 1,920 |
| 15 | 5.04 | 240 | 2.05 | 143 | 2.33 | 149 | 0.77 | 130 | 1.35 | 382 | 2.70 | 2,510 |
| 16 | 4.83 | 232 | 2.13 | 145 | 2.11 | 144 | †0.76 | 126 | 1.38 | 399 | 2.65 | 2,390 |
| 17 | 4.68 | 226 | 2.00 | 142 | 2.72 | 157 | 0.76 | 126 | 1.44 | 436 | 2.65 | 2,390 |
| 18 | 4.38 | 215 | 1.87 | 138 | 2.27 | 147 | 0.77 | 130 | 1.46 | 449 | 2.75 | 2,640 |
| 19 | 4.23 | 206 | 2.10 | 144 | †2.02 | 142 | 0.79 | 136 | 1.48 | 462 | 2.68 | 2,460 |
| 20 | 4.08 | 202 | 2.03 | 143 | 1.782 | 137 | 0.81 | 144 | 1.46 | 449 | 2.58 | 2,220 |
| 21 | 3.99 | 198 | 1.99 | 142 | 1.49 | 140 | 0.87 | 164 | 1.45 | 442 | 2.52 | 2,090 |
| 22 | 4.12 | 198 | 1.98 | 141 | 1.33 | 140 | 0.89 | 172 | 1.46 | 449 | 2.62 | 2,320 |
| 23 | 3.68 | 180 | 2.10 | 144 | 1.36 | 142 | †0.92 | 183 | 1.46 | 449 | 2.70 | 2,510 |
| 24 | 3.49 | 175 | 1.97 | 141 | 1.25 | 148 | 0.96 | 1.99 | 1.44 | 436 | 2.55 | 2,160 |
| 25 | 3.27 | 169 | †1.98 | 141 | 1.12 | 150 | 1.01 | 220 | 1.38 | 399 | 2.65 | 2,390 |
| 26 | 3.20 | 168 | †1.99 | 142 | †0.98 | 150 | 1.02 | 224 | 1.37 | 394 | 2.35 | 2,500 |
| 27 | 3.16 | 167 | 2.00 | 142 | 0.84 | 154 | 1.02 | 224 | 1.34 | 377 | 2.35 | 2,500 |
| 28 | 3.12 | 166 | 1.97 | 141 | 0.80 | 140 | 1.02 | 224 | 1.32 | 366 | 2.25 | 2,260 |
| 29 | 3.00 | 163 | .... | | 0.82 | 147 | 1.01 | 220 | 1.33 | 372 | 2.25 | 2,260 |
| 30 | 2.92 | 161 | .... | .. | 0.81 | 144 | †1.04 | 233 | 1.37 | 394 | 2.32 | 2,428 |
| 31 | 2.64 | 156 | .... | .. | 0.79 | 136 | ... | ... | 1.55 | 512 | | |

* Readings made at regular gauge after June 7th.
† No observations, gauge height interpolated.

## Daily Gauge Height and Discharge of Spray River near Banff, for 1911.—*Continued*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.28 | 2,332 | 1.55 | 995 | 1.22 | 690 | 0.79 | 395 | 0.24 | 225 | 0.67 | 198 |
| 2 | 2.25 | 2,260 | 1.56 | 1,000 | 1.18 | 664 | 0.79 | 390 | 0.20 | 215 | 0.60 | 191 |
| 3 | 2.25 | 2,260 | 1.58 | 1,020 | 1.22 | 696 | 0.77 | 380 | 0.50 | 300 | 0.63 | 194 |
| 4 | 2.15 | 2,050 | 1.58 | 1,020 | 1.29 | 752 | 0.76 | 370 | 0.35 | 255 | 0.65 | 196 |
| 5 | 2.02 | 1,780 | 1.56 | 995 | 1.22 | 696 | 0.76 | 370 | 0.36 | 258 | 0.69 | 199 |
| 6 | 1.95 | 1,660 | 1.55 | 980 | 1.19 | 672 | 0.73 | 355 | 0.34 | 252 | 0.78 | 201 |
| 7 | 2.20 | 2,240 | 1.55 | 980 | 1.17 | 656 | 0.70 | 340 | †0.36 | 250 | 0.72 | 200 |
| 8 | 1.95 | 1,690 | 1.56 | 985 | 1.13 | 624 | 0.70 | 335 | †0.38 | 235 | 0.72 | 200 |
| 9 | †1.88 | 1,580 | 1.56 | 985 | 1.09 | 593 | 0.69 | 330 | †0.40 | 235 | 0.63 | 194 |
| 10 | 1.82 | 1,480 | 1.54 | 955 | 1.07 | 579 | 0.69 | 325 | †0.42 | 230 | 0.52 | 188 |
| 11 | 1.82 | 1,490 | 1.53 | 945 | 1.06 | 572 | 0.69 | 320 | 0.45 | 225 | 0.53 | 189 |
| 12 | 1.75 | 1,390 | 1.50 | 910 | 1.06 | 572 | 0.70 | 320 | 0.54 | 235 | 0.68 | 198 |
| 13 | 1.75 | 1,400 | 1.48 | 880 | †1.05 | 565 | 0.69 | 315 | 0.68 | 238 | 0.74 | 200 |
| 14 | 1.75 | 1,410 | 1.47 | 870 | 1.05 | 565 | 0.69 | 305 | 0.62 | 230 | 0.73 | 201 |
| 15 | 1.85 | 1,590 | 1.46 | 850 | 1.02 | 544 | 0.69 | 310 | 1.11 | 258 | 0.72 | 200 |
| 16 | 1.85 | 1,580 | 1.45 | 830 | 0.99 | 524 | 0.67 | 305 | 1.13 | 255 | 0.62 | 192 |
| 17 | 1.90 | 1,670 | †1.41 | 795 | 0.98 | 518 | 0.65 | 305 | 1.14 | 250 | †0.68 | 198 |
| 18 | 1.85 | 1,560 | 1.37 | 755 | 0.96 | 506 | 0.64 | 305 | 0.95 | 232 | 0.74 | 200 |
| 19 | 1.78 | 1,430 | 1.36 | 745 | 0.92 | 482 | 0.62 | 300 | 0.89 | 225 | 0.98 | 218 |
| 20 | 1.70 | 1,300 | 1.38 | 770 | 0.92 | 482 | 0.64 | 310 | 0.86 | 215 | 0.99 | 218 |
| 21 | 1.72 | 1,310 | 1.36 | 755 | 0.91 | 476 | 0.61 | 305 | 0.72 | 200 | 1.02 | 220 |
| 22 | 1.75 | 1,350 | 1.32 | 725 | 0.89 | 465 | 0.61 | 310 | 0.79 | 202 | 1.07 | 222 |
| 23 | 1.72 | 1,300 | 1.27 | 690 | 0.88 | 455 | 0.59 | 305 | 0.84 | 207 | 0.92 | 211 |
| 24 | 1.68 | 1,220 | 1.24 | 670 | 0.88 | 455 | 0.59 | 310 | 0.78 | 202 | †0.95 | 213 |
| 25 | 1.72 | 1,270 | 1.22 | 660 | 0.84 | 430 | 0.55 | 300 | 0.59 | 190 | 0.99 | 218 |
| 26 | 1.76 | 1,310 | 1.27 | 705 | 0.84 | 430 | 0.54 | 300 | 0.52 | 188 | 1.45 | 245 |
| 27 | 1.68 | 1,180 | 1.22 | 670 | 0.83 | 425 | 0.44 | 270 | 0.42 | 180 | 1.78 | 260 |
| 28 | 1.62 | 1,085 | 1.18 | 640 | 0.83 | 420 | 0.39 | 260 | 0.57 | 190 | 1.68 | 250 |
| 29 | 1.60 | 1,050 | 1.17 | 635 | 0.82 | 410 | 0.37 | 260 | 0.68 | 198 | 1.10 | 200 |
| 30 | 1.55 | 1,000 | 1.17 | 640 | 0.80 | 400 | 0.32 | 240 | 0.75 | 201 | 1.42 | 220 |
| 31 | 1.54 | 990 | 1.18 | 650 | ... | .... | 0.07 | 232 | 2.35 | | †1.68 | 235 |

## Monthly Discharge of Spray River, near Banff, Alta, for 1911.

(Drainage area, 310 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| January | 255 | 156 | 199 | 0.642 | 0.74 | 12,236 |
| February | 153 | 138 | 146 | 0.471 | 0.49 | 8,108 |
| March | 157 | 135 | 143 | 0.461 | 0.53 | 8,793 |
| April | 233 | 116 | 156 | 0.503 | 0.56 | 9,283 |
| May | 512 | 246 | 389 | 1.255 | 1.45 | 23,919 |
| June | 2,640 | 815 | 2,011 | 6.49 | 7.24 | 119,660 |
| July | 2,332 | 990 | 1,523 | 4.91 | 5.66 | 93,646 |
| August | 1,020 | 635 | 829 | 2.67 | 3.08 | 50,973 |
| September | 752 | 400 | 544 | 1.755 | 1.96 | 32,370 |
| October | 395 | 232 | 315 | 1.016 | 1.17 | 19,369 |
| November | 300 | 180 | 226 | 0.729 | 0.81 | 13,448 |
| December | 260 | 188 | 209 | 0.674 | 0.78 | 12,851 |
| The year | | | | | 24.47 | 404,656 |

PLATE No. 12.

Canyon on Cascade River near Bankhead, Alta. Taken by P. M. Sauder.

PLATE No. 13.

Gauging Station on Cascade River near Bankhead, Alta. Taken by P. M. Sauder.

## CASCADE RIVER AT BANKHEAD, ALTA.

This station was established August 16, 1911, by P. M. Sauder. It is located at a small log footbridge on the S. E. 1/4 Sec. 19, Tp. 26, Rge. 11, W. 5th Mer., in the town of Bankhead, on the property of the Bankead Mines and about 100 feet below their dam.

The channel is straight for 100 feet above and below the station. Both banks are low, but are not liable to overflow. The bed is composed of coarse gravel, which is not liable to shift. The current is swift.

Discharge measurements are made from the downstream side of the footbridge. The initial point for soundings is the left end of the bridge and is suitably marked.

The gauge which is a plain staff, graduated to feet and hundredths, is spiked to the cribbing which supports the north end of the bridge. It is referred to a bench-mark on a tree stump on the left bank a few feet downstream from the bridge (elevation above gauge datum, 5.51 feet.)

The gauge was read once each day by R. Lewin, a clerk at the Bankhead Mines.

### DISCHARGE MEASUREMENTS OF CASCADE RIVER AT BANKHEAD, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 27 | H. R. Carscallen | 27 | 45 0 | 2 72 | .... | 122.0 |
| Feb. 14 | do | 27 | 35 8 | 2 82 | .... | 101.0 |
| Mar. 7 | do | 27 | 34 1 | 2 84 | .... | 97 1 |
| Mar. 24 | do | 42 | 53.2 | 2 10 | .... | 111.8 |
| Apr. 26 | H. C. Ritchie | 49 | 55.5 | 2 09 | .... | 116.2 |
| Aug. 16 | H. Brown | 45 1 | 144 3 | 4 95 | 1 58 | 714 2 |
| Aug. 21 | do | 45 1 | 141 3 | 4 38 | 1 46 | 618 7 |
| Sept. 1 | do | 44 6 | 127 8 | 3 89 | 1 36 | 496.4 |
| Sept. 19 | do | 44.8 | 123 7 | 3 84 | 1 19 | 381.5 |
| Oct. 16 | V. A. Newhall | 44 8 | 126 0 | 1 97 | 1 04 | 248 6 |
| Nov. 6 | do | 45 | 100 1 | 1 79 | 0 89 | 178.8 |
| Nov. 23 | do | 43.5 | 99 4 | 1 55 | | 154 1* |
| Dec. 8 | do | 38 | 89 0 | 1 56 | 0 73 | 139 3 |
| Dec. 22 | do | 43 3 | 114.1 | 0.90 | 1 73 | 103.0 |

*No gauge.

Daily Gauge-height and Discharge of Cascade River at Bankhead, Alta., for 1911

| Day. | August. Gauge Height | August. Discharge | September. Gauge Height | September. Discharge | October. Gauge Height | October. Discharge | November. Gauge Height | November. Discharge | December. Gauge Height | December. Discharge. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Feet | Sec.-ft. | Feet | Sec.-ft. | Feet | Sec.-ft. | Feet | Sec.-ft. | Feet | Sec.-ft. |
| 1 | | | 1.35 | 486 | 1.08 | 296 | 0.84 | 160 | | ...... |
| 2 | | | 1.34 | 480 | 1.07 | 287 | 0.85 | 163 | | .... |
| 3 | | | 1.36 | 500 | 1.06 | 280 | 0.85 | 163 | | ...... |
| 4 | | | 1.35 | 493 | 1.05 | 274 | 0.86 | 167 | | .... |
| 5 | | | 1.35 | 496 | 1.04 | 267 | 0.87 | 171 | | ...... |
| 6 | | | 1.35 | 499 | 1.04 | 264 | 0.88 | 175 | | ... |
| 7 | | | 1.35 | 501 | 1.03 | 258 | 0.90 | | ‡ | ... |
| 8 | | | 1.33 | 484 | 1.03 | 257 | 0.93 | | 0.73 | ... |
| 9 | | | 1.32 | 478 | 1.03 | 256 | 0.98 | | 0.75 | ..... |
| 10 | | | 1.30 | 461 | 1.02 | 247 | 1.08 | | 0.92 | .. |
| 11 | | | 1.30 | 464 | 1.02 | 246 | 1.26 | | 1.22 | .... |
| 12 | | | 1.28 | 447 | 1.02 | 244 | 1.50 | | 1.42 | ... |
| 13 | | | 1.27 | 440 | 1.03 | 250 | 1.68 | | 1.62 | ... |
| 14 | | | 1.26 | 434 | 1.01 | 238 | 1.75 | | 1.97 | . |
| 15 | | | 1.26 | 436 | 1.01 | 236 | 1.75 | | 2.27 | .. |
| 16 | 1.58 | 714 | 1.25 | 428 | 1.00 | 228 | 1.73 | | 2.52 | .. |
| 17 | †1.56 | 701 | 1.24 | 420 | 0.99 | 223 | 1.45 | | 2.72 | ... |
| 18 | †1.53 | 675 | 1.22 | 405 | 0.98 | 218 | ‡ | | 3.02 | ....... |
| 19 | 1.50 | 649 | 1.20 | 390 | 0.97 | 214 | | | 2.97 | ...... |
| 20.... | 1.48 | 634 | 1.18 | 374 | 0.96 | 209 | .... | | 2.57 | ....... |
| 21 .... | 1.46 | 619 | 1.16 | 360 | 0.96 | 209 | ...... | . | 2.27 | ....... |
| 22 ... | 1.50 | 659 | 1.14 | 343 | 0.94 | 200 | ...... | . | 1.87 | ....... |
| 23 ... | 1.50 | 656 | 1.12 | 328 | 0.93 | 196 | ...... | . | 1.52 | ....... |
| 24 ... | 1.48 | 633 | 1.12 | 328 | 0.92 | 191 | ...... | . | 1.52 | ....... |
| 25 ... | 1.50 | 651 | 1.11 | 320 | 0.91 | 187 | .... | .... | 1.77 | ....... |
| 26 ....... | 1.50 | 648 | 1.10 | 313 | 0.90 | 183 | ...... | .. | 1.77 | ....... |
| 27 ... | 1.46 | 606 | 1.10 | 313 | 0.89 | 179 | . . | . | 1.77 | ....... |
| 28 .. | 1.44 | 583 | 1.09 | 304 | 0.87 | 171 | . . . | . | 1.82 | ....... |
| 29. ....... | 1.40 | 541 | 1.09 | 304 | 0.86 | 167 | . | .. | 1.82 | ....... |
| 30 ..... | 1.38 | 520 | 1.08 | 298 | 0.85 | 163 | . | . | 1.67 | ....... |
| 31 ....... | 1.36 | 499 | . | . | 0.83 | 156 | . | . | 1.57 | ....... |

† No observation, gauge height interpolated.
‡Gauge carried away by ice on Nov. 18. Replaced Dec. 9.
Note.—Not sufficient data to compute daily discharges after Nov. 6.

Monthly Discharge of Cascade River at Bankhead, Alta., for 1911.

Drainage area, 248 square miles.

| Month. | Discharge in Second-Feet. Maximum | Minimum. | Mean. | Per square mile. | Run-Off. Depth in inches on Drainage area. | Total in acre-feet. |
|---|---|---|---|---|---|---|
| August (16-31) | 714 | 499 | 624 | 2.516 | 1.50 | 19,803 |
| September | 501 | 298 | 411 | 1.657 | 1.85 | 24,456 |
| October | 296 | 156 | 226 | 0.911 | 1.05 | 13,896 |
| November (1-6) | 175 | 160 | 166 | 0.669 | 0.15 | 1,976 |
| The period | | | | | 4.55 | 60,131 |

## Devil's Creek near Bankhead, Alta.

This gauging station, located on the S.E. ¼ Sec. 28, Tp. 26, Rge. 11, W. 5th Mer., and within 300 yards of Lake Minnewanka Chalet, was established June 18, 1910, by J. C. Keith. It is about eight miles north and east of Banff.

The gauge is a plain staff, graduated to feet and hundredths, placed at the right bank. The zero (elev., 95.82) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated forty feet east of the gauge.

The channel is straight for about 100 feet above and 300 feet below the station. Both banks are low, swampy and covered with timber and brush. The stream-bed is of soft mud and very uneven, Several hundred yards downstream is an old dam which raises the water-level about three feet above normal. Consequently the water at the station is deep and sluggish, being apparently dead at ordinary stages of the creek. On this account all discharge measurements are made at the traffic bridge, close to the mouth of the creek on the trail from Banff. The creek here flows in a narrow channel over a rough rocky bed and between high rocky banks. The initial point for soundings is painted on the downstream guard-rail on a line with the inner face of the left abutment.

During 1911, the gauge was read daily by Commander Way, R.N., proprietor of the Lake Minnewanka Chalet, until October 31, and after that by Andrew Roper.

DISCHARGE MEASUREMENTS OF DEVILS CREEK, NEAR BANKHEAD, ALTA., in 1911

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| Jan. 27 | H. R. Carscallen | 24 | 26.9 | 2.41 | 1.11 | 64.9 |
| Feb. 14 | do | 24 | 24.4 | 1.59 | 1.07 | 38.8 |
| Mar. 7 | do | 24 | 22.2 | 1.85 | 1.01 | 41.0 |
| Mar. 24 | do | 24 | 19.4 | 1.76 | 0.94 | 34.2 |
| Apr. 26 | H. C. Ritchie | 24 | 20.1 | 1.93 | 1.03 | 38.9 |
| May 10 | do | 24 | 22.2 | 2.10 | 1.15 | 46.5 |
| June 2 | B. Russell | 24 | 35.8 | 3.15 | 1.53 | 112.9 |
| June 17 | do | 24 | 55.0 | 4.33 | 1.96 | 238.4 |
| July 15 | do | 25 | 49.4 | 4.13 | 1.87 | 204.0 |
| Aug. 16 | H. Brown | 25 | 50.4 | 4.20 | 1.88 | 211.8 |
| Sept. 1 | do | 25 | 46.6 | 3.84 | 1.79 | 179.0 |
| Sept. 19 | do | 25 | 46.5 | 3.64 | 1.78 | 171.1 |
| Oct. 16 | V. A. Newhall | 25 | 40.1 | 3.05 | 1.56 | 122.1 |
| Nov. 6 | do | 24 | 33.4 | 2.78 | 1.42 | 92.9 |
| Nov. 23 | do | 24 | 30.8 | 2.38 | 1.26 | 73.3 |
| Dec. 8 | do | 24 | 28.6 | 2.37 | 1.26 | 67.7 |
| Dec. 22 | do | 22 | 20.4 | 1.76 | 1.22 | 36.0 |
| Dec. 27 | do | 20.5 | 21.9 | 1.77 | 1.27 | 38.8 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF DEVIL'S CREEK, NEAR BANKHEAD, for 1911

| DAY. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | 1.02 | 49 | 1.13 | 60 | 1.09 | 44 | 1.02 | 38 | 1.06 | 41 | 1.45 | 98 |
| 2 | 0.96 | 45 | 1.13 | 56 | 1.06 | 43 | 1.02 | 38 | 1.06 | 41 | 1.54 | 116 |
| 3 | 0.91 | 42 | 1.12 | 56 | 1.07 | 43 | 1.01 | 38 | 1.07 | 41 | 1.66 | 144 |
| 4 | 0.88 | 40 | 1.10 | 53 | 1.05 | 43 | 1.02 | 38 | 1.07 | 41 | 1.66 | 144 |
| 5 | 0.88 | 40 | 1.11 | 53 | 1.16 | 44 | 1.03 | 39 | 1.07 | 41 | 1.67 | 146 |
| 6 | 0.91 | 42 | 1.12 | 53 | 1.02 | 41 | 1.02 | 38 | 1.10 | 43 | 1.68 | 149 |
| 7 | 0.93 | 44 | 1.10 | 50 | 1.03 | 42 | 1.01 | 38 | 1.10 | 43 | 1.70 | 154 |
| 8 | 0.92 | 44 | 1.11 | 49 | 1.05 | 43 | 1.00 | 37 | 1.11 | 44 | 1.68 | 149 |
| 9 | 0.91 | 43 | 1.12 | 49 | 1.05 | 43 | 1.01 | 38 | 1.09 | 42 | 1.66 | 144 |
| 10 | 0.97 | 47 | 1.08 | 44 | 1.00 | 39 | 1.01 | 38 | 1.10 | 43 | 1.68 | 149 |
| 11 | 1.01 | 50 | 1.08 | 43 | 1.00 | 39 | 1.01 | 38 | 1.12 | 47 | 1.71 | 157 |
| 12 | 1.06 | 55 | 1.06 | 41 | 1.00 | 39 | 1.01 | 38 | 1.14 | 49 | 1.77 | 174 |
| 13 | 1.09 | 58 | 1.08 | 40 | 1.00 | 39 | 1.01 | 38 | 1.18 | 52 | 1.86 | 201 |
| 14 | 1.08 | 57 | 1.07 | 39 | 1.02 | 40 | 1.01 | 38 | 1.20 | 55 | 1.92 | 223 |
| 15 | 1.10 | 59 | 1.08 | 40 | 1.00 | 39 | 1.00 | 37 | 1.20 | 56 | 1.96 | 238 |
| 16 | 1.11 | 61 | 1.07 | 39 | 1.00 | 39 | 0.80 | 28 | 1.23 | 59 | 1.99 | 251 |
| 17 | 1.11 | 61 | 1.07 | 40 | 0.96 | 37 | 0.90 | 32 | 1.24 | 61 | 1.99 | 251 |
| 18 | 1.10 | 60 | 1.08 | 40 | 0.95 | 36 | 1.00 | 37 | 1.23 | 61 | 1.99 | 251 |
| 19 | 1.10 | 60 | 1.08 | 41 | 1.00 | 38 | 1.00 | 37 | 1.25 | 65 | 2.01 | 259 |
| 20 | 1.12 | 62 | 1.08 | 41 | 0.96 | 36 | 1.00 | 37 | 1.24 | 65 | 1.99 | 251 |
| 21 | 1.16 | 67 | 1.06 | 40 | 0.96 | 36 | 1.00 | 37 | 1.24 | 66 | 1.98 | 247 |
| 22 | 1.18 | 69 | 1.09 | 42 | 0.95 | 35 | 1.00 | 37 | 1.25 | 67 | 1.97 | 247 |
| 23 | 1.17 | 68 | 1.08 | 41 | 0.97 | 36 | 1.01 | 38 | 1.33 | 76 | 1.97 | 242 |
| 24 | 1.17 | 68 | 1.07 | 42 | 1.00 | 37 | 1.00 | 37 | 1.32 | 76 | 2.06 | 281 |
| 25 | 1.10 | 62 | 1.09 | 43 | 1.00 | 37 | 1.00 | 37 | 1.33 | 78 | 2.07 | 286 |
| 26 | 1.10 | 63 | 1.07 | 42 | 0.90 | 32 | 1.02 | 38 | 1.34 | 80 | 2.06 | 281 |
| 27 | 1.12 | 65 | 1.10 | 44 | 0.60 | 21 | 1.05 | 40 | 1.33 | 80 | 2.06 | 281 |
| 28 | 1.20 | 72 | 1.07 | 43 | 0.50 | 19 | 1.04 | 39 | 1.34 | 81 | 2.08 | 290 |
| 29 | 1.15 | 65 | .... | .... | 0.80 | 28 | 1.05 | 40 | 1.30 | 77 | 2.08 | 290 |
| 30 | 1.15 | 64 | .... | .... | 1.00 | 37 | 1.05 | 40 | 1.33 | 81 | 2.09 | 295 |
| 31 | 1.13 | 61 | .... | .... | 1.02 | 38 | .... | .... | 1.39 | 89 | .... | .... |

DAILY GAUGE-HEIGHT AND DISCHARGE OF DEVILS CREEK, NEAR BANKHEAD, for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.02 | 264 | 1.70 | 154 | 1.79 | 179 | 1.68 | 149 | 1.47 | 102 | 1.31 | 76 |
| 2 | 2.00 | 255 | 1.72 | 160 | 1.77 | 174 | 1.68 | 149 | 1.46 | 100 | 1.33 | 78 |
| 3 | 2.01 | 259 | 1.75 | 168 | 1.80 | 182 | 1.66 | 144 | 1.45 | 98 | 1.33 | 78 |
| 4 | 1.99 | 251 | 1.78 | 176 | 1.88 | 208 | 1.65 | 141 | 1.46 | 100 | 1.29 | 73 |
| 5 | 1.99 | 251 | 1.79 | 179 | 1.90 | 215 | 1.61 | 131 | 1.46 | 100 | 1.31 | 74 |
| 6 | 1.98 | 247 | 1.83 | 191 | 1.89 | 211 | 1.61 | 131 | 1.45 | 98 | 1.21 | 64 |
| 7 | 1.98 | 247 | 1.88 | 208 | 1.88 | 208 | 1.61 | 131 | 1.45 | 98 | 1.34 | 76 |
| 8 | 1.97 | 242 | 1.90 | 215 | 1.88 | 208 | 1.60 | 129 | 1.47 | 102 | 1.28 | 69 |
| 9 | 1.93 | 226 | 1.92 | 223 | 1.88 | 208 | 1.60 | 129 | 1.47 | 102 | 1.29 | 69 |
| 10 | 1.91 | 219 | 1.93 | 226 | 1.86 | 201 | 1.61 | 131 | 1.45 | 98 | 1.26 | 64 |
| 11 | 1.89 | 211 | 1.90 | 215 | 1.86 | 201 | 1.59 | 127 | 1.42 | 93 | 1.25 | 61 |
| 12 | 1.88 | 208 | 1.88 | 208 | 1.85 | 197 | 1.59 | 127 | 1.40 | 90 | 1.29 | 63 |
| 13 | 1.88 | 208 | 1.90 | 215 | 1.81 | 185 | 1.59 | 127 | 1.39 | 89 | 1.22 | 54 |
| 14 | 1.87 | 204 | 1.89 | 211 | 1.80 | 182 | 1.57 | 122 | 1.40 | 90 | 1.25 | 54 |
| 15 | 1.85 | 197 | 1.91 | 219 | 1.80 | 182 | 1.55 | 118 | 1.35 | 83 | 1.11 | 42 |
| 16 | 1.83 | 191 | 1.89 | 211 | 1.78 | 176 | 1.56 | 120 | 1.37 | 86 | 1.25 | 50 |
| 17 | 1.83 | 191 | 1.87 | 204 | 1.78 | 176 | 1.54 | 116 | 1.36 | 84 | 1.22 | 46 |
| 18 | 1.83 | 191 | 1.88 | 208 | 1.78 | 176 | 1.55 | 118 | 1.39 | 89 | 1.21 | 43 |
| 19 | 1.82 | 188 | 1.89 | 211 | 1.78 | 176 | 1.55 | 118 | 1.39 | 89 | 1.22 | 42 |
| 20 | 1.79 | 179 | 1.88 | 208 | 1.78 | 176 | 1.54 | 116 | †1.39 | 89 | 1.10 | 34 |
| 21 | 1.79 | 179 | 1.87 | 204 | 1.78 | 176 | 1.53 | 114 | 1.36 | 84 | 1.08 | 31 |
| 22 | 1.79 | 179 | 1.89 | 211 | 1.77 | 174 | 1.54 | 116 | 1.35 | 83 | 1.22 | 36 |
| 23 | 1.78 | 176 | 1.86 | 201 | 1.77 | 174 | 1.54 | 116 | 1.30 | 77 | 1.22 | 36 |
| 24 | 1.78 | 176 | 1.84 | 194 | 1.73 | 162 | 1.52 | 112 | 1.33 | 81 | 1.28 | 40 |
| 25 | 1.77 | 174 | 1.88 | 208 | 1.70 | 154 | 1.52 | 112 | 1.33 | 81 | 1.28 | 40 |
| 26 | 1.73 | 162 | 1.89 | 211 | 1.69 | 151 | 1.50 | 108 | 1.36 | 84 | 1.28 | 40 |
| 27 | 1.71 | 157 | 1.87 | 204 | 1.69 | 151 | 1.50 | 108 | 1.38 | 86 | 1.27 | 39 |
| 28 | 1.71 | 157 | 1.85 | 197 | 1.68 | 149 | 1.47 | 102 | 1.37 | 84 | 1.22 | 36 |
| 29 | 1.69 | 151 | 1.80 | 182 | 1.66 | 144 | 1.47 | 102 | 1.38 | 85 | 1.21 | 36 |
| 30 | 1.69 | 151 | 1.79 | 179 | 1.67 | 146 | 1.47 | 102 | 1.29 | 74 | 1.21 | 36 |
| 31 | 1.68 | 149 | 1.78 | 176 | .... | .... | 1.47 | 102 | ... | .... | †1.21 | 36 |

† No observation, gauge height interpolated.

MONTHLY DISCHARGE OF DEVIL'S CREEK NEAR BANKHEAD, ALTA., for 1911.

(Drainage area, 58 square miles).

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| January | 72 | 40 | 56.2 | 0.969 | 1.12 | 3,456 |
| February | 60 | 39 | 45.2 | 0.779 | 0.81 | 2,510 |
| March | 44 | 19 | 37.5 | 0.647 | 0.75 | 2,306 |
| April | 40 | 28 | 37.4 | 0.645 | 0.72 | 2,226 |
| May | 89 | 41 | 59.4 | 1.024 | 1.18 | 3,652 |
| June | 295 | 98 | 213 | 3.672 | 4.10 | 12,674 |
| July | 264 | 149 | 201 | 3.466 | 4.00 | 12,359 |
| August | 226 | 154 | 199 | 3.431 | 3.96 | 12,236 |
| September | 215 | 144 | 180 | 3.103 | 3.46 | 10,711 |
| October | 149 | 102 | 122 | 2.103 | 2.42 | 7,501 |
| November | 102 | 74 | 90.0 | 1.551 | 1.73 | 5,355 |
| December | 78 | 31 | 52.1 | 0.898 | 1.04 | 3,204 |
| The year | | | | | 25.29 | 78,190 |

## KANANASKIS RIVER NEAR KANANASKIS, ALTA.

This station was established August 31, 1911, by P. M. Sauder. It is located on the N.W. ¼ Sec. 33, Tp. 24, Rge. 8, W. 5th Mer. The station is about three miles east of Kananaskis station and about one and a half miles west of Horseshoe Falls siding, about 350 yards north and east of the C. P. R. bridge spanning the river and about 200 feet above the mouth of the stream.

The channel is straight for 400 feet above and 50 feet below the station. Both banks are high; the right bank is composed of rock and the left of coarse gravel. The bed of the stream is solid rock near the right bank and coarse gravel throughout the remainder of the cross-section. The current is very swift.

Discharge measurements are made from a car suspended from a cable, a current meter being used for velocity observations. The initial point for soundings is a spike driven in the upstream side of the cable support on the left bank and distances are marked at every five feet by a tagged wire.

The gauge, which is of the standard chain type, is supported by two posts in the right bank, about eight feet upstream from the cable. It is referred to a bench-mark on a stump six feet upstream, elevation 15.09.

The gauge was read once each day by the Calgary Power Co., the observations being taken by J. Gipson for the company.

### DISCHARGE MEASUREMENTS OF KANANASKIS RIVER NEAR KANANASKIS, ALTA., for 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Feb. 11 | H. R. Carscallen | 35 | 66.8 | 1.97 | ... | 131.7 |
| Mar. 4 | do | 32 | 58.4 | 1.87 | .... | 109.4 |
| Mar. 22 | do | 32 | 56.1 | 2.19 | ... | 122.8 |
| Sept. 6 | H. Brown | 63.5 | 178.6 | 5.68 | 7.03 | 1,014.7 |
| Sept. 16 | do | 62.1 | 143.5 | 5.04 | 6.46 | 724.0 |
| Oct. 13 | V. A. Newhall | 60.5 | 101.3 | 3.77 | 5.76 | 371.9 |
| Nov. 29 | do | 55 | 74.0 | 2.88 | 5.62 | 212.1 |
| Dec. 11 | do | 59 | 90.7 | 2.38 | 5.62 | 215.9 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF KANANASKIS RIVER, NEAR KANANASKIS, ALTA., for 1911.

| Day. | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft* |
| 1 | 6 73 | 860 | 5 83 | 404 | 5 37 | 172 | ... | ...... |
| 2 | 6 72 | 855 | 5 85 | 415 | 5 40 | 187 | 5 16 | ...... |
| 3 | 6 74 | 865 | 5 81 | 394 | 5 38 | 177 | 5 15 | ...... |
| 4 | 7 34 | 1168 | 5 80 | 389 | 5 35 | 162 | 5 14 | ...... |
| 5 | 7 10 | 1047 | 5 76 | 369 | 5 34 | 157 | 5 15 | ...... |
| 6 | 7 00 | 996 | 5 75 | 364 | 5.36 | 167 | 5 16 | ...... |
| 7 | 6 88 | 936 | 5 71 | 344 | 5 38 | 177 | 5 13 | ...... |
| 8 | 6 76 | 875 | 5 69 | 334 | 5 30 | 136 | 5 12 | ...... |
| 9 | 6 71 | 850 | 5 70 | 339 | 5 25 | 111 | 5 10 | ...... |
| 10 | 6 63 | 809 | 5 68 | 329 | 5 25 | 111 | 5 11 | ...... |
| 11 | 6 61 | 799 | 5 67 | 324 | 5 25 | 111 | ... | ...... |
| 12 | 6 58 | 784 | 5 66 | 318 | | | ... | ...... |
| 13 | 6 54 | 764 | 5 65 | 313 | | | ... | ...... |
| 14 | 6 53 | 759 | 5 66 | 318 | | | ... | ...... |
| 15 | 6 48 | 733 | 5 64 | 308 | | | ... | ...... |
| 16 | 6 43 | 708 | 5 63 | 203 | | ... | | ...... |
| 17 | 6 36 | 673 | 5 64 | 308 | | ... | 5 25 | ...... |
| 18 | 6 30 | 642 | 5 62 | 298 | | | 5 35 | ...... |
| 19 | 6 30 | 642 | 5 61 | 293 | ... | ... | 5 35 | ...... |
| 20 | 6 23 | 607 | 5 59 | 283 | ..... | ... | 5 33 | ...... |
| 21 | 6 15 | 566 | 5 58 | 278 | ..... | .... | 5 31 | ...... |
| 22 | 6 17 | 577 | 5 57 | 273 | .... | .... | 5 30 | ...... |
| 23 | 6 12 | 551 | 5 56 | 268 | ..... | ....... | 5 29 | ...... |
| 24 | 6 08 | 531 | 5 55 | 263 | | ..... | 5 28 | ...... |
| 25 | 6 05 | 516 | 5 54 | 258 | 5 24 | ..... | 5 26 | ...... |
| 26 | 6 01 | 496 | 5 52 | 248 | 5 27 | ....... | 5 26 | ...... |
| 27 | 5 99 | 485 | 5 51 | 243 | 5 28 | ....... | 5 20 | ...... |
| 28 | 5 98 | 480 | 5 45 | 212 | ...... | ....... | 5 18 | ...... |
| 29 | 5 90 | 440 | 5 44 | 207 | ..... | ...... | 5 17 | ...... |
| 30 | 5 88 | 430 | 5 43 | 202 | ..... | ...... | 5 15 | ...... |
| 31 | ... | ... | 5 40 | 187 | ...... | ....... | 5 14 | ...... |

NOTE.—Stream frozen over on Nov. 12, observer did not read the gauge from Nov. 12 to 24, Nov. 29 to Dec. 1, and Dec. 11 to 15. The gauge height readings from Nov. 25 to end of year are of little value. It was difficult to read the gauge and the observer did not cut a large enough hole. His readings do not agree with those of the hydrographer. As the observer was away from home at the time of the visit of the hydrographer it was not until after the end of the year that he was shown the correct method of making observations.

MONTHLY DISCHARGE OF KANANASKIS RIVER NEAR KANANASKIS, ALTA., for 1911.

(Drainage area, 406 square miles.)

| Month. | Discharge in Second-Feet. | | | Run-Off. | | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| September | 1,168 | 430 | 715 | 1 761 | 1 96 | 42,545 |
| October | 415 | 187 | 300 | 0 739 | 0 85 | 18,446 |
| November (1-11) | 187 | 111 | 152 | 0 374 | 0 15 | 3,316 |
| The period | | | .... | ......... | 2 96 | 64,307 |

## Bow River near Morley, Alta.

This station was established May 25, 1910, by J. C. Keith. It is located at the traffic bridge in Sec. 22, Tp. 25, Rge. 7, W. 5th Mer., in the Stony Indian reserve, a short distance from the Indian agency and about three quarters of a mile from the village of Morley.

The channel is straight for about 600 feet above the station, then curves slightly to the right, but is almost straight for more than half a mile. It is straight for about 500 feet below the station, then curves sharply to the left. The right bank is low and partly covered with brush, but is not liable to overflow. The left bank is high, steep, gravelly and free from brush. The bed of the stream is composed of sand and gravel. The current is swift but smooth.

Discharge measurements are made from the downstream side of the bridge, which is a two-span steel structure supported by concrete abutments and pier, with a short wooden approach on the south and supported by piles. The initial point for soundings is the anchor-bolt in the bed-plate on the north pier, and distances are marked at every five feet on the bottom chord of the bridge.

The gauge, which is of the standard type, is fixed to the floor of the bridge near the centre pier. The length of chain from the bottom of the weight to the marker is 19.17 feet. The zero is referred to bench-marks as follows:— (1) wooden block nailed to the downstream pile in the first row supporting the approach on the left bank (elevation, 12.09); (2) the top of a nut on a bolt in the pile nearest to the south abutment (elevation, 8.58).

During 1911 the gauge was read from January 1 to October 14 by S. Christianson, and from October 15 to the end of the year by W. B. Steinhauer.

Since the Calgary Power and Transmission Company have been operating their plant at the Horseshoe Falls which is only about eight miles upstream, the water surface has fluctuated a great deal and the records have not been satisfactory. This station, was, therefore, abandoned at the end of 1911, and since then observations have been made at the C. P. R. bridge near Kananaskis, which is above the falls and the power plant.

### Discharge Measurements of Bow River near Morley, Alta., in 1911.

| Date. | Hydrographer. | Width | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 21 | H. R. Carscallen | 143 | 328 1 | 2 06 | 2 83 | 675 0† |
| Feb. 10 | do | 89 | 302 5 | 2 22 | 2 95 | 671 3† |
| Mar. 3 | do | 114 | 369 5 | 1 66 | 2 85 | 613 5x |
| Mar. 21 | do | 114 | 412 0 | 1 77 | 2 53 | 730 6x |
| Apr. 5 | H. C. Ritchie | 107 | 406 6 | 1 80 | 0 80 | 733 2‡ |
| Apr. 25 | do | 162 5 | 668 1 | 1 41 | 0 89 | 941 6 |
| May 9 | do | 179 | 866 3 | 2 53 | 1 85 | 2,190 |
| May 30 | B. Russell | 196 5 | 865 9 | 2 74 | 2 04 | 2,377 |
| June 14 | do | 241 2 | 1,748 | 7 07 | 6 08 | 12,375▲ |
| July 12 | do | 217 5 | 1,350 | 5 71 | 4 42 | 7,702 |
| Aug. 14 | H. Brown | 198 4 | 1,200 | 4 94 | 3 69 | 5,930 |
| Sept. 23 | do | 198 | 932 1 | 2 95 | 2 26 | 2,746 |
| Oct. 12 | V. A. Newhall | 174 4 | 804 3 | 2 26 | 1 73 | 1,821 |
| Nov. 17 | do | 174 6 | 915 5 | 1 50 | 3 50 | 1,374* |
| Nov. 27 | do | 177 6 | 952 8 | 0 85 | 3 24 | 807 2* |
| Dec. 14 | do | 187 6 | 841 8 | 1 30 | 2 74 | 1,091** |

† Stream frozen over, conditions bad, results approximate.
x Stream frozen over.
‡ Stream partly frozen over, results may be slightly inaccurate.
▲ May be slight error due to inaccuracy of soundings.
* Large amount of slush ice, results only approximate.
** Large amount of slush ice. Compared with the records at Banff and Calgary the discharge appears to be too high.

DAILY GAUGE-HEIGHT AND DISCHARGE OF BOW RIVER NEAR MORLEY, ALTA., for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.85 | .... | 2.75 | 590 | 2.85 | 614 | 0.74 | 694 | 1.20 | 1,240 | 3.35 | 5,040 |
| 2 | 2.30 | .... | 2.75 | 586 | 2.85 | 614 | 0.70 | 670 | 1.27 | 1,317 | 4.40 | 7,700 |
| 3 | †2.40 | .... | 2.80 | 610 | 2.83 | 604 | 0.70 | 670 | 1.36 | 1,422 | 4.80 | 8,740 |
| 4 | †2.45 | .... | 2.75 | 582 | 2.75 | 564 | 0.70 | 670 | 1.40 | 1,470 | 4.90 | 9,000 |
| 5 | †2.50 | .... | 2.85 | 630 | 2.80 | 588 | 0.76 | 708 | 1.60 | 1,720 | †4.62 | 8,272 |
| 6 | 2.60 | .... | 2.85 | 626 | 2.75 | 564 | 0.88 | 808 | 1.90 | 2,160 | 4.35 | 7,570 |
| 7 | †2.60 | .... | 2.90 | 652 | 2.85 | 614 | 0.65 | 674 | 1.80 | 2,010 | 4.05 | 6,790 |
| 8 | 2.60 | .... | 2.85 | 620 | 2.80 | 588 | 0.68 | 708 | 1.80 | 2,010 | 3.95 | 6,530 |
| 9 | 2.15 | .... | 2.90 | 646 | 2.80 | 588 | 0.75 | 768 | 1.82 | 2,040 | 3.85 | 6,275 |
| 10 | 1.95 | .... | 2.90 | 642 | 2.70 | 564 | 0.72 | 768 | 1.80 | 2,010 | 3.90 | 6,400 |
| 11 | 2.15 | .... | 2.95 | 672 | 2.65 | 562 | 0.70 | 774 | 1.75 | 1,935 | 4.40 | 7,700 |
| 12 | 2.25 | .... | 3.00 | 704 | 2.60 | 560 | 0.65 | 755 | 1.80 | 2,010 | 5.15 | 9,690 |
| 13 | 2.45 | .... | 2.95 | 672 | 2.60 | 580 | *0.35 | 340 | 1.85 | 2,085 | 5.80 | 11,550 |
| 14 | 2.50 | .... | 2.90 | 642 | 2.55 | 576 | 0.65 | 755 | 1.80 | 2,010 | 6.10 | 12,460 |
| 15 | 2.70 | .... | 2.85 | 614 | 2.65 | 652 | 0.70 | 790 | 1.75 | 1,935 | 6.20 | 12,770 |
| 16 | 2.75 | .... | 2.75 | 564 | 2.60 | 648 | 0.68 | 776 | 1.95 | 2,240 | 6.15 | 12,615 |
| 17 | 2.95 | .... | 2.80 | 588 | 2.60 | 672 | 0.70 | 790 | 2.10 | 2,480 | 6.10 | 12,460 |
| 18 | 2.95 | .... | 2.85 | 614 | 2.63 | 720 | 0.74 | 822 | 2.20 | 2,640 | 6.05 | 12,305 |
| 19 | 2.80 | .... | 2.80 | 588 | 2.60 | 724 | 0.70 | 790 | 2.18 | 2,608 | 6.00 | 12,150 |
| 20 | 2.85 | .... | 2.80 | 588 | 2.56 | 726 | 0.75 | 830 | 2.25 | 2,725 | 5.75 | 11,405 |
| 21 | 2.80 | 654 | 2.75 | 564 | 2.55 | 746 | 0.80 | 870 | 2.27 | 2,759 | 5.65 | 11,115 |
| 22 | 2.85 | 680 | 2.85 | 614 | 2.50 | 790 | *0.35 | 340 | 2.26 | 2,742 | 5.75 | 11,405 |
| 23 | 2.80 | 646 | 2.85 | 614 | 2.47 | 856 | 0.90 | 950 | 2.37 | 2,943 | 6.20 | 12,770 |
| 24 | 2.70 | 590 | 2.83 | 604 | 2.30 | 814 | 1.22 | 1,262 | 2.27 | 2,759 | 6.35 | 13,235 |
| 25 | 2.70 | 586 | 2.85 | 614 | 2.25 | 862 | 0.98 | 1,022 | 2.17 | 2,592 | 6.45 | 13,545 |
| 26 | 2.60 | 536 | 2.80 | 588 | 2.15 | 878 | †1.06 | 1,100 | 2.10 | 2,480 | 6.05 | 12,305 |
| 27 | 2.55 | 512 | 2.85 | 614 | 2.07 | 904 | 1.15 | 1,190 | 2.05 | 2,400 | 5.65 | 11,115 |
| 28 | 2.65 | 554 | 2.80 | 588 | 1.05 | 920 | 1.10 | 1,140 | 1.95 | 2,240 | 5.60 | 10,970 |
| 29 | 2.75 | 598 | .... | .... | 0.85 | 766 | 1.17 | 1,210 | 1.98 | 2,288 | 5.55 | 10,825 |
| 30 | 2.70 | 570 | .... | .... | 0.80 | 732 | 1.12 | 1,160 | 2.06 | 2,416 | 5.55 | 10,825 |
| 31 | 2.75 | 592 | .... | .... | 0.76 | 708 | .... | .... | 2.60 | 3,400 | .... | .... |

Plate No. 14.

Gauging Station on Ghost River at Gillie's Ranche in Winter.
Taken by V. A. Newhall.

Winter Gauging of Southfork River near Cowley, Alta. Taken by P. M. Sauder.

DAILY GAUGE-HEIGHT AND DISCHARGE OF BOW RIVER NEAR MORLEY, ALTA., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5.50 | 10,680 | 3.86 | 6,300 | †3.05 | 4,345 | 1.95 | 2,240 | 1.48 | 1,566 | 3.30 | .... |
| 2 | 5.55 | 10,825 | †3.90 | 6,400 | 3.10 | 4,460 | 1.97 | 2,272 | †1.48 | 1,566 | 3.26 | .... |
| 3 | 5.40 | 10,390 | 3.95 | 6,530 | 3.15 | 4,575 | 1.95 | 2,240 | †1.48 | 1,566 | 3.31 | .... |
| 4 | 5.20 | 9,830 | 4.00 | 6,660 | 3.40 | 5,160 | 1.90 | 2,160 | 1.48 | 1,566 | 3.19 | .... |
| 5 | †4.95 | 9,135 | 4.05 | 6,790 | 3.30 | 4,920 | 1.85 | 2,085 | 1.35 | 1,410 | 3.26 | .... |
| 6 | 4.70 | 8,480 | 4.15 | 7,050 | †3.21 | 4,713 | 1.80 | 2,010 | 1.61 | 1,734 | 3.14 | .... |
| 7 | 4.90 | 9,000 | 4.25 | 7,310 | 3.12 | 4,506 | 1.70 | 1,860 | 1.45 | 1,530 | 3.03 | .... |
| 8 | 5.00 | 9,270 | 4.30 | 7,440 | 3.00 | 4,230 | 1.78 | 1,980 | 1.53 | 1,629 | 3.10 | .... |
| 9 | 4.75 | 8,610 | 4.15 | 7,050 | 2.95 | 4,120 | 1.70 | 1,860 | .... | .... | 3.31 | .... |
| 10 | 4.55 | 8,090 | 4.03 | 6,738 | 3.20 | 4,690 | 1.56 | 1,668 | .... | .... | 3.03 | .... |
| 11 | 4.40 | 7,700 | †3.91 | 6,426 | 2.75 | 3,700 | 1.65 | 1,790 | .... | .... | 2.82 | .... |
| 12 | 4.40 | 7,700 | 3.80 | 6,150 | 2.75 | 3,700 | 1.70 | 1,860 | 1.73 | .... | 2.85 | .... |
| 13 | 4.25 | 7,310 | 3.70 | 5,900 | 2.70 | 3,600 | †1.70 | 1,860 | 3.05 | .... | 2.75 | .... |
| 14 | 4.30 | 7,440 | 3.65 | 5,775 | 2.70 | 3,600 | 1.70 | 1,860 | 3.03 | .... | 2.74 | .... |
| 15 | 4.35 | 7,570 | 3.60 | 5,650 | 2.65 | 3,500 | 1.69 | 1,846 | 3.24 | .... | 2.73 | .... |
| 16 | 4.55 | 8,090 | 3.60 | 5,650 | 2.60 | 3,400 | 1.77 | 1,965 | 3.28 | .... | 2.74 | .... |
| 17 | 4.80 | 8,740 | †3.54 | 5,500 | 2.55 | 3,300 | 1.69 | 1,846 | 3.25 | .... | 2.68 | .... |
| 18 | 4.70 | 8,480 | †3.47 | 5,328 | 2.50 | 3,200 | 1.68 | 1,832 | †3,56 | .... | 2.27 | .... |
| 19 | †4.47 | 7,882 | 3.40 | 5,160 | 2.45 | 3,100 | 1.66 | 1,804 | 3.88 | .... | 2.32 | .... |
| 20 | 4.25 | 7,310 | 3.43 | 5,232 | 2.35 | 2,905 | 1.59 | 1,707 | 3.98 | .... | 2.74 | .... |
| 21 | 4.18 | 7,128 | 3.45 | 5,280 | 2.30 | 2,810 | 1.69 | 1,846 | 3.99 | .... | 2.69 | .... |
| 22 | 4.22 | 7,232 | 3.40 | 5,160 | 2.30 | 2,810 | 1.68 | 1,832 | 3.96 | .... | 2.63 | .... |
| 23 | 4.25 | 7,310 | 3.35 | 5,040 | 2.27 | 2,759 | 1.71 | 1,875 | 4.02 | .... | 2.73 | .... |
| 24 | 4.15 | 7,050 | †3.27 | 4,851 | 2.18 | 2,608 | †1.70 | 1,860 | †3.83 | .... | 2.76 | .... |
| 25 | 4.15 | 7,050 | 3.20 | 4,690 | 2.15 | 2,560 | 1.69 | 1,846 | †3.63 | .... | 2.62 | .... |
| 26 | 4.35 | 7,570 | †3.50 | 5,400 | 2.10 | 2,480 | 1.59 | 1,707 | †3.44 | .... | 2.69 | .... |
| 27 | 4.30 | 7,440 | 3.80 | 6,150 | 2.05 | 2,400 | 1.48 | 1,566 | 3.24 | 807 | 2.74 | .... |
| 28 | 4.15 | 7,050 | 3.05 | 4,345 | 2.00 | 2,320 | †1.42 | 1,494 | 3.07 | 724 | 2.72 | .... |
| 29 | 4.05 | 6,790 | 3.03 | 4,299 | 2.00 | 2,320 | †1.36 | 1,422 | 3.13 | 800 | 2.69 | .... |
| 30 | 3.95 | 6,530 | 2.93 | 4,076 | 1.95 | 2,240 | 1.30 | 1,350 | 3.07 | 798 | 2.68 | .... |
| 31 | 3.80 | 6,150 | †2.99 | 4,208 | .... | .. | 1.39 | 1,458 | .... | .... | 2.74 | .... |

During January, February, March and November. Daily discharges for these months are only approximate.
† No observation, gauge height interpolated.
* Negative gauge height. Low water caused by Calgary Power and Transmission Co. holding back the water.
NOTE—Data insufficient to compute the daily discharge from Jan. 1 to 20, Nov. 9 to 26 and Dec. 1 to 31. Ice conditions.

MONTHLY DISCHARGE OF BOW RIVER NEAR MORLEY, ALTA., for 1911.

(Drainage area, 2111 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| January (21-31) | 680 | 512 | 593 | 0.281 | 0.11 | 12,938 |
| February | 704 | 564 | 615 | 0.291 | 0.30 | 34,155 |
| March | 920 | 560 | 687 | 0.325 | 0.37 | 42,242 |
| April | 1,262 | 340 | 827 | 0.392 | 0.44 | 49,210 |
| May | 3,400 | 1,240 | 2,229 | 1.06 | 1.22 | 137,058 |
| June | 13,545 | 5,040 | 10,184 | 4.82 | 5.38 | 605,990 |
| July | 10,825 | 6,150 | 8,059 | 3.82 | 4.40 | 495,529 |
| August | 7,440 | 4,076 | 5,759 | 2.73 | 3.15 | 354,108 |
| September | 5,160 | 2,240 | 3,501 | 1.66 | 1.85 | 208,324 |
| October | 2,272 | 1,350 | 1,840 | 0.872 | 1.00 | 113,140 |
| November (1-8 27-30) | 1,734 | 724 | 1,308 | 0.620 | 0.28 | 31,133 |
| The period | | | .. | ... | 18.50 | 2,083,827 |

## Ghost River at Gillies' Ranche, Alta.

This station was established on August 17, 1911, by L. R. Brereton. It is located on the N. E. ¼ Sec. 23, Tp. 26, Rge. 6, W. 5th Mer., about one quarter of a mile below Gillies' ranche buildings.

The gauge is a plain staff, graduated to feet and hundredths, nailed to a post sunk in the bed of the stream at the left bank. The zero of the gauge (elev., 90.87) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the right bank of the river 270 feet due north of the quarter mound on the east boundary of Sec. 23, Tp. 26, Rge. 6, W. 5th Mer., and 469 feet east and slightly south of the gauge.

Discharge measurements are made from the downstream side of a traffic bridge on the S.E. ¼ Sec. 13, Tp. 26, Rge. 6, W. 5th Mer., about 100 yards from the mouth of the river. The initial point for soundings is the stream face of the west, or right, abutment of the bridge. During very low stages of the stream it can be waded and discharge measurements are then made by wading near the gauge

The channel at the bridge is straight for about 150 feet above and below the station. The right bank is high and composed of solid rock, and cannot overflow. The left is low, composed of gravel, slightly covered with trees, but is not liable to overflow. The bed of the stream is composed of coarse gravel and may shift in high stages.

During 1911 the gauge was read by Miss E. Gillies.

### Discharge Measurements of Ghost River at Gillies' Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 3 | H. C. Ritchie | 58 0 | 81 2 | 1 60 | ... | 130 0 |
| June 9 | R. T Sailman | 67 0 | 155 5 | 1 97 | ... | 305 9 |
| July 13 | L. R. Brereton | 89 0 | 164 4 | 2 79 | | 457.9 |
| Aug. 18 | do | 91 0 | 193 1 | 3.97 | 2 46 | 768.0 |
| Sept. 19 | do | 70 0 | 143 4 | 2 80 | 1 95 | 401.1 |
| Oct. 20 | do | 68 0 | 124 4 | 2 46 | 1 72 | 305.6 |
| Nov. 9 | V. A. Newhall | 52 5 | 68 5 | 2 92 | 1 30 | 200.0 |
| Nov. 28 | do | 48 0 | 75 3 | 2 94 | * | 221 6† |
| Dec. 15 | do | 51 0 | 71 6 | 2 68 | * | 192 1† |

* No gauge.
† Gauging made near the site of gauge. Ice conditions but the probable error small.

## Daily Gauge-height and Discharge of Ghost River at Gillies' Ranche, Alta., for 1911.

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 2.11 | 498 | 1.85 | 355 | 1.44 | 228 |
| 2 | | | 2.06 | 465 | 1.86 | 359 | 1.44 | 228 |
| 3 | | | 2.43 | 740 | 1.86 | 359 | 1.49 | 240 |
| 4 | | | 3.03 | 1235 | 1.85 | 355 | 1.52 | 247 |
| 5 | | | 2.60 | 879 | 1.84 | 351 | 1.45 | 230 |
| 6 | | | 2.55 | 838 | 1.77 | 324 | 1.44 | 228 |
| 7 | | | 2.31 | 644 | 1.77 | 324 | 1.45 | 230 |
| 8 | | | 2.26 | 606 | 1.80 | 335 | 1.34 | 207 |
| 9 | | | 2.16 | 532 | 1.80 | 335 | 1.25 | 191 |
| 10 | | | 2.15 | 525 | 1.80 | 335 | 1.25 | 191 |
| 11 | | | 2.13 | 511 | 1.80 | 335 | 1.25 | 191 |
| 12 | | | 2.07 | 472 | 1.78 | 328 | | ... |
| 13 | | | 2.06 | 465 | 1.70 | 300 | | ... |
| 14 | | | 2.00 | 429 | 1.69 | 297 | 1.55 | ... |
| 15 | | | 1.99 | 423 | 1.69 | 297 | 1.55 | ... |
| 16 | | | 2.00 | 429 | 1.67 | 290 | 1.45 | ... |
| 17 | 2.56 | 846 | 2.00 | 429 | 1.60 | 269 | 1.47 | ... |
| 18 | 2.44 | 748 | 1.95 | 401 | 1.57 | 261 | 1.66 | ... |
| 19 | 2.44 | 748 | 1.95 | 401 | 1.55 | 255 | 1.66 | ... |
| 20 | 2.56 | 846 | 1.93 | 391 | 1.56 | 258 | 1.62 | ... |
| 21 | 2.46 | 764 | 1.93 | 391 | 1.56 | 258 | ... | ... |
| 22 | 2.67 | 936 | 1.94 | 396 | 1.56 | 258 | | ... |
| 23 | 2.52 | 813 | 1.90 | 377 | 1.56 | 258 | ... | ... |
| 24 | 2.33 | 659 | 1.89 | 373 | 1.56 | 258 | ... | ... |
| 25 | 2.89 | 1118 | 1.90 | 377 | 1.56 | 258 | ... | ... |
| 26 | 2.67 | 936 | 1.94 | 396 | 1.56 | 258 | ... | ... |
| 27 | 2.45 | 756 | 1.96 | 407 | 1.45 | 230 | ... | ... |
| 28 | 2.37 | 691 | 1.93 | 391 | 1.44 | 228 | ... | ... |
| 29 | 2.31 | 644 | 1.89 | 373 | 1.44 | 228 | ... | ... |
| 30 | 2.20 | 561 | 1.86 | 359 | 1.44 | 228 | | ... |
| 31 | 2.16 | 532 | | | 1.45 | 230 | | ... |

Note.—On Nov. 12, the river was frozen to the bottom of the gauge and the height of water could not be read. A thaw on Nov. 14 caused the water to overflow the ice and on Nov. 20 the gauge was carried out by the ice which broke up. Satisfactory arrangements regarding remuneration could not be made and no observations were therefore reported after Nov. 21. Not sufficient data to compute daily discharge from Nov. 14 to 20.

## Monthly Discharge of Ghost River at Gillies' Ranche, Alta., for 1911.

(Drainage area, 367 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| August (17-31) | 1,118 | 532 | 773 | 2.106 | 1.18 | 22,998 |
| September | 1,235 | 359 | 505 | 1.376 | 1.54 | 30,050 |
| October | 359 | 228 | 291 | 0.793 | 0.91 | 17,893 |
| November (1-11) | 247 | 191 | 219 | 0.597 | 0.24 | 4,778 |
| The period | | | | | 3.87 | 75,719 |

## Jumpingpound Creek near Jumping Pound, Alta.

This station was established in 1906 by J. F. Hamilton. It is located at a traffic bridge on a road diversion on the S. E. ¼ Sec. 30, Tp. 24, Rge. 4, W. 5th Mer., and about 300 yards from Jumping Pound P. O.,

The channel is straight for about 600 feet above and 500 feet below the station. The current is sluggish at and above the station, but breaks into rapids about 150 feet below the station. The right bank is composed of gravel and boulders, covered with clay, and is not liable to overflow. The left bank is similar, but not so high, and is liable to overflow in excessive floods. The bed of the stream is composed of coarse gravel and boulders. It is rough and may shift in flood stages. The stream is divided into several channels during its higher stages by a pier and pile bents supporting the bridge.

At low-water stage of the stream discharge measurements are made at wading sections, either above or below the bridge. During higher stages of the stream, discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the west side of the right abutment. Distances are marked on the railing of the bridge, at every five feet from the initial point.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to the downstream face of the first pile bent west of the main truss of the bridge. The zero (elev., 89.84) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated about thirty feet northeast of the east end of the bridge.

The gauge was read during 1911 by John Bateman, the postmaster at Jumping Pound.

### Discharge Measurements of Jumpingpound Creek at Jumping Pound, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 2 | H. C. Ritchie | 77 | 168.3 | 0.21 | 2.02 | 35.2 |
| June 8 | R. T. Sailman | 99.8 | 215.7 | 0.83 | 2.56 | 178.2 |
| July 12 | L. R. Brereton | 98 | 209.2 | 0.62 | 2.39 | 130.6 |
| Aug. 16 | do | 109 | 268.5 | 1.30 | 2.92 | 350.7 |
| Sept. 14 | do | 98 | 208.6 | 0.66 | 2.44 | 137.9 |
| Oct. 19 | do | 75 | 169.7 | 0.36 | 2.23 | 60.2 |

### Daily Gauge-height and Discharge of Jumpingpound Creek at Jumping Pound, Alta., for 1911.

| Day. | May. | | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | †2.02 | 30.8 | 3.30 | 548 | 2.98 | 382 | 2.35 | 106 | 2.56 | 184 | 2.47 | 149 |
| 2 | 2.02 | 30.8 | 3.20 | 496 | 2.99 | 387 | 2.53 | 172 | 2.54 | 176 | 2.49 | 156 |
| 3 | †2.02 | 30.8 | 3.00 | 392 | 2.81 | 297 | 2.65 | 223 | 2.95 | 366 | 2.49 | 156 |
| 4 | 2.02 | 30.8 | 2.80 | 292 | 2.80 | 292 | 2.70 | 246 | 2.95 | 366 | 2.48 | 152 |
| 5 | 2.02 | 30.8 | 2.60 | 201 | 2.75 | 269 | 2.75 | 269 | 2.90 | 341 | 2.49 | 156 |
| 6 | 2.02 | 30.8 | 2.60 | 201 | 2.65 | 223 | 2.75 | 269 | 2.82 | 302 | 2.45 | 141 |
| 7 | 2.02 | 30.8 | 2.60 | 201 | 2.60 | 201 | 4.35 | 1,116 | 2.72 | 255 | 2.43 | 134 |
| 8 | 2.02 | 30.8 | 2.56 | 184 | 2.55 | 180 | 4.50 | 1,200 | 2.70 | 246 | 2.39 | 120 |
| 9 | 2.02 | 30.8 | 2.49 | 156 | 2.51 | 164 | 4.00 | 921 | 2.63 | 214 | 2.37 | 113 |
| 10 | 2.02 | 30.8 | 2.49 | 156 | 2.50 | 160 | 3.50 | 652 | 2.63 | 214 | 2.36 | 109 |
| 11 | 2.02 | 30.8 | 2.49 | 156 | 2.50 | 160 | 3.25 | 522 | 2.55 | 180 | 2.33 | 100 |
| 12 | 2.02 | 30.8 | 2.48 | 152 | 2.39 | 120 | 3.00 | 392 | 2.55 | 180 | 2.32 | 96.4 |
| 13 | 2.03 | 32.2 | 2.48 | 152 | 2.35 | 106 | 2.95 | 366 | 2.50 | 160 | 2.30 | 90 |
| 14 | 2.30 | 90 | 2.47 | 149 | 2.30 | 90 | 2.85 | 316 | 2.45 | 141 | 2.29 | 87.2 |
| 15 | 2.40 | 123 | 2.47 | 149 | 2.30 | 90 | 3.01 | 397 | 2.42 | 130 | 2.30 | 90 |
| 16 | 3.00 | 392 | 2.45 | 141 | 2.28 | 84.4 | 2.92 | 351 | 2.40 | 123 | 2.29 | 87.2 |
| 17 | 2.90 | 341 | 2.44 | 137 | 2.25 | 76 | 2.85 | 316 | 2.38 | 116 | 2.28 | 84.4 |
| 18 | 2.70 | 246 | 2.42 | 130 | 2.25 | 76 | 2.73 | 260 | 2.37 | 113 | 2.29 | 87.2 |
| 19 | 2.60 | 201 | 2.40 | 123 | 2.24 | 73.4 | 2.70 | 246 | 2.36 | 109 | 2.23 | 70.8 |
| 20 | 2.50 | 160 | 2.30 | 90 | 2.24 | 73.4 | 2.60 | 201 | 2.36 | 109 | .... | .... |
| 21 | 2.40 | 123 | 2.21 | 65.6 | 2.24 | 73.4 | 2.70 | 246 | 2.38 | 116 | .... | .... |
| 22 | 2.50 | 160 | 2.15 | 52 | 3.30 | 548 | 2.70 | 246 | 2.40 | 123 | .... | .... |
| 23 | 2.40 | 123 | 2.15 | 52 | 3.25 | 522 | 2.65 | 223 | 2.46 | 145 | .... | .... |
| 24 | 2.40 | 123 | 2.55 | 180 | 3.00 | 392 | 2.60 | 201 | 2.48 | 152 | .... | .... |
| 25 | 2.40 | 123 | 2.91 | 346 | 2.78 | 283 | 2.73 | 260 | 2.49 | 156 | .... | .... |
| 26 | 2.50 | 160 | 2.70 | 246 | 2.75 | 269 | 2.73 | 260 | 2.50 | 160 | .... | .... |
| 27 | 2.50 | 160 | 2.65 | 223 | 2.65 | 223 | 2.70 | 246 | 2.50 | 160 | .... | .... |
| 28 | 2.40 | 123 | 2.95 | 366 | 2.56 | 184 | 2.68 | 237 | 2.52 | 168 | .... | .... |
| 29 | 2.50 | 160 | 2.95 | 366 | 2.45 | 141 | 2.62 | 210 | 2.49 | 156 | .... | .... |
| 30 | 2.90 | 341 | 2.99 | 387 | 2.39 | 120 | 2.60 | 201 | 2.47 | 149 | .... | .... |
| 31 | 3.00 | 392 | .... | .... | 2.35 | 106 | 2.58 | 193 | .... | .... | .... | .... |

† No observations, gauge height interpolated.

MONTHLY DISCHARGE OF JUMPINGPOUND CREEK NEAR JUMPING POUND, ALTA., for 1911

(Drainage area, 187 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| May | 392 | 30.8 | 127 | 0.679 | 0.78 | 7,809 |
| June | 548 | 52.0 | 216 | 1.155 | 1.29 | 12,853 |
| July | 548 | 73.4 | 205 | 1.096 | 1.26 | 12,605 |
| August | 1,209 | 106.0 | 357 | 1.909 | 2.20 | 21,951 |
| September | 366 | 109.0 | 184 | 0.984 | 1.10 | 10,949 |
| October (1-19) | 156 | 70.8 | 115 | 0.615 | 0.43 | 4,334 |
| The period | | | | | 7.06 | 70,501 |

## BOW RIVER AT CALGARY, ALTA.

The old station established, May 5, 1908, by P. M. Sauder at the Cushing traffic bridge on the S. E. ¼ Sec. 12, Tp. 24, Rge. 1, W. 5th Mer., was not satisfactory. A new gauging station, was, therefore, established on November 25, 1910, by H. R. Carscallen. It is located at the Langevin traffic bridge, on Fourth Street east, in the N. E. ¼ Sec. 15, Tp. 24. Rge. 1, W. 5th Mer. As the cross-section at the Langevin bridge was affected by some old bridge piers, a plain staff gauge was at first fixed to a breakwater several hundred feet upstream from the bridge, but on November 14, 1911, a chain gauge was established on Langevin bridge and the observations have been made with it since that date.

The river flows in one channel at all stages. It is almost straight for about half a mile above and one quarter of a mile below the station. Both banks are low but are not liable to overflow. The bed of the stream is composed of coarse gravel, and may shift in flood stages of the stream.

Discharge measurements are made from the downstream side of the bridge, which is a two-span steel structure supported by concrete abutments and pier. The initial point for soundings is the south face of the left abutment.

The gauge, which is the standard chain type, is fixed to the floor of the bridge at a point about the centre of the downstream side of the north span of the bridge. The length of the chain from the bottom of the weight to the marker is 22.28 feet. The zero of the gauge is referred to the top of the downstream side of the centre pier of the bridge. The zero of the plain staff gauge on the breakwater (elev., 87.96) was referred to a permanent iron bench-mark (assumed elev., 100.00) situated at the intersection of Second and Third avenues east.

During 1910, the gauge was read by Daniel Hall. During 1911 the gauge was read from January 1 to May 17 by Daniel Hall, from May 21 to July 4 by James Lumley, from July 4 to December 9 by Andrew Brown, and from December 10 to the end of the year by William Peterson.

## Discharge Measurements of Bow River at Calgary, Alta., in 1910*-11.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| 1910 | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Nov. 25 | H. R. Carscallen | 170.6 | 491.8 | 3.22 | 1.71 | 1,583†x |
| Dec. 13 | do | 214.8 | 738.4 | 1.76 | 1.67 | 1,302x |
| 1911 | | | | | | |
| Jan. 4 | H. R. Carscallen | | | | 1.87 | 600.8▲x |
| Feb. 3 | do | 212 | 311.4 | 3.02 | 3.60 | 942.x |
| Feb. 22 | do | 212 | 286.3 | 2.88 | 3.34 | 823.4x |
| Mar. 11 | do | 212 | 370.6 | 2.68 | 3.30 | 832.x |
| Apr. 24 | H. C. Ritchie | 284 | 755.4 | 1.90 | 1.57 | 1,438 |
| May 8 | do | 290.5 | 901.4 | 2.66 | 2.37 | 2,394 |
| May 15 | do | 290.5 | 881.1 | 2.63 | 2.36 | 2,317 |
| May 26 | do | 294 | 964.8 | 3.02 | 2.70 | 2,916 |
| June 9 | B. Russell | 307 | 1,428 | 4.85 | 4.15 | 6,936 |
| June 19 | do | 320 | 1,962 | 6.85 | 5.68 | 13,438 |
| July 6 | do | 315.8 | 1,808 | 5.58 | 4.82 | 10,093 |
| Aug. 12 | H. Brown | 312 | 1,658 | 4.96 | 4.44 | 8,224 |
| Aug. 28 | do | 293 | 1,451 | 3.89 | 3.76 | 5,643 |
| Sept. 12 | do | 298.8 | 1,295 | 3.38 | 3.30 | 4,371 |
| Sept. 26 | do | 295 | 1,194 | 2.79 | 2.87 | 3,230 |
| Nov. 23 | N. M. Sutherland | 242 | 795.4 | 1.95 | 2.19 | 1,551x |
| Dec. 7 | do | 293 | 851.7 | 0.89 | 4.44 | 5,754.7x |
| Dec. 22 | do | 277 | 795.3 | 0.91 | 4.30 | 722.9x |

* Other gaugings at the old gauging station in 1910 were published in the Second Annual Report. Data are insufficient to compute daily discharges in November and December of 1910.

† Gauging made at Centre St. bridge.

▲ Gauging was made at traffic bridge on sec. 14 and the discharge of Elbow river was deducted to obtain the discharge of Bow river at the regular station. x Ice conditions.

## Daily Gauge-height and Discharge of Bow River at Calgary, Alta., for 1910

| Day. | November Gauge Height. | November Discharge. | December Gauge Height. | December Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.45 | 1,270 |
| 2 | | | 1.60 | 1,380 |
| 3 | | | 1.65 | 1,410 |
| 4 | | | 1.55 | 1,310 |
| 5 | | | 1.62 | 1,350 |
| 6 | | | 1.75 | 1,450 |
| 7 | | | 1.79 | 1,470 |
| 8 | | | 1.97 | 1,620 |
| 9 | | | 1.97 | 1,600 |
| 10 | | | 1.97 | 1,580 |
| 11 | | | 2.05 | 1,660 |
| 12 | | | 1.67 | 1,300 |
| 13 | | | 2.04 | 1,590 |
| 14 | | | 2.05 | 1,560 |
| 15 | | | 1.97 | 1,470 |
| 16 | | | 1.78 | 1,240 |
| 17 | | | 1.85 | 1,250 |
| 18 | | | 1.73 | 1,130 |
| 19 | | | 1.89 | 1,190 |
| 20 | | | 1.80 | 1,100 |
| 21 | | | 1.78 | 1,050 |
| 22 | | | 1.69 | 970 |
| 23 | | | 1.78 | 980 |
| 24 | | | 1.44 | 810 |
| 25 | | | 1.70 | 880 |
| 26 | | | 1.74 | 860 |
| 27 | | | 1.75 | 820 |
| 28 | | | 1.80 | 810 |
| 29 | 1.30 | 1,180 | 1.80 | 770 |
| 30 | 1.40 | 1,230 | 1.64 | 700 |
| 31 | .... | .... | 1.97 | 760 |

Note.—Ice conditions during the whole period and daily discharges are therefore only approximate.

DAILY GAUGE-HEIGHT AND DISCHARGE OF BOW RIVER AT CALGARY, ALTA., for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.83 | 690 | 3.74 | 960 | 3.35 | 840 | 2.64 | 890 | 1.64 | 1,496 | 3.87 | 5,970 |
| 2 | 1.70 | 640 | 3.65 | 940 | 3.30 | 820 | 2.47 | 860 | 1.70 | 1,550 | 4.05 | 6,600 |
| 3 | 1.42 | 600 | 3.57 | 928 | 3.42 | 868 | 2.57 | 940 | 1.83 | 1,670 | 4.17 | 7,032 |
| 4 | 1.90 | 600 | 3.73 | 1,005 | 3.40 | 860 | 2.44 | 930 | 1.84 | 1,680 | 4.96 | 10,144 |
| 5 | 2.38 | * | 3.67 | 975 | 3.40 | 860 | 2.45 | 980 | 1.98 | 1,836 | 4.75 | 9,240 |
| 6 | 2.87 | ... | 3.68 | 980 | 3.35 | 840 | 2.67 | 1,120 | 2.25 | 2,170 | 4.55 | 8,450 |
| 7 | 3.02 | ... | 3.66 | 970 | 3.35 | 840 | 2.75 | 1,200 | 2.33 | 2,288 | 4.32 | 7,576 |
| 8 | 3.73 | ... | 3.67 | 975 | 3.37 | 848 | 2.57 | 1,170 | 2.35 | 2,320 | 4.30 | 7,500 |
| 9 | 3.85 | ... | 3.67 | 975 | 3.36 | 844 | 2.70 | 1,270 | 2.37 | 2,352 | 4.27 | 7,392 |
| 10 | 3.44 | ... | 3.65 | 965 | 3.35 | 840 | 2.73 | 1,330 | 2.34 | 2,304 | 4.12 | 6,852 |
| 11 | 2.95 | ... | 3.65 | 965 | 3.35 | 840 | 2.64 | 1,340 | 2.27 | 2,198 | 4.10 | 6,780 |
| 12 | 3.12 | ... | 3.70 | 990 | 3.35 | 840 | 2.50 | 1,320 | 2.24 | 2,156 | 4.22 | 7,212 |
| 13 | 3.45 | ... | 3.63 | 955 | 3.35 | 840 | 2.45 | 1,340 | 2.34 | 2,304 | 4.57 | 8,526 |
| 14 | 3.80 | ... | 3.55 | 920 | 3.40 | 860 | 1.84 | 1,040 | 2.37 | 2,352 | 5.85 | 14,290 |
| 15 | 4.10 | ... | 3.54 | 916 | 3.45 | 880 | 1.97 | 1,180 | 2.37 | 2,352 | 5.97 | 14,890 |
| 16 | 4.85 | ... | 3.50 | 900 | 3.37 | 848 | 2.05 | 1,300 | 2.40 | 2,400 | 6.05 | 15,300 |
| 17 | 4.86 | ... | 3.37 | 848 | 3.37 | 848 | 1.87 | 1,220 | 2.97 | 3,534 | 6.00 | 15,040 |
| 18 | 4.75 | ... | 3.45 | 880 | 3.33 | 832 | 2.07 | 1,450 | 2.94 | 3,468 | 5.84 | 14,240 |
| 19 | 4.55 | ... | 3.43 | 872 | 3.46 | 884 | 1.67 | 1,190 | 2.90 | 3,380 | 5.75 | 13,800 |
| 20 | 4.46 | * | 3.24 | 796 | 3.60 | 940 | 1.70 | 1,270 | 2.85 | 3,270 | 5.60 | 13,320 |
| 21 | 4.37 | 1,000 | 3.43 | 872 | 3.56 | 924 | 1.76 | 1,390 | 2.85 | 3,270 | 5.52 | 13,180 |
| 22 | 4.30 | 990 | 3.35 | 840 | 3.56 | 924 | 1.88 | 1,560 | 3.00 | 3,600 | 5.47 | 13,150 |
| 23 | 4.27 | 1,000 | 3.42 | 868 | 3.56 | 924 | 1.15 | 1,060 | 3.05 | 3,720 | 5.77 | 14,340 |
| 24 | 4.27 | 1,020 | 3.24 | 796 | 3.35 | 840 | 1.56 | 1,428 | 2.97 | 3,534 | 6.10 | 15,740 |
| 25 | 4.05 | 950 | 3.44 | 876 | 3.15 | 810 | 2.33 | 2,288 | 2.90 | 3,380 | 6.25 | 16,460 |
| 26 | 3.93 | 910 | 3.44 | 876 | 3.08 | 820 | 1.73 | 1,577 | 2.77 | 3,094 | 6.05 | 15,840 |
| 27 | 3.67 | 830 | 3.45 | 880 | 2.95 | 810 | 1.70 | 1,550 | 2.69 | 2,920 | 5.56 | 14,080 |
| 28 | 3.93 | 960 | 3.43 | 872 | 2.95 | 850 | 1.66 | 1,514 | 2.65 | 2,840 | 5.47 | 13,330 |
| 29 | 3.94 | 980 | .... | ... | 2.80 | 830 | 1.68 | 1,532 | 2.59 | 2,722 | 5.47 | 13,330 |
| 30 | 3.90 | 990 | ... | .. | 2.82 | 880 | 1.67 | 1,523 | 2.82 | 3,204 | 5.49 | 13,430 |
| 31 | 3.97 | 1,040 | .... | ... | 2.70 | 870 | ... | .. | 3.00 | 3,600 | .... | .... |

DAILY GAUGE-HEIGHT AND DISCHARGE OF BOW RIVER AT CALGARY, ALTA., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5.55 | 13,730 | 4.15 | 7,000 | 3.65 | 5,310 | 2.78 | 3,116 | 1.93 | 1,776 | 4.30 | 1,070 |
| 2 | 5.45 | 13,230 | 4.16 | 7,040 | 3.67 | 5,370 | 2.75 | 3,050 | 1.92 | 1,764 | 4.30 | 980 |
| 3 | 5.40 | 12,980 | 4.18 | 7,120 | 3.70 | 5,460 | 2.75 | 3,050 | 1.92 | 1,764 | 4.52 | 1,050 |
| 4 | 5.30 | 12,480 | 4.37 | 7,908 | 4.00 | 6,420 | 2.73 | 3,006 | 1.93 | 1,776 | 4.55 | 990 |
| 5 | 5.06 | 11,280 | 4.45 | 8,280 | 3.97 | 6,312 | 2.68 | 2,900 | 1.95 | 1,800 | 4.53 | 880 |
| 6 | 4.74 | 9,680 | 4.45 | 8,280 | 3.85 | 5,910 | 2.65 | 2,840 | 1.95 | 1,800 | 4.50 | 770 |
| 7 | 4.77 | 9,830 | 5.05 | 11,230 | 3.77 | 5,670 | 2.75 | 3,050 | 1.85 | 1,690 | 4.45 | 744 |
| 8 | 5.05 | 11,230 | 5.83 | 15,130 | 3.65 | 5,310 | 2.85 | 3,270 | 1.45 | 1,340 | 4.40 | 748 |
| 9 | 4.95 | 10,730 | 4.97 | 10,830 | 3.55 | 5,020 | 2.75 | 3,050 | 1.43 | 1,324 | 4.50 | 740 |
| 10 | 4.75 | 9,730 | 4.73 | 9,630 | 3.48 | 4,828 | 2.42 | 2,432 | 1.40 | 1,300 | 4.43 | 746 |
| 11 | 4.85 | 10,230 | 4.55 | 8,760 | 3.45 | 4,750 | 2.45 | 2,480 | 1.25 | 1,185 | 4.51 | 739 |
| 12 | 4.54 | 8,712 | 4.45 | 8,280 | 3.40 | 4,620 | 2.40 | 2,400 | 1.20 | 1,150 | 4.37 | 750 |
| 13 | 4.42 | 8,136 | 4.30 | 7,600 | 3.37 | 4,542 | 2.42 | 2,432 | 0.90 | 960 | 4.46 | 743 |
| 14 | 4.40 | 8,040 | 4.25 | 7,400 | 3.35 | 4,490 | 2.40 | 2,400 | 1.32 | 1,200 | 4.47 | 742 |
| 15 | 4.58 | 8,904 | 4.23 | 7,320 | 3.32 | 4,412 | 2.23 | 2,142 | 1.50 | 1,295 | 4.25 | 760 |
| 16 | 4.53 | 8,664 | 4.20 | 7,200 | 3.32 | 4,412 | 2.18 | 2,076 | 2.00 | 1,700 | 4.47 | 742 |
| 17 | 4.60 | 9,000 | 4.15 | 7,000 | 3.25 | 4,230 | 2.43 | 2,448 | 2.35 | 2,080 | 4.37 | 750 |
| 18 | 4.65 | 9,240 | 4.00 | 6,420 | 3.23 | 4,178 | 2.40 | 2,400 | 2.47 | 2,200 | 4.32 | 754 |
| 19 | 4.67 | 9,336 | 4.00 | 6,420 | 3.20 | 4,100 | 2.30 | 2,240 | 2.48 | 2,160 | 4.25 | 760 |
| 20 | 4.57 | 8,856 | 3.97 | 6,312 | 3.05 | 3,720 | 2.17 | 2,064 | 2.48 | 2,120 | 4.32 | 754 |
| 21 | 4.52 | 8,616 | 3.95 | 6,240 | 3.10 | 3,840 | 2.25 | 2,170 | 2.45 | 2,010 | 4.37 | 750 |
| 22 | 4.53 | 8,664 | 3.95 | 6,240 | 3.05 | 3,720 | 2.15 | 2,040 | 2.37 | 1,840 | 4.34 | 753 |
| 23 | 4.55 | 8,760 | 3.90 | 6,060 | 3.00 | 3,600 | 2.17 | 2,064 | 2.35 | 1,720 | 4.35 | 752 |
| 24 | 4.45 | 8,280 | 3.85 | 5,910 | 2.97 | 3,534 | 2.20 | 2,100 | 2.35 | 1,740 | 4.55 | 736 |
| 25 | 4.40 | 8,040 | 3.85 | 5,910 | 2.95 | 3,490 | 2.23 | 2,142 | 2.30 | 1,660 | 4.67 | 726 |
| 26 | 4.46 | 8,328 | 3.90 | 6,060 | 2.90 | 3,380 | 2.25 | 2,170 | 2.25 | 1,610 | 4.75 | 720 |
| 27 | 4.55 | 8,760 | 3.85 | 5,910 | 2.88 | 3,336 | 2.13 | 2,016 | 2.23 | 1,590 | 5.51 | 659 |
| 28 | 4.40 | 8,040 | 3.75 | 5,610 | 2.85 | 3,270 | 2.10 | 1,980 | 4.28 | 1,360 | 5.35 | 672 |
| 29 | 4.25 | 7,400 | 3.70 | 5,460 | 2.80 | 3,160 | 2.10 | 1,980 | 4.27 | 1,230 | 5.15 | 688 |
| 30 | 4.23 | 7,320 | 3.63 | 5,250 | 2.80 | 3,160 | 1.97 | 1,824 | 4.25 | 1,120 | 5.35 | 672 |
| 31 | 4.15 | 7,000 | 3.70 | 5,460 | .... | .... | 1.95 | 1,800 | .... | .... | 5.62 | 650 |

* Not sufficient data to compute daily discharge from Jan. 5 to Jan. 20.

NOTE:—Ice conditions during January, February, March, November and December. Daily discharges for those months are only approximate, particularly December which may be a little low.

MONTHLY DISCHARGE OF BOW RIVER NEAR CALGARY, ALTA., for 1910-11.

(Drainage area, 3138 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| 1910 | | | | | | |
| November 29-30 | 1,230 | 1,180 | 1,205 | 0.348 | 0.03 | 4,780 |
| December | 1,660 | 700 | 1,205 | 0.384 | 0.44 | 74,093 |
| The period | ...... | ......... | ......... | ......... | 0.47 | 78,873 |
| 1911 | | | | | | |
| January (1-4) 21-30 | 1,040 | 600 | 880 | 0.280 | 0.16 | 26,182 |
| February | 1,005 | 796 | 914 | 0.291 | 0.30 | 50,761 |
| March | 940 | 810 | 857 | 0.273 | 0.31 | 52,695 |
| April | 2,288 | 860 | 1,292 | 0.412 | 0.46 | 76,879 |
| May | 3,720 | 1,496 | 2,676 | 0.852 | 0.98 | 164,541 |
| June | 16,460 | 5,970 | 11,434 | 3.640 | 4.06 | 680,370 |
| July | 13,730 | 7,000 | 9,459 | 3.010 | 3.47 | 581,611 |
| August | 15,130 | 5,250 | 7,396 | 2.360 | 2.72 | 454,762 |
| September | 6,420 | 3,160 | 4,452 | 1.420 | 1.58 | 264,912 |
| October | 3,270 | 1,800 | 2,424 | 0.772 | 0.89 | 149,046 |
| November | 2,200 | 960 | 1,609 | 0.513 | 0.57 | 95,740 |
| December | 1,070 | 650 | 774 | 0.247 | 0.28 | 47,591 |
| The period | ...... | ......... | ... | | 15.78 | 2,645,090 |

## Elbow River at Calgary, Alta.

This station was established May 8, 1908, by P. M. Sauder. It is located near the old General Hospital in Calgary, in the S. W. ¼ Sec. 14, Tp. 24, Rge. 1, W. 5th Mer. There are no tributaries below this station, and there is no water diverted from the river except that used by the City of Calgary, whose intake is about eleven miles upstream.

The stream is confined to one channel. The left bank is high and does not overflow. The right bank is covered with brush, and may overflow at extreme flood-stage of the stream. The bed of the stream is composed of boulders and gravel and is not liable to change at the station, but may do so further up the stream where there is a small ripple. The channel is straight for about 500 feet below and above the station. The current is slow in low-water stages of the stream but fairly swift in the higher stages.

Discharge measurements are made by means of a cable-car, tagged wire, and stay wire. The initial point for soundings is the zero of the tagged wire, at its fastening to the cable support, on the left bank.

The original gauge was a plain staff graduated to feet and hundredths, attached to a twelve-inch post sunk in the bed of the stream at the left bank. The zero of the gauge (elev., 83.51) is referred to a permanent iron bench-mark (assumed elev., 100.00) which is situated about twenty-five feet south of the cable support on the left bank.

After November 14 gauge-height observations were made with a chain gauge established on that date by H. R. Carscallen on the upstream side of the new traffic bridge spanning Elbow River between Eleventh and Twelfth avenues east. The zero (elev., 84.75) is referred to a bench-mark (assumed elev., 100.00) on the extreme upstream corner of the cement wing-wall of the left abutment of the bridge. The length of the chain from the bottom of the weight to the marker is 16.03 feet.

During 1911 the gauge was read once each day by Mrs. I. S. White.

It is estimated by J. T. Child, City Engineer, that the City of Calgary diverted an average of 11 cubic feet per second during 1911.

### Discharge Measurements of Elbow River at Calgary, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 5 | H. R. Carscallen | 120 0 | 193 1 | 0 33 | 1 10 | 64 0† |
| Jan. 16 | do | 120 0 | 181 1 | 0 25 | 0 90 | 45 1† |
| Feb. 6 | do | 120 0 | 215 8 | 0 40 | 1 97 | 85 4† |
| Feb. 18 | do | 100 0 | 204 0 | 0 54 | 2 22 | 111 0† |
| Mar. 14 | do | 100 0 | 178 3 | 0 58 | 2 05 | 103 6† |
| Apr. 6 | do | 85 0 | 143 0 | 0 64 | 0 33 | 90 9† |
| Apr. 15 | do | 123 0 | 249 5 | 0 66 | 0 57 | 165 3 |
| May 1 | H. C. Ritchie | 133 0 | 269 2 | 0 79 | 0 68 | 211 5 |
| May 25 | do | 137 5 | 346 2 | 1 22 | 1 21 | 422 5 |
| June 5 | B. Russell | 148 0 | 457 3 | 2 06 | 2 01 | 942 4 |
| June 21 | do | 144 0 | 395 6 | 1 65 | 1 59 | 654 5 |
| July 5 | do | 142 5 | 441 6 | 1 93 | 1 90 | 852 6 |
| Aug. 3 | H. T. Thomas | 140 0 | 394 6 | 1 59 | 1 56 | 629 6 |
| Aug. 9 | H. Brown | 150 5 | 675 1 | 3 63 | 3 46 | 2,385 0 |
| Aug. 23 | do | 139 0 | 410 8 | 1 67 | 1 66 | 686 4 |
| Sept. 8 | do | 142 5 | 461 6 | 2 10 | 2 01 | 967 6 |
| Sept. 25 | do | 135 5 | 347 8 | 1 30 | 1 33 | 453 1 |
| Oct. 18 | B. Russell | 132 0 | 331 8 | 1 04 | 1 08 | 344 5 |
| Nov. 21 | N. McL. Sutherland | 127 0 | 279 1 | 0 82 | 2 24* | 229 1† |
| Dec. 6 | do | 115 0 | 241 2 | 0 40 | 2 30* | 95 8† |
| Dec. 23 | do | 105 0 | 206 2 | 0 73 | 2 10* | 151 1† |

* New chain gauge. † Ice conditions.

Daily Gauge-height and Discharge of Elbow River at Calgary, Alta., for 1911

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.06 | 71 | 1.78 | 73 | 2.30 | 128 | 0.55 | 80 | 0.71 | 209 | 2.61 | 1,466 |
| 2 | 0.99 | 65 | 1.79 | 74 | 2.26 | 123 | 0.45 | 79 | 0.68 | 201 | 2.51 | 1,370 |
| 3 | 0.90 | 60 | 1.86 | 78 | 2.25 | 122 | †0.42 | 82 | 0.66 | 196 | 2.37 | 1,244 |
| 4 | 0.87 | 54 | 1.89 | 79 | 2.25 | 123 | 0.38 | 84 | 0.64 | 190 | 2.25 | 1,139 |
| 5 | 1.09 | 64 | 1.96 | 85 | 2.26 | 125 | 0.51 | 102 | 0.73 | 215 | 2.09 | 1,006 |
| 6 | 1.12 | 64 | 2.00 | 88 | 2.23 | 121 | 0.47 | 105 | 0.73 | 215 | 1.83 | 807 |
| 7 | 1.25 | 69 | 1.95 | 84 | 2.26 | 126 | 0.60 | 147 | 0.74 | 218 | 1.74 | 743 |
| 8 | 1.34 | 71 | 2.03 | 91 | 2.25 | 125 | 0.49 | 143 | 0.78 | 230 | 1.69 | 708 |
| 9 | 1.19 | 63 | 1.99 | 87 | 2.21 | 121 | 0.47 | 152 | 0.76 | 224 | 1.65 | 682 |
| 10 | †1.05 | 57 | 1.96 | 85 | 2.22 | 122 | 0.67 | 198 | 0.71 | 209 | 1.61 | 655 |
| 11 | †0.90 | 51 | 1.98 | 86 | 2.17 | 116 | 0.63 | 188 | 0.71 | 209 | 1.78 | 771 |
| 12 | 0.76 | 48 | 2.02 | 90 | 2.09 | 107 | 0.89 | 267 | 0.68 | 201 | 1.99 | 926 |
| 13 | 0.79 | 47 | .2.03 | 91 | 2.14 | 114 | 0.80 | 236 | 0.78 | 230 | 2.21 | 1,105 |
| 14 | 0.74 | 45 | 2.00 | 88 | 2.08 | 107 | 0.67 | 198 | 1.02 | 319 | 2.17 | 1,071 |
| 15 | 0.99 | 48 | 2.07 | 95 | 2.08 | 116 | 0.69 | 203 | 0.98 | 302 | 2.09 | 1,006 |
| 16 | 0.90 | 45 | 2.03 | 91 | 2.09 | 128 | 0.79 | 233 | 1.18 | 392 | 2.02 | 950 |
| 17 | 1.01 | 47 | 2.10 | 98 | 1.96 | 118 | 0.92 | 278 | 1.97 | 911 | 1.97 | 911 |
| 18 | 1.59 | 64 | 2.21 | 110 | 1.92 | 123 | 0.87 | 260 | 1.75 | 750 | 1.85 | 821 |
| 19 | 1.59 | 64 | 2.16 | 104 | 1.86 | 124 | 0.84 | 250 | 1.59 | 641 | 1.70 | 715 |
| 20 | 1.60 | 64 | 2.10 | 98 | 1.82 | 128 | 0.98 | 302 | 1.40 | 520 | 1.65 | 682 |
| 21 | 1.68 | 68 | 2.12 | 101 | 2.26 | 255 | 1.30 | 458 | 1.36 | 495 | 1.59 | 641 |
| 22 | 1.69 | 68 | 2.23 | 115 | 1.97 | 191 | 1.43 | 539 | 1.32 | 470 | 1.58 | 635 |
| 23 | 1.72 | 70 | 2.27 | 120 | 1.92 | 199 | 1.17 | 388 | 1.33 | 477 | 1.67 | 695 |
| 24 | 1.69 | 68 | 2.19 | 111 | 1.84 | 192 | 1.16 | 383 | 1.29 | 452 | 1.76 | 757 |
| 25 | 1.68 | 68 | 2.16 | 108 | 1.81 | 203 | 1.10 | 354 | 1.28 | 447 | 2.40 | 1,270 |
| 26 | 1.75 | 72 | 2.20 | 113 | 1.70 | 193 | 1.06 | 336 | 1.25 | 430 | 1.99 | 926 |
| 27 | 1.64 | 66 | 2.23 | 119 | 1.60 | 185 | 0.99 | 306 | 1.22 | 413 | 1.95 | 896 |
| 28 | 1.74 | 71 | 2.27 | 123 | 1.55 | 189 | 0.89 | 267 | 1.22 | 413 | 2.00 | 934 |
| 29 | 1.75 | 72 | .... | .. | 1.40 | 170 | 0.80 | 236 | 1.43 | 539 | 2.02 | 950 |
| 30 | 1.76 | 72 | .... | .... | 0.90 | 90 | 0.73 | 215 | 1.86 | 829 | 2.05 | 974 |
| 31 | 1.78 | 73 | .... | .... | 0.69 | 86 | ... | .... | 2.16 | 1,063 | .... | .... |

## Daily Gauge-height and Discharge of Elbow River at Calgary, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* |
| 1 | 2.33 | 1,208 | 1.25 | 430 | 1.50 | 583 | 1.30 | 458 | 0.95 | 290 | 2.08 | 87 |
| 2 | 2.31 | 1,191 | 1.55 | 615 | 1.47 | 564 | 1.29 | 452 | 0.93 | 282 | 2.07 | 70 |
| 3 | 2.10 | 1,014 | 1.60 | 648 | 1.45 | 552 | 1.32 | 470 | 0.92 | 278 | 2.15 | 91 |
| 4 | 1.99 | 926 | 1.80 | 785 | 2.69 | 1,546 | 1.30 | 458 | 0.92 | 278 | 2.10 | 75 |
| 5 | 1.88 | 843 | 1.89 | 851 | 2.40 | 1,270 | 1.29 | 452 | 0.90 | 270 | 2.11 | 70 |
| 6 | 1.75 | 750 | 1.90 | 858 | 2.25 | 1,139 | 1.28 | 447 | 0.84 | 250 | 2.28 | 92 |
| 7 | 1.70 | 715 | 2.31 | 1,191 | 2.16 | 1,063 | 1.26 | 436 | 0.80 | 236 | 2.16 | 76 |
| 8 | 1.64 | 675 | 4.05 | 3,159 | 2.08 | 998 | 1.24 | 424 | 0.49 | 157 | 2.07 | 75 |
| 9 | 1.61 | 655 | 3.35 | 2,252 | 1.99 | 926 | 1.21 | 408 | 0.14 | 103 | 2.05 | 64 |
| 10 | 1.55 | 615 | 2.91 | 1,769 | 1.93 | 881 | 1.18 | 392 | ‡ | 85 | 2.16 | 90 |
| 11 | 1.48 | 570 | 2.69 | 1,546 | 1.89 | 851 | 1.14 | 373 | ‡ | 75 | 2.28 | 129 |
| 12 | 1.42 | 533 | 2.41 | 1,279 | 1.84 | 814 | 1.13 | 368 | ‡ | 80 | 2.35 | 146 |
| 13 | 1.35 | 489 | 2.30 | 1,182 | 1.77 | 764 | 1.12 | 364 | ‡ | 100 | 2.20 | 114 |
| 14 | 1.31 | 464 | 2.15 | 1,055 | 1.68 | 702 | 1.11 | 359 | 2.02* | 120 | 2.06 | 85 |
| 15 | 1.33 | 477 | 2.00 | 934 | 1.61 | 655 | 1.10 | 354 | 2.15 | 183 | 2.05 | 89 |
| 16 | 1.38 | 508 | 2.18 | 1,080 | 1.56 | 622 | 1.10 | 354 | 2.46 | 377 | 2.07 | 97 |
| 17 | 1.35 | 489 | 1.93 | 881 | 1.55 | 615 | 1.08 | 345 | 2.34 | 293 | 2.35 | 196 |
| 18 | 1.33 | 477 | 1.78 | 771 | 1.48 | 570 | 1.06 | 336 | 2.35 | 300 | 2.20 | 150 |
| 19 | 1.51 | 590 | 1.67 | 695 | 1.43 | 539 | 1.05 | 332 | 2.36 | 307 | 1.91 | 61 |
| 20 | 1.47 | 564 | 1.91 | 866 | 1.41 | 526 | 1.05 | 332 | 2.37 | 314 | 2.10 | 130 |
| 21 | 1.41 | 526 | 1.75 | 750 | 1.38 | 508 | 1.03 | 323 | 2.24 | 231 | 2.27 | 207 |
| 22 | 1.39 | 514 | 1.73 | 736 | 1.37 | 501 | 1.03 | 323 | 2.44 | 340 | 1.99 | 100 |
| 23 | 1.65 | 682 | 1.69 | 708 | 1.37 | 501 | 1.04 | 328 | 2.18 | 180 | 2.08 | 143 |
| 24 | 1.59 | 641 | 1.64 | 675 | 1.35 | 489 | 1.04 | 328 | 2.19 | 175 | 2.23 | 225 |
| 25 | 1.48 | 570 | 1.61 | 655 | 1.33 | 477 | 1.03 | 323 | 2.25 | 192 | 1.99 | 107 |
| 26 | 1.41 | 526 | 1.75 | 750 | 1.33 | 477 | 1.02 | 319 | 2.26 | 185 | 1.76 | 31 |
| 27 | 1.45 | 552 | 1.70 | 715 | 1.32 | 470 | 1.02 | 319 | 2.49 | 270 | 1.79 | 38 |
| 28 | 1.39 | 514 | 1.67 | 695 | 1.32 | 470 | 1.01 | 314 | 2.20 | 144 | 1.79 | 38 |
| 29 | 1.31 | 464 | 1.62 | 661 | 1.32 | 470 | 0.99 | 306 | 2.28 | 162 | 1.76 | 31 |
| 30 | 1.28 | 447 | 1.59 | 641 | 1.31 | 464 | 0.98 | 302 | 2.12 | 105 | 1.76 | 31 |
| 31 | 1.26 | 436 | 1.54 | 609 | .... | .... | 0.95 | 290 | | .... | 2.08 | 149 |

† No observation, gauge height interpolated.
‡ Water below zero of gauge.
* Chain gauge installed.
Note—Ice conditions during January, February, March, November and December. Daily discharges for those months are only approximate.

## Monthly Discharge of Elbow River at Calgary, Alta., for 1911.

(Drainage area, 482 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| January | 73 | 45 | 62.2 | 0.129 | 0.15 | 3,824 |
| February | 123 | 73 | 95.9 | 0.199 | 0.21 | 5,326 |
| March | 255 | 86 | 141.0 | 0.293 | 0.34 | 8,670 |
| April | 539 | 79 | 236.0 | 0.490 | 0.55 | 14,043 |
| May | 1,063 | 190 | 407.0 | 0.844 | 0.97 | 25,025 |
| June | 1,466 | 635 | 915.0 | 1.898 | 2.12 | 54,446 |
| July | 1,208 | 436 | 633.0 | 1.313 | 1.51 | 38,922 |
| August | 3,159 | 430 | 982.0 | 2.037 | 2.35 | 60,381 |
| September | 1,546 | 464 | 700.0 | 1.452 | 1.62 | 41,653 |
| October | 470 | 290 | 367.0 | 0.761 | 0.88 | 22,566 |
| November | 377 | 75 | 212.0 | 0.440 | 0.49 | 12,615 |
| December | 225 | 31 | 100.0 | 0.207 | 0.24 | 6,149 |
| The year | | | | | | 293,620 |

## Nose Creek near Calgary, Alta.

This station was established April 24, 1911, by H. C. Ritchie. It is located at the traffic bridge on the N. W. ¼ Sec. 13, Tp. 24, Rge. 1, W. 5th Mer. The station is about one and a half miles east of the centre of the city and about one quarter of a mile above the junction of Nose Creek with Bow River.

Discharge measurements are made from the downstream side of the bridge at high stages and at a wading section downstream in low water.

The channel is straight for about 50 feet above and 150 feet below the station. A small island just below the bridge divides the stream into two channels in low water and causes cross-currents at the bridge. Both banks are high, steep, gravelly and clear of brush. The bed of the stream is composed of coarse gravel.

The gauge is a plain staff graduated to feet and hundredths, spiked to the upstream face of the upper pile of a row near the left bank. The zero (elev., 92.83) is referred to a permanent iron bench-mark (assumed elev., 100.00 feet) on the left bank near the end of the bridge.

The gauge was read once each day, by A. N. Baily.

### Discharge Measurements of Nose Creek, near Calgary, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| May 5 | H. C. Ritchie | 16 0 | 5 8 | 1 08 | 1 59 | 6 2 |
| May 17 | do | 24 5 | 31 9 | 1 65 | 2 00 | 52 9 |
| May 29 | do | 23 5 | 25.2 | 1 32 | 1 85 | 33.2 |
| June 8 | B. Russell | 22 5 | 21 7 | 0 80 | 1 75 | 17 4 |
| July 5 | do | 18 9 | 14 6 | 0 44 | 1 65 | 6.4 |
| Aug. 2 | H. T. Thomas | 14 6 | 7 9 | 0 66 | 1.56 | 5.2 |
| Aug. 24 | H. Brown | 16 1 | 9 7 | 0 91 | 1 66 | 8.8 |
| Sept. 13 | do | 16 3 | 10 7 | 0 63 | 1 65 | 6 7 |
| Sept. 27 | do | 16.9 | 44 5 | 0 21 | 1.67 | 9.3 |

### Daily Gauge-height and Discharge of Nose Creek, near Calgary, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 1 62 | 7 2 | 1.74 | 16 2 | 1 75 | 17.4 |
| 2 | | | 1 64 | 7 9 | 1 70 | 11 5 | 1 73 | 15 0 |
| 3 | | | 1.60 | 6 5 | 1 75 | 17 4 | 1.65 | 8 3 |
| 4 | | | 1 62 | 7 2 | 1 76 | 18 6 | 1 65 | 8.3 |
| 5 | | | 1.60 | 6 5 | 1.70 | 11 5 | 1 60 | 6.5 |
| 6 | | | 1 70 | 11 5 | 1 68 | 10 2 | 1.62 | 7.2 |
| 7 | | | 1 71 | 12.7 | 1 70 | 11 5 | 1.60 | 6.5 |
| 8 | | | 1 65 | 8 3 | 1 76 | 18 6 | 1.58 | 5 9 |
| 9 | | | 1 68 | 10 2 | 1 75 | 17 4 | 1 63 | 7 6 |
| 10 | | | 1.63 | 7 6 | 1.73 | 15 0 | 1.67 | 9 6 |
| 11 | | | 1 63 | 7 6 | 1 69 | 10.9 | 1 70 | 11.5 |
| 12 | | | 1.65 | 8 3 | 1 65 | 8 3 | 1.66 | 8.9 |
| 13 | | | 1 76 | 18 6 | 1 68 | 10 2 | 1 70 | 11.5 |
| 14 | | | 1 80 | 23 6 | 2 35 | 1 10 | 1 68 | 10.2 |
| 15 | | | 1.75 | 17.4 | 2 30 | 1.02 | 1.63 | 7.6 |
| 16 | | | 1 80 | 23 6 | 2 15 | 77 2 | 1 57 | 5.7 |
| 17 | | | 2 20 | 85 3 | 1 89 | 36 2 | 1.59 | 6.2 |
| 18 | | | 2 10 | 69 1 | 1 90 | 37 6 | 1 63 | 7.6 |
| 19 | | | 1 90 | 37 6 | 1 75 | 17 4 | 1 68 | 10.2 |
| 20 | | | 1 80 | 23 6 | 1 65 | 8 3 | 1 71 | 12.7 |
| 21 | | | 1 82 | 26 3 | 1 63 | 7 6 | 1 68 | 10 2 |
| 22 | | | 1 73 | 15 0 | 1 60 | 6.5 | 1 65 | 8 3 |
| 23 | | | 1 80 | 23 6 | 1 63 | 7 6 | 1 70 | 11 5 |
| 24 | 1 75 | 17 4 | 1 85 | 30 4 | 2 00 | 52 9 | 1 67 | 9 6 |
| 25 | 1.78 | 21 1 | 1.70 | 11.5 | 2 32 | 105 | 1.65 | 8.3 |
| 26 | 1 73 | 15 0 | 1 68 | 10 2 | 2 25 | 93 5 | 1 63 | 7.6 |
| 27 | 1.68 | 10 2 | 1 79 | 22 4 | 1 80 | 23 6 | 1.60 | 6.5 |
| 28 | 1 65 | 8.3 | 1 88 | 34 7 | 1 73 | 15.0 | 1.60 | 6.5 |
| 29 | 1.65 | 8.3 | 1.83 | 27 7 | 1 73 | 15 0 | 1 59 | 6.2 |
| 30 | 1.60 | 6.5 | 1 77 | 19 9 | 1.75 | 17 4 | 1 58 | 5.9 |
| 31 | ....... | ....... | 1 75 | 17.4 | ....... | ....... | 1.58 | 5.9 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF NOSE CREEK, NEAR CALGARY, ALTA., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.60 | 6.5 | 1.65 | 8.3 | 1.65 | 8.3 | 1.58 | 5.9 |
| 2 | 1.60 | 6.5 | 1.65 | 8.3 | 1.66 | 8.9 | 1.58 | 5.9 |
| 3 | 1.60 | 6.5 | 1.66 | 8.9 | 1.66 | 8.9 | 1.59 | 6.2 |
| 4 | 1.64 | 7.9 | 1.75 | 17.4 | 1.67 | 9.6 | 1.60 | 6.5 |
| 5 | 1.70 | 11.5 | 1.75 | 17.4 | 1.66 | 8.9 | 1.58 | 5.9 |
| 6 | 1.68 | 10.2 | 1.70 | 11.5 | 1.66 | 8.9 | 1.58 | 5.9 |
| 7 | 1.72 | 13.9 | 1.69 | 10.9 | 1.65 | 8.3 | 1.57 | 5.7 |
| 8 | 1.85 | 30.4 | 1.67 | 9.6 | 1.65 | 8.3 | 1.57 | 5.7 |
| 9 | 1.93 | 42.1 | 1.65 | 8.3 | 1.65 | 8.3 | 1.57 | 5.7 |
| 10 | 1.79 | 22.4 | 1.67 | 9.6 | 1.65 | 8.3 | 1.57 | 5.7 |
| 11 | 1.78 | 21.1 | 1.67 | 9.6 | 1.65 | 8.3 | 1.57 | 5.7 |
| 12 | 1.75 | 17.4 | 1.68 | 10.2 | 1.64 | 7.9 | 1.57 | 5.7 |
| 13 | 1.66 | 8.9 | 1.68 | 10.2 | 1.63 | 7.6 | 1.57 | 5.7 |
| 14 | 1.65 | 8.3 | 1.67 | 9.6 | 1.62 | 7.2 | 1.57 | 5.7 |
| 15 | 1.70 | 11.5 | 1.68 | 10.2 | 1.61 | 6.9 | 1.57 | 5.7 |
| 16 | 1.75 | 17.4 | 1.65 | 8.3 | 1.60 | 6.5 | | |
| 17 | 1.80 | 23.6 | 1.64 | 7.9 | 1.60 | 6.5 | | |
| 18 | 1.75 | 17.4 | 1.65 | 8.3 | 1.59 | 6.2 | | |
| 19 | 1.75 | 17.4 | 1.65 | 8.3 | 1.58 | 5.9 | | |
| 20 | 1.71 | 12.7 | 1.65 | 8.3 | 1.59 | 6.2 | | |
| 21 | 1.68 | 10.2 | 1.66 | 8.9 | 1.59 | 6.2 | | |
| 22 | 1.68 | 10.2 | 1.68 | 10.2 | 1.60 | 6.5 | | |
| 23 | 1.67 | 9.6 | 1.70 | 11.5 | 1.62 | 7.2 | | |
| 24 | 1.69 | 10.9 | 1.69 | 10.9 | 1.63 | 7.6 | | |
| 25 | 1.71 | 12.7 | 1.68 | 10.2 | 1.63 | 7.6 | | |
| 26 | 1.75 | 17.4 | 1.65 | 8.3 | 1.61 | 6.9 | | |
| 27 | 1.73 | 15.0 | 1.65 | 8.3 | 1.61 | 6.9 | | |
| 28 | 1.75 | 17.4 | 1.65 | 8.3 | 1.60 | 6.5 | | |
| 29 | 1.70 | 11.5 | 1.66 | 8.9 | 1.59 | 6.2 | | |
| 30 | 1.68 | 10.2 | 1.66 | 8.9 | 1.59 | 6.2 | | |
| 31 | 1.65 | 8.3 | .... | .. | 1.58 | 5.9 | | |

MONTHLY DISCHARGE OF NOSE CREEK NEAR CALGARY, ALTA., for 1911.

(Drainage area, 294 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| April 24-30 | 21.1 | 6.5 | 12.4 | 0.042 | 0.01 | 172 |
| May | 85.3 | 6.5 | 20.6 | 0.070 | 0.08 | 1,267 |
| June | 110.0 | 6.5 | 30.3 | 0.103 | 0.12 | 1,803 |
| July | 17.4 | 5.7 | 8.7 | 0.030 | 0.03 | 535 |
| August | 42.1 | 6.5 | 14.4 | 0.049 | 0.06 | 885 |
| September | 17.4 | 7.9 | 9.8 | 0.033 | 0.04 | 583 |
| October | 9.6 | 5.9 | 7.4 | 0.025 | 0.03 | 455 |
| November (1-15) | 6.5 | 5.7 | 5.8 | 0.020 | 0.01 | 173 |
| The period | | | | | 0.38 | 5,873 |

### Canadian Pacific Railway Company Canal near Calgary, Alta.

This station was established on May 18, 1911, by H. C. Ritchie. It is located at a bridge (No. 3) on the north side of the N. E. 1/4 Sec. 21, Tp. 23, Rge. 29, W. 4th Mer., and is about six miles from the intake of the canal.

The channel is straight for about 300 feet above and 500 feet below the station. The banks are high, composed of clay and cut to a uniform slope. The bed is also composed of clay. The current is moderate and uniform.

Discharge measurements are made from the downstream side of the bridge, which is a wooden structure supported by piles. The initial point for soundings is a spike driven into the rail at the inner face of the left abutment.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the downstream side of one of the piles supporting the bridge. It is referred to two bench-marks as follows: (1) an iron post in the left bank two feet from the lower end of the left abutment; elevation, 11.31 feet above the datum of the gauge; (2) the top of the downstream end of the sill capping the piles of the left abutment; elevation, 14.55 feet above the datum of the gauge.

The gauge-height observations for 1911 were supplied by the Canadian Pacific Railway Company, A. Hatcher taking the reading once each day for the company.

### Discharge Measurements of Canadian Pacific Railway Company Canal near Calgary, Alta., for 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 17 | H. C. Ritchie | 63.0 | 57.9 | 2.35 | .... | 136.3* |
| May 5 | do | 64.5 | 85.8 | 2.47 | .... | 212.1* |
| May 18 | do | 44.5 | 45.6 | 1.26 | 1.87 | 57.6 |
| June 6 | B. Russell | 53.0 | 87.3 | 1.84 | 2.60 | 161.1 |
| July 10 | do | 59.5 | 190.4 | 2.11 | 3.75 | 401.5‡ |
| Aug. 4 | H. T. Thomas | 56.4 | 101.2 | 1.44 | 2.60 | 145.3‡ |
| Aug. 24 | H. Brown | 46.5 | 55.8 | 1.27 | 2.00 | 70.8 |
| Sept. 13 | do | 56.2 | 125.3 | 2.30 | 3.29 | 288.8 |
| Sept. 22 | L. R. Brereton | 50.0 | 75.8 | 1.61 | 2.40 | 122.3 |

* Gauging made at a wading section near the intake. Water was turned into the canal for a few days in April to fill the pool in the canal.

‡ Gauging made at a bridge (No. 1.) on the north side of Sec. 36, Tp. 23, Rge. 1, W. 5th Mer.

## Daily Gauge-height and Discharge of Canadian Pacific Railway Company Canal near Calgary, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | ... | .... | 2.10 | 83 | 2.40 | 122 | 3.15 | 259 | 2.60 | 154 | 2.25 | 101 |
| 2 | ... | .. | 2.40 | 122 | 2.43 | 127 | 3.15 | 259 | 2.60 | 154 | 2.30 | 108 |
| 3 | ... | .. | 3.10 | 248 | 2.47 | *133 | 3.15 | 259 | 2.60 | 154 | 2.35 | 115 |
| 4 | . | . | 3.00 | 228 | 2.87 | †202 | 3.15 | 259 | 2.60 | 154 | 3.80 | 415 |
| 5 | .... | .. | 3.00 | 228 | 2.57 | 149 | 3.15 | 259 | 2.60 | 154 | 3.90 | 441 |
| 6 | ... | .... | 3.00 | 228 | 2.57 | 149 | 3.15 | 259 | 2.75 | 180 | 3.90 | 441 |
| 7 | ... | .. | 3.00 | 228 | 2.57 | 149 | 3.10 | 248 | 2.85 | 198 | 3.85 | 428 |
| 8 | ... | ... | 3.00 | 228 | 2.57 | 149 | 3.00 | 228 | 2.80 | 189 | 3.50 | 340 |
| 9 | ... | . | 3.00 | 228 | 2.52 | 141 | 3.00 | 228 | 2.80 | 189 | 2.90 | 208 |
| 10 | ... | | 3.00 | 228 | 2.50 | 138 | 3.75 | 402 | 2.75 | 180 | 2.85 | 198 |
| 11 | .... | . | 3.00 | 228 | 2.58 | 151 | 3.85 | 428 | 2.75 | 180 | 2.85 | 198 |
| 12 | . | . | 2.80 | 189 | 2.56 | 148 | 3.60 | 364 | 2.75 | 180 | 2.85 | 198 |
| 13 | ... | | 2.60 | 154 | 2.70 | 171 | 3.60 | 364 | 2.80 | 189 | 3.10 | 248 |
| 14 | | | 2.70 | 171 | 2.90 | 208 | 3.40 | 316 | 2.90 | 208 | 3.15 | 259 |
| 15 | .... | . | 2.55 | 146 | 2.95 | 218 | 3.40 | 316 | 2.80 | 189 | 3.15 | 259 |
| 16 | . | . | 2.45 | 130 | 2.95 | 218 | 3.40 | 316 | 2.60 | 154 | 3.00 | 228 |
| 17 | | | 2.25 | 101 | 3.55 | 352 | 3.45 | 328 | 2.50 | 138 | 2.85 | 198 |
| 18 | | | 2.15 | 89 | 3.53 | 347 | 3.45 | 328 | 2.50 | 138 | 2.85 | 198 |
| 19 | | | 1.70 | 43 | 3.53 | 347 | 3.45 | 328 | 2.50 | 138 | 2.85 | 198 |
| 20 | .. | . | 2.65 | 162 | 3.80 | 415 | 3.45 | 328 | 2.50 | 138 | 2.80 | 189 |
| 21 | | | 2.60 | 154 | 3.80 | 415 | 3.45 | 328 | 2.50 | 138 | 2.50 | 138 |
| 22 | | .. | 2.60 | 154 | 3.95 | 454 | 3.00 | 228 | 2.45 | 130 | 2.40 | 122 |
| 23 | | | 2.25 | 101 | 3.95 | 454 | 3.00 | 228 | 2.45 | 130 | 2.40 | 122 |
| 24 | | | 2.20 | 95 | 4.00 | 467 | 3.00 | 228 | 2.25 | 101 | 2.40 | 122 |
| 25 | | | 2.20 | 95 | 3.45 | 328 | 2.95 | 218 | 2.20 | 95 | 2.40 | 122 |
| 26 | .... | | 2.20 | 95 | 3.45 | 328 | 2.90 | 208 | 2.20 | 95 | 3.80 | 415x |
| 27 | | | 2.22 | 97 | 3.45 | 328 | 2.70 | 171 | 2.20 | 95 | 3.85 | 428x |
| 28 | | .... | 2.20 | 95 | 3.45 | 328 | 2.70 | 171 | 2.20 | 95 | 0.75 | 0.00 |
| 29 | .. | .. | 2.20 | 95 | 3.20 | 270 | 2.70 | 171 | 2.00 | 71 | . | ... |
| 30 | 1.65 | 39 | 2.20 | 95 | 3.20 | 270 | 2.60 | 154 | 2.00 | 71 | .. | .. |
| 31 | .... | . | 2.30 | 108 | ... | .... | 2.60 | 154 | 2.00 | 71 | . | ... |

* Opened one gate at 7.00 p.m.
† Closed one gate at 8.30 p.m.
x Water shut off at intake for the season.

Note—Water was turned into the canal for a few days about the middle of April to fill the pool in the canal. Canal was opened for the irrigation season on April 30. Gauge heights from April 30 to May 17 were interpolated from observations made at bridge No. 2.

## Monthly Discharge of Canadian Pacific Railway Company Canal near Calgary, Alta., for 1911.

| Month. | Discharge in Second-Feet. | | | Total Discharge in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | |
| April (30) | 39 | 39 | 39 | 77 |
| May | 248 | 43 | 150 | 9,223 |
| June | 467 | 122 | 256 | 15,233 |
| July | 428 | 154 | 260 | 16,540 |
| August | 208 | 71 | 144 | 8,854 |
| September (1-28) | 441 | 0 | 230 | 12,774 |
| The period (April 30 to Sept. 28) | | | | 62,701 |

## Fish Creek near Priddis, Alta.

This station was established May 13, 1907, by P. M. Sauder. It is on the S. W. ¼ Sec. 26, Tp. 22, Rge. 3, W. 5th Mer., about one mile from Priddis and near Percival's buildings.

A plain staff gauge, graduated to feet and hundredths, is placed vertically at the left bank, about 200 yards north of Mr. Percival's house. The zero of the gauge (elev., 90.81) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated 36 feet west and a little south of the gauge.

The channel is straight for 300 feet above and 150 feet below the station. The left bank is high, and will not overflow. The right bank is low, covered with brush and timber, and is liable to overflow in extreme high water. The bed is composed of gravel, but not liable to shift. The current is sluggish in extreme low stage of the stream.

Measurements are made by wading at or near the gauge, during low-water stages of the stream, and high-water stages are computed from slope measurements by the use of Kutter's formula. It is proposed to establish a cable station at this point for high-water measurements.

During 1911, the gauge was read by Fred Percival.

### Discharge Measurements of Fish Creek near Priddis, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 27 | H. R. Carscallen | 37 | 40 5 | 0 60 | 1 26 | 24 3 |
| June 3 | J. C. Milligan | 42 | 62 0 | 1 26 | 1 85 | 77.8 |
| June 13 | R. T. Sailman | 38 | 51 9 | 0 72 | 1 48 | 37 4 |
| July 18 | L. R. Brereton | 37 | 46 0 | 0 58 | 1 36 | 27 0 |
| Aug. 23 | do | 49 | 66 3 | 0 85 | 1 70 | 56 4 |
| Sept. 27 | do | 49 5 | 71 4 | 0 93 | 1 79 | 66.8 |

### Daily Gauge-height and Discharge of Fish Creek near Priddis, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height | Discharge | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1 70 | 58 0 | 1 00 | 12 0 | 1 80 | 69 0 | 2 70 | 220 0 |
| 2 | 1 70 | 58 0 | 1 00 | 12.0 | 1.99 | 93 6 | 2 80 | 242 0 |
| 3 | 1 70 | 58 0 | 0 96 | 10 4 | 1 90 | 81 0 | 2 10 | 109.0 |
| 4 | 1 74 | 62 0 | 0 96 | 10 4 | 1 90 | 81.0 | 2 09 | 108 0 |
| 5 | 1 74 | 62 0 | 0 96 | 10 4 | 1 80 | 69 0 | 2.09 | 108 0 |
| 6 | 1 78 | 66.6 | 0 99 | 11 6 | 1 60 | 48 0 | 1 80 | 69 0 |
| 7 | 1 78 | 66 6 | 1 04 | 13 6 | 1 65 | 53 0 | 1 71 | 59 0 |
| 8 | 1 82 | 71 4 | 0 93 | 9 4 | 1 66 | 54 0 | 1.68 | 56 0 |
| 9 | 1 82 | 71 4 | 0.93 | 9 4 | 1 73 | 61 0 | 1.68 | 56 0 |
| 10 | 2 00 | 95 0 | 0 93 | 9.4 | 1.60 | 48.0 | 1.70 | 58 0 |
| 11 | 2 00 | 95 0 | 0.89 | 8 2 | 1 60 | 48.0 | 1.73 | 61.0 |
| 12 | 2 00 | 95.0 | 0 88 | 7 9 | 1 45 | 36.0 | 1.71 | 59 0 |
| 13 | 1 66 | 54 0 | 0 88 | 7 9 | 1.61 | 49 0 | 1.71 | 59 0 |
| 14 | 1 46 | 36 8 | 1 58 | 46 4 | 1 60 | 48 0 | 1.44 | 35 4 |
| 15 | 1 87 | 77.4 | 2 22 | 128 0 | 1 50 | 40.0 | 1.44 | 35.4 |
| 16 | 1 87 | 77 4 | 2 60 | 200 0 | 1 50 | 40 0 | 1 40 | 33 0 |
| 17 | 1 87 | 77 4 | 3 02 | 293 0 | 1.50 | 40 0 | 1 40 | 33 0 |
| 18 | 1 70 | 58 0 | 2 55 | 190.0 | 1 31 | 27 6 | 1.51 | 40 8 |
| 19 | 1.70 | 58 0 | 1 95 | 88 0 | 1 30 | 27.0 | 1 90 | 81 0 |
| 20 | 1 65 | 53 0 | 1.70 | 58 0 | 1.30 | 27.0 | 1.70 | 58 0 |
| 21 | 1 63 | 51 0 | 1 60 | 48 0 | 1 22 | 22 2 | 1 60 | 48.0 |
| 22 | 1 65 | 53 0 | 1 60 | 48 0 | 1 22 | 22 2 | 1 60 | 48 0 |
| 23 | 1 53 | 42 4 | 1 40 | 33 0 | 1.33 | 28 8 | 1 60 | 48.0 |
| 24 | 1 53 | 42 4 | 1.39 | 32 4 | 1.38 | 31 8 | 1.48 | 38 4 |
| 25 | 1.53 | 42 4 | 1.39 | 32.4 | 1.55 | 44.0 | 1.39 | 32 4 |
| 26 | 1 33 | 28 8 | 1.60 | 48 0 | 1 65 | 53 0 | 1 35 | 30.0 |
| 27 | 1 28 | 25 8 | 1 60 | 48 0 | 1 75 | 63 0 | 1.31 | 27.6 |
| 28 | 1 23 | 22 8 | 2 60 | 200 0 | 1 90 | 81 0 | 1 26 | 24 6 |
| 29 | 1 23 | 22 8 | 2 70 | 220 0 | 2 00 | 95 0 | 1.26 | 24 6 |
| 30 | 1.23 | 22 8 | 2 40 | 160 0 | 2 60 | 200.0 | 1 26 | 24.6 |
| 31 | .... | .... | 2 04 | 101.0 | .... | .... | 1.26 | 24 6 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF FISH CREEK NEAR PRIDDIS, ALTA., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge. | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.25 | 24.0 | 1.50 | 40.0 | 1.56 | 44.8 | 1.35 | 30.0 |
| 2 | 1.25 | 24.0 | 1.45 | 36.0 | 1.56 | 44.8 | 1.35 | 30.0 |
| 3 | 1.25 | 24.0 | 1.70 | 58.0 | 1.60 | 48.0 | 1.25 | 24.0 |
| 4 | 1.26 | 24.6 | 2.10 | 109.0 | 1.71 | 59.0 | 1.20 | 21.0 |
| 5 | 1.48 | 38.4 | 2.00 | 95.0 | 1.65 | 53.0 | 1.20 | 21.0 |
| 6 | 1.60 | 48.0 | 2.10 | 109.0 | 1.56 | 44.8 | 1.20 | 21.0 |
| 7 | 2.40 | 160.0 | 1.80 | 69.0 | 1.55 | 44.0 | 1.21 | 21.6 |
| 8 | 5.00 | 930.0 | 1.80 | 69.0 | 1.55 | 44.0 | 1.20 | 21.0 |
| 9 | 3.70 | 471.0 | 1.65 | 53.0 | 1.45 | 36.0 | 1.25 | 24.0 |
| 10 | 3.00 | 288.0 | 1.60 | 48.0 | 1.44 | 35.4 | 1.25 | 24.0 |
| 11 | 2.70 | 220.0 | 1.60 | 48.0 | 1.44 | 35.4 | 1.25 | 24.0 |
| 12 | 2.40 | 160.0 | 1.50 | 40.0 | 1.43 | 34.8 | 1.25 | 24.0 |
| 13 | 2.30 | 142.0 | 1.45 | 36.0 | 1.37 | 31.2 | 1.25 | 24.0 |
| 14 | 2.00 | 95.0 | 1.45 | 36.0 | 1.36 | 30.6 | 1.25 | 24.0 |
| 15 | 1.95 | 88.0 | 1.43 | 34.8 | 1.35 | 30.0 | 1.25 | 24.0 |
| 16 | 2.30 | 142.0 | 1.35 | 30.0 | 1.35 | 30.0 | 1.25 | 24.0 |
| 17 | 2.15 | 117.0 | 1.45 | 36.0 | 1.35 | 30.0 | | ..... |
| 18 | 1.95 | 88.0 | 1.45 | 36.0 | 1.30 | 27.0 | | ... |
| 19 | 1.90 | 81.0 | 1.35 | 30.0 | 1.32 | 28.2 | | ... |
| 20 | 1.80 | 69.0 | 1.34 | 29.4 | 1.35 | 30.0 | | ... |
| 21 | 1.80 | 69.0 | 1.40 | 33.0 | 1.35 | 30.0 | | |
| 22 | 1.75 | 63.0 | 1.50 | 40.0 | 1.33 | 28.8 | | |
| 23 | 1.70 | 58.0 | 1.55 | 44.0 | 1.33 | 28.8 | | |
| 24 | 1.65 | 53.0 | 1.55 | 44.0 | 1.33 | 28.8 | | |
| 25 | 1.70 | 58.0 | 1.56 | 44.8 | 1.25 | 24.0 | | |
| 26 | 1.85 | 75.0 | 1.64 | 52.0 | 1.58 | 46.4 | | |
| 27 | 1.85 | 75.0 | 1.75 | 63.0 | 1.71 | 59.0 | | |
| 28 | 1.75 | 63.0 | 1.77 | 65.4 | 1.70 | 58.0 | | |
| 29 | 1.60 | 48.0 | 1.80 | 69.0 | 1.55 | 44.0 | | |
| 30 | 1.60 | 48.0 | 1.65 | 53.0 | 1.25 | 24.0 | | ... |
| 31 | 1.51 | 40.8 | | ... | 1.25 | 24.0 | | ... |

MONTHLY DISCHARGE OF FISH CREEK NEAR PRIDDIS, ALTA., for 1911.

(Drainage area, 109 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches in Drainage area. | Total in acre-feet. |
| April | 95 | 22.8 | 56.8 | 0.521 | 0.58 | 3,380 |
| May | 293 | 7.9 | 68.0 | 0.624 | 0.72 | 4,181 |
| June | 200 | 22.2 | 56.0 | 0.514 | 0.57 | 3,332 |
| July | 242 | 24.6 | 62.9 | 0.577 | 0.67 | 3,868 |
| August | 930 | 24.0 | 125.0 | 1.147 | 1.32 | 7,686 |
| September | 109 | 29.4 | 51.7 | 0.474 | 0.53 | 3,076 |
| October | 59 | 24.0 | 37.3 | 0.342 | 0.39 | 2,294 |
| November (1-16) | 30 | 21.0 | 23.8 | 0.218 | 0.13 | 755 |
| The period | ....... | ......... | ..... | ........ | 4.91 | 28,572 |

## NORTH BRANCH OF SHEEP RIVER AT MILLARVILLE, ALTA.

This station was established May 22, 1908, by P. M. Sauder. It is located on the S. W. ¼ Sec. 12, Tp. 21, Rge. 3, W. 5th Mer., 100 feet from Malcolm T. Millar's house, Millarville P.O.

Discharge measurements are made at the traffic bridge about one mile downstream on the road allowance on the east boundary of Sec. 12. At low stages the stream is gauged at a wading section about 100 yards downstream from the gauge. The cross-section at the gauge is unsuitable for measurements, the stream being very deep and sluggish at this point.

Owing to the speed of the current above and below the station and the instability of the stream-bed, the factors governing the relation of gauge-height to discharge are continually changing, especially in high stages of the stream. During 1911, an exceptional amount of rainfall resulted in a series of high-water periods. In consequence, the stream changed to such an extent that the data accumulated were found insufficient for the compilation of daily discharges.

The gauge, which is a plain staff, graduated to feet and hundredths, is nailed to the cribwork at the left side of the stream, constructed by Mr. Millar for the preservation of the creek bank. The zero (elev., 82.67) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated 36 feet southwest of the N.E. corner of Sec. 2, Tp. 21, Rge. 3, W. 5th Mer., and about 100 yards west of the gauge. The high water in August, 1911, carried away the original gauge and on the 24th of the month a new gauge was installed in the same position as the former gauge but at elev. 81.40.

During 1911, the gauge was read once daily by Malcolm T. Millar.

DISCHARGE MEASUREMENTS OF NORTH BRANCH OF SHEEP RIVER, AT MILLARVILLE, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 26 | H. R. Carscallen | 41 | 30.8 | 3.12 | 2.15 | 96.0 |
| June 14 | R. T. Sailman | 97 | 248.2 | 1.47 | 2.79 | 365.6 |
| July 20 | L. R. Brereton | 59 | 193.0 | 0.66 | 2.15 | 128.4 |
| Aug. 24 | do | 72 | 207.4 | 0.61 | *2.97 | 126.5 |
| Oct. 8 | do | 41.5 | 43.8 | 1.70 | *2.79 | 74.8 |

* New gauge, datum 1.27 below old gauge datum.

DAILY GAUGE-HEIGHT IN FEET OF NORTH BRANCH OF SHEEP RIVER AT MILLARVILLE, ALTA., for 1911.

| Day | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .... | 1.73 | 1.70 | 3.10 | 2.70 | 2.20 | 2.88 | 2.86 | 2.32 |
| 2 | .... | 1.69 | 1.75 | 3.00 | 2.79 | 2.10 | 2.78 | 2.86 | 2.32 |
| 3 | .... | 1.60 | 1.75 | 2.60 | 2.60 | 2.15 | 2.95 | 2.95 | 2.32 |
| 4 | .... | 1.60 | 1.75 | 2.60 | 2.50 | 2.40 | 3.43 | 2.90 | 2.32 |
| 5 | .... | 1.60 | 1.83 | 2.45 | 2.40 | 2.45 | 3.50 | 2.84 | 2.32 |
| 6 | .... | 1.60 | 2.10 | 2.35 | 2.40 | 2.48 | 3.50 | 2.80 | 2.32 |
| 7 | .... | 1.60 | 1.80 | 2.30 | 2.32 | 4.68 | 3.45 | 2.78 | 2.32 |
| 8 | .... | 1.60 | 1.78 | 2.30 | 2.19 | 5.72 | 3.42 | 2.76 | 2.32 |
| 9 | .... | 1.75 | 1.72 | 2.23 | 2.10 | 4.58 | 3.35 | 2.74 | 2.32 |
| 10 | .... | 2.72 | 1.72 | 2.18 | 2.10 | 4.51 | 3.30 | 2.74 | 2.32 |
| 11 | .... | 2.25 | 1.67 | 2.16 | 2.10 | 3.80 | 3.19 | 2.73 | 2.32 |
| 12 | .... | 1.75 | 1.67 | 2.14 | 2.10 | 3.50 | 3.15 | 2.72 | 2.32 |
| 13 | .... | 1.54 | 1.83 | 2.14 | 2.00 | 3.00 | 3.11 | 2.69 | 2.32 |
| 14 | .... | 1.54 | 2.00 | 2.83 | 2.00 | 2.95 | 3.00 | 2.69 | 2.32 |
| 15 | .... | 1.50 | 2.49 | 2.55 | 1.98 | 3.15 | 2.94 | 2.67 | 2.32 |
| 16 | .... | 1.83 | 3.65 | 2.35 | 1.84 | 2.93 | 2.94 | 2.67 | ....... |
| 17 | .... | 1.86 | 3.20 | 2.23 | 1.80 | 2.63 | 2.95 | 2.64 | ....... |
| 18 | .... | 1.83 | 2.77 | 2.23 | 1.80 | 2.45 | 2.85 | 2.61 | ....... |
| 19 | .... | 1.73 | 2.55 | 2.06 | 2.10 | 2.20 | 2.83 | 2.55 | ....... |
| 20 | .... | 1.85 | 2.45 | 2.04 | 2.10 | 2.04 | 2.77 | 2.55 | ....... |
| 21 | .... | 2.05 | 2.33 | 2.04 | 2.06 | 1.85 | 2.77 | 2.55 | ....... |
| 22 | .... | 2.30 | 2.25 | 2.04 | 2.00 | 1.73 | 2.78 | 2.55 | ....... |
| 23 | 1.93 | 2.30 | 2.20 | 2.04 | 2.00 | 1.75 | 2.82 | 2.55 | ....... |
| 24 | 1.97 | 2.15 | 2.13 | 2.13 | 1.84 | *2.97 | 2.83 | 2.40 | ....... |
| 25 | 1.70 | 2.10 | 2.13 | 2.25 | 1.80 | 2.98 | 2.85 | 2.40 | ....... |
| 26 | 1.47 | 2.15 | 2.13 | 2.20 | 1.80 | 3.20 | 2.92 | 2.39 | ....... |
| 27 | 1.47 | 1.85 | 2.29 | 2.15 | 1.80 | 3.15 | 2.93 | 2.39 | ....... |
| 28 | 1.47 | 1.82 | 2.58 | 2.15 | 1.78 | 3.03 | 2.93 | 2.39 | ....... |
| 29 | 1.60 | 1.69 | 2.77 | 2.40 | 1.78 | 2.94 | 2.87 | 2.40 | ....... |
| 30 | 1.73 | 1.70 | 3.10 | 2.86 | 1.75 | 2.88 | 2.87 | 2.40 | ....... |
| 31 | 1.73 | ....... | 3.30 | ....... | 1.70 | 2.88 | ....... | 2.35 | ....... |

* New gauge established, datum 1.27 below old gauge datum.

## South Branch of Sheep River near Black Diamond, Alta.

This station was established May 23, 1908, by P. M. Sauder. It is located at the steel highway bridge on the road allowance between Secs. 8 and 17, Tp. 20, Rge. 2, W. 5th Mer. It is one half mile from Black Diamond P.O.

The gauge, which is of the standard chain type, is fastened to the downstream side of the floor of the bridge, about midway between the west abutment and the centre pier. Bench-mark No. 1 consists of two nail-heads on the north face of the west abutment; elevation, 9.37 above the zero of the gauge. Bench-mark No. 2 is a block of wood nailed to the north face of the centre pier; elevation, 7.67.

The channel is straight for about 150 feet above the station, then swings sharply to the left. It is straight for about 500 feet below the station, then turns gradually to the right. Both banks are composed of gravel. The right bank is low, partly covered with brush, and overflows in higher stages of the stream. The left bank is high and cannot overflow. The bed is composed of coarse gravel; it is permanent in low-water stages of the stream, but a gravel bar at the right bank, which is covered during high-water stages, is liable to shift. The river has considerable fall and the current is swift.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the outer edge of the bed-plate on the west end of the bridge. Distances from the initial point are marked at every five feet, on the bottom chord of the bridge.

During 1911, the gauge was read by Herbert Arnold, merchant at Black Diamond.

## Discharge Measurements of South Branch of Sheep River near Black Diamond, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 25 | H. R. Carscallen | 76.1 | 99.3 | 1.93 | 0.95 | 191.4 |
| May 19 | R. T. Sailman | 77.0 | 127.2 | 2.73 | 1.36 | 347.0 |
| June 15 | do | 81.5 | 184.1 | 4.00 | 1.96 | 735.9 |
| July 20 | L. R. Brereton | 72.0 | 96.8 | 2.39 | 1.06 | 231.6 |
| Aug. 26 | do | 78.5 | 138.8 | 2.20 | 1.41 | 305.7 |
| Sept. 29 | do | 78.0 | 115.3 | 1.85 | 1.15 | 213.2 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF SOUTH BRANCH OF SHEEP RIVER NEAR BLACK DIAMOND, ALTA., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.13 | 29 | 0.63 | 100 | 2.33 | 1025 |
| 2 | | | 0.43 | 61 | 0.63 | 100 | 2.43 | 1103 |
| 3 | | | *0.07 | 20 | 0.65 | 104 | 2.43 | 1103 |
| 4 | | | 0.53 | 79 | 0.73 | 124 | 1.93 | 713 |
| 5 | | | 0.43 | 61 | 0.88 | 168 | 1.83 | 635 |
| 6 | | | 0.43 | 61 | 1.13 | 255 | 1.63 | 497 |
| 7 | | | 0.35 | 50 | 0.78 | 138 | 1.53 | 437 |
| 8 | | | 0.33 | 47 | 0.80 | 143 | 1.49 | 415 |
| 9 | | | 0.43 | 61 | 0.73 | 124 | 1.54 | 443 |
| 10 | | | 0.48 | 70 | 0.73 | 124 | 1.64 | 504 |
| 11 | | | 0.53 | 79 | 0.64 | 102 | 1.69 | 536 |
| 12 | | | 0.71 | 119 | 0.68 | 111 | 1.94 | 721 |
| 13 | | | 0.53 | 79 | 0.78 | 138 | 1.99 | 760 |
| 14 | | | 0.53 | 79 | 0.68 | 111 | 1.99 | 760 |
| 15 | | | 0.43 | 61 | 1.08 | 237 | 1.96 | 737 |
| 16 | | | 0.58 | 89 | 2.45 | 1119 | 1.84 | 643 |
| 17 | | | 0.58 | 89 | 1.93 | 713 | 1.86 | 659 |
| 18 | | | 0.63 | 100 | 1.61 | 484 | 1.64 | 504 |
| 19 | | | 0.48 | 70 | 1.36 | 350 | 1.64 | 504 |
| 20 | | | 0.68 | 111 | 1.28 | 314 | 1.69 | 536 |
| 21 | | | 0.91 | 178 | 1.26 | 306 | 1.84 | 643 |
| 22 | | | 1.03 | 220 | 1.26 | 306 | 1.84 | 643 |
| 23 | | | 0.83 | 152 | 1.13 | 255 | 1.52 | 432 |
| 24 | | | 0.88 | 168 | 1.06 | 230 | 1.47 | 404 |
| 25 | | | 0.94 | 188 | 0.98 | 202 | 1.82 | 628 |
| 26 | | | 0.93 | 184 | 0.95 | 192 | 1.59 | 472 |
| 27 | 0.94 | 188 | 0.83 | 152 | 0.93 | 184 | 1.54 | 443 |
| 28 | 0.85 | 158 | 0.68 | 111 | 1.03 | 220 | †1.51 | 426 |
| 29 | 0.44 | 63 | 0.53 | 79 | 1.23 | 293 | 1.49 | 415 |
| 30 | 0.48 | 70 | 0.53 | 79 | 1.83 | 635 | 1.54 | 443 |
| 31 | 0.63 | 100 | ... | | 2.28 | 986 | ... | ....... |

DAILY GAUGE-HEIGHT AND DISCHARGE OF SOUTH BRANCH OF SHEEP RIVER NEAR BLACK DIAMOND, ALTA., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.64 | 504 | †1.13 | 255 | 1.22 | 236 | 1.12 | 204 |
| 2 | 1.52 | 432 | 1.32 | 331 | 1.14 | 210 | †1.12 | 204 |
| 3 | 1.49 | 415 | 1.46 | 399 | 1.34 | 280 | 1.12 | 204 |
| 4 | 1.19 | 277 | †1.57 | 461 | 2.74 | 1217 | 1.06 | 186 |
| 5 | 1.14 | 259 | 1.69 | 536 | †2.76 | 1233 | 1.04 | 181 |
| 6 | 1.19 | 277 | 1.84 | 643 | 2.79 | 1256 | 1.04 | 181 |
| 7 | 1.19 | 277 | 4.04 | 2360 | 2.04 | 671 | 1.04 | 181 |
| 8 | 1.24 | 297 | 3.24 | 1720 | 2.04 | 671 | 1.04 | 181 |
| 9 | 1.19 | 277 | 2.54 | 1162 | 2.04 | 671 | 1.04 | 181 |
| 10 | 1.14 | 259 | 2.44 | 1076 | 1.84 | 526 | 1.04 | 181 |
| 11 | 1.06 | 230 | 2.24 | 910 | 1.89 | 558 | 1.04 | 181 |
| 12 | 1.04 | 223 | 2.14 | 826 | 2.19 | 788 | 1.04 | 181 |
| 13 | 1.01 | 212 | 1.94 | 656 | 1.74 | 464 | 1.04 | 181 |
| 14 | 0.99 | 206 | 1.89 | 610 | 1.66 | 419 | 0.99 | 166 |
| 15 | 0.82 | 149 | 1.59 | 418 | 1.54 | 362 | 0.99 | 166 |
| 16 | †0.94 | 188 | 1.62 | 424 | 1.46 | 328 | 0.99 | 166 |
| 17 | 1.06 | 230 | 1.51 | 366 | 1.36 | 287 | 0.96 | 158 |
| 18 | 1.04 | 223 | 1.42 | 320 | 1.34 | 280 | 0.94 | 152 |
| 19 | 1.04 | 223 | 1.34 | 284 | 1.26 | 250 | 0.92 | 147 |
| 20 | 1.07 | 234 | 1.34 | 280 | 1.24 | 243 | 0.94 | 152 |
| 21 | 1.04 | 223 | 1.29 | 260 | 1.34 | 280 | 0.92 | 147 |
| 22 | 1.06 | 230 | 1.26 | 250 | 1.34 | 280 | 0.89 | 138 |
| 23 | 1.06 | 230 | 1.24 | 243 | 1.32 | 272 | 0.92 | 147 |
| 24 | 1.04 | 223 | 1.19 | 226 | 1.39 | 299 | 0.92 | 147 |
| 25 | 1.04 | 223 | 1.14 | 210 | 1.29 | 260 | †0.90 | 141 |
| 26 | 1.06 | 230 | 1.41 | 307 | 1.24 | 243 | 0.89 | 138 |
| 27 | 1.04 | 223 | 1.34 | 280 | 1.22 | 236 | 0.84 | 126 |
| 28 | 1.02 | 216 | 1.34 | 280 | 1.22 | 236 | 0.82 | 121 |
| 29 | 0.94 | 188 | 1.34 | 280 | 1.19 | 226 | 0.84 | 126 |
| 30 | 0.94 | 188 | 1.29 | 260 | 1.14 | 210 | 0.84 | 126 |
| 31 | 0.94 | 188 | 1.24 | 243 | ...... | ...... | 0.84 | 126 |

* Negative gauge height water below zero of the gauge.
† No observation, gauge height interpolated.

MONTHLY DISCHARGE OF SOUTH BRANCH OF SHEEP RIVER NEAR BLACK DIAMOND, Alta., for 1911.

(Drainage area, 241 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| March (27-31) | 188 | 63 | 116 | 0.481 | 0.09 | 1,150 |
| April | 220 | 20 | 97.5 | 0.405 | 0.45 | 5,802 |
| May | 1,119 | 100 | 286 | 1.187 | 1.37 | 17,585 |
| June | 1,103 | 415 | 606 | 2.515 | 2.81 | 36,060 |
| July | 504 | 149 | 250 | 1.037 | 1.20 | 15,372 |
| August | 2,360 | 210 | 544 | 2.257 | 2.60 | 33,449 |
| September | 1,256 | 210 | 450 | 1.867 | 2.08 | 26,777 |
| October | 204 | 121 | 162 | 0.672 | 0.77 | 9,961 |
| The period | | | | | 11.37 | 146,156 |

SHEEP RIVER NEAR OKOTOKS, ALTA.

This station was established by J. F. Hamilton in 1906. It is located at the Canadian Pacific Railway bridge about one mile from Okotoks, on the N. W. ¼ Sec. 22, Tp. 20, Rge. 29, W. 4th Mer.

The railway company has replaced the old wooden structure by a two-span steel bridge resting on cement abutments and central pier. In consequence the cross-section has undergone considerable change since the station was first established. The old wooden piers still remain in the cross-section and these, as well as a number of short piles in the bed of the stream above the section, considerably affect the velocity observations.

The channel is straight for 500 feet above and below the station, the current being swift throughout this course. The right bank is high with a gradual slope; the left bank is comparatively low and will overflow in high stages of the stream. Both banks are covered with brush and large trees. The bed of the stream is composed of sand and coarse gravel and shifts considerably.

The gauge is a plain staff, graduated to feet and tenths, imbedded in the cement of the left face of the centre pier near the downstream end. Owing to a timber, rock-filled cribbing around the pier only high-water observations can be read on this gauge and for low stages an auxiliary gauge, graduated to feet and hundredths, was spiked to the cribwork opposite the permanent gauge on the left side of the pier.

The gauges are referred to a bench-mark on the top of the left abutment at its southwest corner. This is a Canadian Pacific Railway bench-mark and the elevation marked upon it, 3431.57, is used for reference. The elevation of the gauge datum for the permanent gauge imbedded in the pier is 3420.12 feet and that of the gauge datum for the auxiliary gauge on the cribwork of the pier is 3418.12 feet.

During 1911, the gauge was read by Miss May Henderson.

DISCHARGE MEASUREMENTS OF SHEEP RIVER NEAR OKOTOKS, ALTA., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 21 | H. C. Ritchie | 99.0 | 198.9 | 2.20 | 3.24 | 438.2 |
| May 20 | R. T. Sailman | 98.0 | 258.2 | 2.25 | 3.48 | 581.6 |
| June 15 | do | 98.5 | 337.3 | 3.01 | 4.02 | 1,016.7 |
| July 25 | L. R. Brereton | 146.0 | 165.8 | 1.61 | 3.00 | 267.2 |
| Aug. 28 | do | 98.0 | 418.8 | 1.17 | 2.76 | 489.7 |
| Sept. 30 | do | 98.0 | 385.8 | 0.91 | 2.55 | 352.2 |

DAILY GAUGE-HEIGHT AND DISCHARGE OF SHEEP RIVER, NEAR OKOTOKS, ALTA., for 1911.

| DAY. | April | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.40 | 110 | 2.70 | 182 | 4.90 | 1720 | 4.10 | 1080 |
| 2 | 2.30 | 92 | 2.70 | 182 | 4.70 | 1560 | 4.00 | 1000 |
| 3 | 2.10 | 66 | 2.70 | 182 | 4.70 | 1560 | †3.80 | 840 |
| 4 | 2.30 | 92 | 2.70 | 182 | 4.30 | 1240 | 3.60 | 680 |
| 5 | 2.30 | 92 | 3.00 | 294 | 3.90 | 920 | 3.50 | 600 |
| 6 | 2.30 | 92 | 3.30 | 484 | 3.70 | 760 | 3.40 | 520 |
| 7 | 2.30 | 92 | 3.10 | 348 | 3.60 | 680 | 3.40 | 520 |
| 8 | 2.50 | 130 | 2.90 | 250 | 3.50 | 600 | 3.40 | 520 |
| 9 | 2.50 | 130 | 2.90 | 250 | 3.60 | 680 | 3.40 | 520 |
| 10 | 3.30 | 484 | 3.00 | 294 | 3.60 | 680 | 3.20 | 372 |
| 11 | 3.70 | 804 | 2.90 | 250 | 3.70 | 760 | 3.20 | 372 |
| 12 | 3.00 | 294 | †2.95 | 272 | 4.00 | 1000 | 3.00 | 268 |
| 13 | 2.90 | 250 | 3.00 | 294 | †4.15 | 1120 | 3.00 | 268 |
| 14 | 2.70 | 182 | 3.10 | 348 | 4.30 | 1240 | 3.00 | 268 |
| 15 | 2.70 | 182 | 3.50 | 632 | 4.00 | 1000 | 3.00 | 268 |
| 16 | 2.70 | 182 | 4.20 | 1186 | 3.80 | 840 | 2.80 | 194 |
| 17 | 3.00 | 294 | 4.70 | 1580 | 3.70 | 760 | 2.90 | 226 |
| 18 | †3.00 | 294 | 4.50 | 1408 | 3.60 | 680 | 2.90 | 226 |
| 19 | 3.00 | 294 | 3.70 | 764 | 3.60 | 680 | 2.90 | 226 |
| 20 | 3.00 | 294 | 3.50 | 600 | 3.50 | 600 | 3.10 | 316 |
| 21 | 3.10 | 348 | 3.40 | 520 | 3.40 | 520 | 3.00 | 268 |
| 22 | 3.50 | 644 | 3.40 | 520 | 3.30 | 440 | 3.00 | 268 |
| 23 | 3.30 | 484 | 3.40 | 520 | 3.40 | 520 | 3.00 | 268 |
| 24 | 3.20 | 408 | 3.20 | 372 | 3.40 | 520 | 3.00 | 268 |
| 25 | 3.30 | 484 | 3.10 | 316 | 4.00 | 1000 | †3.00 | 268 |
| 26 | 3.20 | 408 | 3.10 | 316 | 3.50 | 600 | 3.00 | 268 |
| 27 | 3.00 | 294 | 3.30 | 440 | 3.70 | 760 | 2.90 | 226 |
| 28 | 3.00 | 294 | 3.50 | 600 | 3.70 | 760 | 2.90 | 226 |
| 29 | 2.80 | 214 | 3.80 | 840 | 3.50 | 600 | 2.90 | 226 |
| 30 | 2.60 | 154 | 4.40 | 1320 | †3.80 | 840 | 2.80 | 194 |
| 31 | .... | .. | 4.90 | 1720 | .... | ...... | 2.80 | 194 |

### Daily Gauge-height and Discharge of Sheep River, near Okotoks, Alta., for 1911.—*Continued.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.90 | 226 | 2.60 | 380 | †2.53 | 341 | 2.30 | 232 |
| 2 | 3.20 | 372 | †3.16 | 814 | 2.52 | 335 | 2.30 | 232 |
| 3 | 3.50 | 600 | †3.73 | 1270 | 2.59 | 374 | 2.30 | 232 |
| 4 | 3.80 | 840 | 4.30 | 1726 | 2.58 | 369 | †2.29 | 229 |
| 5 | 3.90 | 920 | 3.75 | 1286 | 2.56 | 358 | 2.28 | 225 |
| 6 | 3.90 | 920 | 3.58 | 1150 | 2.50 | 324 | ... | ... |
| 7 | 5.52 | 2310 | 3.40 | 1006 | 2.50 | 324 | ... | ... |
| 8 | 5.54 | 2410 | 3.40 | 1006 | 2.48 | 314 | ... | ... |
| 9 | 4.90 | 1970 | 3.35 | 966 | †2.46 | 304 | ... | ... |
| 10 | 4.20 | 1480 | †3.30 | 926 | 2.45 | 299 | ... | ... |
| 11 | 4.00 | 1404 | 3.25 | 886 | 2.43 | 289 | ... | ... |
| 12 | 3.70 | 1246 | 3.25 | 886 | 2.35 | 253 | ... | ... |
| 13 | 3.50 | 1086 | 3.24 | 878 | †2.35 | 253 | ... | ... |
| 14 | 3.20 | 846 | †3.12 | 782 | 2.35 | 253 | ... | ... |
| 15 | 3.10 | 766 | †3.00 | 686 | 2.32 | 240 | ... | ... |
| 16 | 3.30 | 926 | 2.87 | 582 | 2.30 | 232 | ... | ... |
| 17 | 3.20 | 846 | 2.76 | 494 | 2.30 | 232 | ... | ... |
| 18 | 2.80 | 526 | †2.68 | 433 | †2.29 | 229 | ... | ... |
| 19 | 2.80 | 526 | 2.60 | 389 | 2.28 | 225 | ... | ... |
| 20 | 2.90 | 606 | 2.58 | 360 | 2.28 | 225 | ... | ... |
| 21 | 2.90 | 606 | 2.60 | 380 | 2.27 | 222 | ... | ... |
| 22 | 2.80 | 526 | †2.60 | 380 | †2.28 | 225 | ... | ... |
| 23 | †2.80 | 526 | 2.60 | 380 | 2.29 | 229 | ... | ... |
| 24 | 2.80 | 526 | 2.57 | 363 | 2.30 | 232 | ... | ... |
| 25 | 2.70 | 446 | 2.58 | 369 | 2.30 | 232 | ... | ... |
| 26 | 2.90 | 606 | 2.60 | 380 | †2.50 | 324 | ... | ... |
| 27 | 2.90 | 606 | 2.60 | 380 | 2.70 | 446 | ... | ... |
| 28 | 2.76 | 494 | 2.60 | 380 | †2.50 | 324 | ... | ... |
| 29 | †2.71 | 454 | 2.58 | 369 | 2.30 | 232 | ... | ... |
| 30 | 2.66 | 420 | 2.55 | 352 | †2.30 | 232 | ... | ... |
| 31 | 2.65 | 413 | ... | ... | 2.30 | 232 | ... | ... |

† No observation, gauge-height interpolated.

### Monthly Discharge of Sheep River near Okotoks, Alta., for 1911.

(Drainage area, 624 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| April | 804 | 66 | 273 | 0.438 | 0.49 | 16,245 |
| May | 1,720 | 182 | 563 | 0.902 | 1.04 | 34,618 |
| June | 1,720 | 440 | 855 | 1.370 | 1.53 | 50,876 |
| July | 1,080 | 194 | 386 | 0.619 | 0.71 | 23,734 |
| August | 2,410 | 226 | 853 | 1.367 | 1.58 | 52,449 |
| September | 1,726 | 352 | 688 | 1.103 | 1.23 | 40,939 |
| October | 446 | 222 | 281 | 0.450 | 0.52 | 17,278 |
| November (1-5) | 232 | 225 | 230 | 0.369 | 0.07 | 2,281 |
| The period | | | | | 7.17 | 238,420 |

### Pekisko Creek at Pekisko, Alta.

This station was established October 6, 1911, by L. R. Brereton. It is located on the N.W. ¼ Sec. 8, Tp. 17, Rge. 2, W. 5th Mer., about 200 yards from Mr. Geo. Lane's ranche house and is about twenty-five miles southwest of High River.

Discharge measurements are made from a small suspension foot-bridge at high stages and at a wading section near the station in low water. The initial point for soundings is the stream side of the large tree on the left bank to which the end of the bridge is attached.

The channel is straight for 200 feet above and 150 feet below the station. Both banks are fairly low, sparsely covered with brush and trees, and liable to overflow in high stages of the stream. The bed is composed of fine gravel.

The gauge is a plain staff, graduated to feet and hundredths, spiked to a post driven into the bed of the stream at the right bank about ten feet downstream from the bridge. The zero (elev., 93.90) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the left bank 125 feet N. 55° E. from the gauge.

The gauge was read once daily by F. R. Pike, Mr. Lane's ranche foreman.

As the station was established very late in the season the data obtained was insufficient to compute daily discharges.

Discharge Measurements of Pekisko Creek at Pekisko, Alta., in 1911

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Aug. 31 | L. R. Brereton | 42 9 | 43 4 | 0 81 | .. | 35 2 |
| Oct 6 | do | 44 6 | 41 6 | 1 19 | 1 46 | 49.5 |

Daily Gauge-height in feet of Pekisko Creek, near Pekisko, Alta., for 1911.

| | October. | November. |
|---|---|---|
| 1 | | 1 25 |
| 2 | | 1 25 |
| 3 | | 1 25 |
| 4 | | 1 25 |
| 5 | | 1.24 |
| 6 | 1 46 | 1 20 |
| 7 | 1 46 | 1 20 |
| 8 | 1 46 | |
| 9 | 1 45 | |
| 10 | 1 44 | |
| 11 | 1 43 | |
| 12 | 1 43 | |
| 13 | 1 41 | |
| 14 | 1 35 | |
| 15 | 1 35 | |
| 16 | 1 35 | |
| 17 | 1 34 | |
| 18 | 1 34 | |
| 19 | 1 32 | |
| 20 | 1 31 | |
| 21 | 1 31 | |
| 22 | 1 31 | |
| 23 | 1 31 | |
| 24 | 1 30 | |
| 25 | 1 30 | |
| 26 | 1 25 | |
| 27 | 1 25 | |
| 28 | 1 25 | |
| 29 | 1 25 | |
| 30 | 1.25 | |
| 31 | 1 25 | |

## Stimson Creek near Pekisko, Alta.

This station was established October 6, 1911, by L. R. Brereton. It is located on the S.E. ¼ Sec. 14, Tp. 17, Rge. 2, W. 5th Mer., at the traffic bridge on the surveyed trail running southwest from High River.

Discharge measurements are made from the downstream side of the bridge and in low stages a wading section near the station is used. The initial point for soundings is the east side of the first pile at the left abutment.

The channel is straight for 300 feet above and 200 feet below the station. The current is swift and at low stages the water surface is rough at the station and a short distance above, owing to the presence of rapids. The right bank is high and clear of brush; the left bank is high with a gradual slope and is partly covered by a sparse growth of willows. The bed is composed of coarse gravel.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the upstream side of the first pile bent from the right abutment. The zero (elev., 92.54) is referred to a permanent iron bench-mark (assumed elev., 100.00 feet) situated on the right bank a few feet upstream from the end of the bridge.

The gauge was read once daily by J. F. Mitchell, a farmer living within 300 yards of the bridge.

### Discharge Measurements of Stimson Creek, near Pekisko, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Aug. 31 | L. R. Brereton | 27 | 26 6 | 0 49 | ... | 13 0 |
| Oct. 6 | do | 28 5 | 32.5 | 0.84 | 1 19 | 27 2 |

### Daily Gauge-height and Discharge of Stimson Creek, near Pekisko, Alta. for 1911.

| Day. | October. Gauge Height | October. Discharge | November. Gauge Height | November. Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1 06 | 24 |
| 2 | | | 1 05 | 24 |
| 3 | | | 1 05 | 24 |
| 4 | | | 1 05 | 24 |
| 5 | | | 1 00 | 22 |
| 6 | 1 19 | 28 | 1 00 | 22 |
| 7 | 1 18 | 27 | 1 00 | 22 |
| 8 | 1 16 | 27 | 1 00 | 22 |
| 9 | 1 10 | 25 | 1 00 | 22 |
| 10 | 1 05 | 24 | 1 00 | 22 |
| 11 | 1 02 | 23 | 1 00 | 22 |
| 12 | 1 01 | 22 | 1 00 | 22 |
| 13 | 1 06 | 24 | 1 00 | 22 |
| 14 | 1 05 | 24 | 1 00 | 22 |
| 15 | 1 04 | 23 | 1.00 | 22 |
| 16 | 1 03 | 23 | | |
| 17 | 1 05 | 24 | | |
| 18 | 1 04 | 23 | | |
| 19 | 1 04 | 23 | | |
| 20 | 1.01 | 22 | | |
| 21 | 1 04 | 23 | | |
| 22 | 1.06 | 24 | | |
| 23 | 1 06 | 24 | | |
| 24 | 1 07 | 24 | | |
| 25 | 1.05 | 24 | | |
| 26 | 1 00 | 22 | | |
| 27 | 1 05 | 24 | | |
| 28 | 1 06 | 24 | | |
| 29 | 1 08 | 24 | | |
| 30 | 1 07 | 24 | | |
| 31 | 1 07 | 24 | | |

MONTHLY DISCHARGE of Stimson Creek, near Pekisko, Alta., for 1911.

(Drainage area, 82 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| October (6-31) | 28 | 22 | 24.9 | 0.304 | 0.28 | 1,235 |
| November (1-15) | 24 | 22 | 22.5 | 0.271 | 0.15 | 669 |
| The period | | | | | 0.43 | 1,904 |

## FINDLAY AND McDOUGAL DITCH NEAR HIGH RIVER, ALTA.

This station was established on June 17, 1911, by J. C. Milligan. It is located on the S.W. ¼ Sec. 31, Tp. 18, Rge. 29, W. 4th Mer., and is about four and one half miles west of High River.

The gauge, which is a plain staff graduated to feet and inches, is nailed to a post driven into the bed of the ditch, near the left bank. The zero of the gauge (elev., 99.25) is referred to the top of a stake (assumed elev., 100.00) on the right bank, and 50 feet southeast of the gauge.

The channel is straight for 150 feet above and 175 feet below the gauge. The right bank is built up from the excavation of the ditch and is low. The left is clean, high and gravelly. The bed is composed of clay and is not liable to shift.

Discharge measurements are made with a meter by wading. The initial point for soundings is a stake on the right bank.

The gauge is read by H. Robertson.

DISCHARGE MEASUREMENTS of Findlay and McDougal Ditch, near High River, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 24 | L. R. Brereton | 6.60 | 5.40 | 0.91 | 1.25 | 4.89 |
| Aug. 30 | do | 5.20 | 1.67 | 0.42 | 0.75 | 0.70 |
| Oct. 5 | do | 6.80 | 4.36 | 0.65 | 1.10 | 2.83 |

## LITTLE BOW DITCH AT HIGH RIVER, ALTA.

This canal, about 2000 feet in length, was built by the Alberta Government to divert water from Highwood river into Little Bow river. This latter stream has a small flow and in dry seasons does not supply sufficient water for domestic and stock watering purposes. Shortly after its construction, the diverting dam was damaged, and the ditch was not used until summer of 1910, when the dam was repaired. The gauging station near High River, on the Highwood river, is below the intake to the ditch, so the discharge of the latter has been added to that obtained for the former to get the total discharge of the main stream.

This gauging station, located on Sec. 6, Tp. 19, Rge. 28, W. 4th Mer., at a traffic bridge, and 100 feet from the power-house of the town of High River, was established August 1, 1910, by J. C. Keith.

The gauge is a plain staff, graduated to feet and hundredths, spiked to the cribbing on the left bank. The zero (elev., 91.06) is referred to a bench-mark (assumed elev., 100.00) on the right bank about 60 feet upstream from the gauge.

The channel is straight for several hundred feet above and below the station. Both banks are high, clean and steep, cribbed for twenty feet above and below the bridge, and will not overflow.

Discharge measurements are made from the bridge. The initial point for soundings is on line with the cribbing on the left bank.

The gauge was read daily by Mr. Phillip Weinard.

Discharge Measurements of Little Bow Ditch at High River, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 25 | R. T. Sailman | 11.3 | 24.4 | 1.35 | 2.58 | 33.0 |
| July 22 | L. R. Brereton | 8.2 | 4.07 | 1.55 | 1.42 | 6.30 |
| Aug. 29 | do | 9.4 | 4.72 | 1.72 | 1.70 | 8.13 |
| Oct. 4 | do | 9.0 | 4.49 | 1.52 | 1.46 | 6.81 |

Daily Gauge-height and Discharge of Little Bow Ditch at High River, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ...... | ..... | 1.69 | 9.7 | 2.40 | 26.2 | 3.50 | 74.4 |
| 2 | ...... | ..... | 1.52 | 7.6 | 2.44 | 27.6 | 3.65 | 83.0 |
| 3 | ...... | ..... | 1.57 | 8.0 | 3.24 | 60.8 | 3.84 | 94.7 |
| 4 | ...... | ..... | 1.60 | 8.4 | 2.50 | 29.8 | 3.25 | 61.3 |
| 5 | ...... | ..... | 1.60 | 8.4 | 2.60 | 33.4 | 2.96 | 47.7 |
| 6 | ...... | ..... | 1.66 | 9.2 | 2.75 | 39.1 | 2.85 | 43.0 |
| 7 | ...... | ..... | 1.59 | 8.3 | 2.65 | 35.3 | 2.46 | 28.4 |
| 8 | ...... | ..... | 1.59 | 8.3 | 2.60 | 33.4 | 2.15 | 18.7 |
| 9 | ...... | ..... | 1.86 | 12.4 | 2.62 | 34.2 | 3.52 | 0.0* |
| 10 | ...... | ..... | 1.88 | 12.7 | 2.60 | 33.4 | 2.45 | 0.0* |
| 11 | ...... | ..... | 1.89 | 12.9 | 2.50 | 29.8 | 2.86 | 0.0* |
| 12 | ...... | ..... | 1.80 | 11.3 | 2.50 | 29.8 | 3.25 | 0.0* |
| 13 | ...... | ..... | 1.87 | 12.6 | 2.60 | 33.4 | 3.65 | 0.0* |
| 14 | ...... | ..... | 1.79 | 11.1 | 2.55 | 31.6 | 2.80 | 41.0 |
| 15 | ...... | ..... | 1.80 | 11.3 | 2.55 | 31.6 | 2.80 | 41.0 |
| 16 | ...... | ..... | 1.96 | 14.3 | 3.85 | 95.3 | 2.70 | 37.2 |
| 17 | ...... | ..... | 1.98 | 14.8 | 3.25 | 61.3 | 2.60 | 33.4 |
| 18 | ...... | ..... | 2.23 | 20.8 | 2.90 | 45.1 | 2.55 | 31.6 |
| 19 | ...... | ..... | 2.13 | 18.2 | 2.75 | 39.1 | 2.24 | 21.1 |
| 20 | ...... | ..... | 2.30 | 22.9 | 2.68 | 36.4 | 2.19 | 19.7 |
| 21 | ...... | ..... | 2.75 | 39.1 | 2.66 | 35.7 | 2.08 | 17.0 |
| 22 | ...... | ..... | 3.05 | 51.7 | 2.69 | 36.8 | 2.11 | 17.7 |
| 23 | ...... | ..... | 3.12 | 55.0 | 2.67 | 36.1 | 2.17 | 19.2 |
| 24 | ...... | ..... | 2.53 | 30.9 | 2.60 | 33.4 | 2.10 | 17.5 |
| 25 | ...... | ..... | 2.60 | 33.4 | 2.58 | 32.7 | 2.20 | 20.0 |
| 26 | 2.15 | 18.7 | 2.62 | 34.2 | 2.56 | 32.0 | 2.03 | 15.9 |
| 27 | 2.12 | 18.0 | 2.63 | 34.5 | 2.54 | 31.2 | 1.98 | 14.8 |
| 28 | 2.30 | 22.9 | 2.57 | 32.3 | 2.55 | 31.6 | 2.08 | 17.0 |
| 29 | 2.04 | 16.1 | 2.52 | 30.5 | 2.63 | 34.5 | 1.95 | 14.1 |
| 30 | 1.93 | 13.7 | 2.41 | 26.6 | 2.80 | 41.0 | 2.03 | 15.9 |
| 31 | 1.87 | 12.6 | ...... | ..... | 3.02 | 50.4 | ...... | ...... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Little Bow Ditch at High River, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis. charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.15 | 18.7 | 1.40 | 6.2 | 1.45 | 6.7 | 1.49 | 7.1 | 1.55 | 7.8 |
| 2 | 2.07 | 16.8 | 1.41 | 6.3 | 1.44 | 6.6 | 1.48 | 7.0 | 1.50 | 7.2 |
| 3 | 2.02 | 15.6 | 1.45 | 6.7 | 1.47 | 6.9 | 1.47 | 6.9 | 1.50 | 7.2 |
| 4 | 2.10 | 17.5 | 1.45 | 6.7 | 2.28 | 22.3 | 1.49 | 7.1 | 1.50 | 7.2 |
| 5 | 2.15 | 18.7 | 1.51 | 7.3 | 2.20 | 20.0 | 1.50 | 7.2 | 1.55 | 7.8 |
| 6 | 2.06 | 16.5 | 1.54 | 7.7 | 2.02 | 15.6 | 1.50 | 7.2 | 1.53 | 7.6 |
| 7 | 2.05 | 16.3 | 1.74 | 10.4 | 1.97 | 14.5 | 1.46 | 6.8 | 1.70 | 9.8 |
| 8 | 1.95 | 14.1 | 2.46 | 28.4 | 1.95 | 14.1 | 1.46 | 6.8 | 1.64 | 9.0 |
| 9 | 1.83 | 11.8 | 2.15 | 18.7 | 1.82 | 11.7 | 1.45 | 6.7 | 1.55 | 7.8 |
| 10 | 1.44 | 6.6 | 1.95 | 14.1 | 1.80 | 11.3 | 6.9 | 6.9 | 1.70 | 9.8 |
| 11 | 1.63 | 8.8 | 1.86 | 12.4 | 1.70 | 9.8 | 1.47 | 6.9 | 1.70 | 9.8 |
| 12 | 1.53 | 7.6 | 1.85 | 12.2 | 1.68 | 9.5 | 1.44 | 6.6 | 1.90 | 13.1 |
| 13 | 1.54 | 7.7 | 1.70 | 9.8 | 1.65 | 9.1 | 1.40 | 6.2 | 2.05 | 16.3 |
| 14 | 1.63 | 8.8 | 1.66 | 9.2 | 1.62 | 8.7 | 1.40 | 6.2 | 2.02 | 15.6 |
| 15 | 1.50 | 7.2 | 1.63 | 8.8 | 1.58 | 8.2 | 1.38 | 6.0 | 2.01 | 15.4 |
| 16 | 1.62 | 8.7 | 1.67 | 9.4 | 1.55 | 7.8 | 1.38 | 6.0 | | |
| 17 | 1.58 | 8.2 | 1.64 | 9.0 | 1.55 | 7.8 | 1.37 | 5.9 | | |
| 18 | 1.60 | 8.4 | 1.55 | 7.8 | 1.54 | 7.7 | 1.37 | 5.9 | | |
| 19 | 1.60 | 8.4 | 1.50 | 7.2 | 1.55 | 7.8 | 1.35 | 5.7 | | |
| 20 | 1.60 | 8.4 | 1.49 | 7.1 | 1.54 | 7.7 | 1.35 | 5.7 | | |
| 21 | 1.43 | 6.5 | 1.47 | 6.9 | 1.53 | 7.6 | 1.35 | 5.7 | | |
| 22 | 1.42 | 6.4 | 1.43 | 6.5 | 1.55 | 7.8 | 1.35 | 5.7 | | |
| 23 | 1.45 | 6.7 | 1.43 | 6.5 | 1.53 | 7.6 | 1.35 | 5.7 | | |
| 24 | 1.43 | 6.5 | 1.44 | 6.6 | 1.52 | 7.4 | 1.35 | 5.7 | | |
| 25 | 1.41 | 6.3 | 1.60 | 8.4 | 1.51 | 7.3 | 1.34 | 5.6 | | |
| 26 | 1.36 | 5.8 | 1.64 | 9.0 | 1.52 | 7.4 | 1.50 | 7.2 | | |
| 27 | 1.42 | 6.4 | 1.56 | 7.9 | 1.52 | 7.4 | 1.55 | 7.8 | | |
| 28 | 1.41 | 6.3 | 1.60 | 8.4 | 1.50 | 7.2 | 1.64 | 9.0 | | |
| 29 | 1.38 | 6.0 | 1.52 | 7.4 | 1.50 | 7.2 | 1.44 | 6.6 | | |
| 30 | 1.36 | 5.8 | 1.47 | 6.9 | 1.49 | 7.1 | 1.37 | 5.9 | | |
| 31 | 1.37 | 5.9 | 1.45 | 6.7 | | | 1.35 | 5.7 | | |

* Headgates closed for repairs. No flow in ditch.

MONTHLY DISCHARGE of Little Bow Ditch at High River, Alta., for 1911.

| Month | Discharge in Second-Feet. | | | Total Discharge in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | |
| March (26-31) | 22.9 | 12.6 | 17.0 | 202 |
| April | 55.0 | 7.6 | 20.4 | 1,214 |
| May | 95.3 | 26.2 | 38.1 | 2,343 |
| June | 94.7 | 0.0 | 28.2 | 1,678 |
| July | 18.7 | 5.8 | 9.8 | 603 |
| August | 28.4 | 6.2 | 9.2 | 566 |
| September | 22.3 | 6.6 | 9.6 | 571 |
| October | 9.0 | 5.6 | 6.5 | 400 |
| November (1-15) | 16.3 | 7.2 | 10.1 | 300 |
| The period | | | | 7,877 |

## Highwood River at High River, Alta.

This station was first established some years ago, by the Irrigation Surveys. It was re-established May 28, 1908, by P. M. Sauder. It is located at the highway bridge in the town of High River, on the N.W. ¼ Sec. 6, Tp. 19, Rg. 28 W. 4th Mer.

A plain staff gauge, graduated to feet and tenths, is fastened vertically to the down-stream face of the centre pier. It is referred to bench-marks as follows: (1) top of crib pier to which the gauge height is fixed, elevation 10.41; (2) top of crib abutment on the left bank, elevation 10.40; (3) southwest corner of concrete pier supporting north end of C. P. R. bridge, elevation 8.38.

The channel is straight for about 300 feet above and below the station. The right bank is low and liable to overflow. It is composed of gravel and sand and covered with brush. The left bank is low, but is protected from overflow by a crib work. The current is swift in high stages of the stream, but is sluggish in low water.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inside edge of the crib abutment, supporting the north end of the bridge. Distances are marked on the bottom chord of the bridge at every five feet from the initial point. There is an eddy about the centre pier and special care must be exercised by the hydographer in making discharge measurements at this station. At extreme low water, a check measurement is made at a wading station about 300 yards below the bridge.

Little Bow Ditch diverts water from Highwood River at a point about half a mile above this station. For some time previous to 1910, the diverting dam was out of repair and water could only be diverted during high-water periods. In the summer of 1910 this dam was repaired and water has since been diverted. A gauge was established on the canal and records of the flow are given above.

During a flood in 1908, Highwood River overflowed its left bank some distance above the traffic bridge and did considerable damage to property. To prevent a repetition of this occurrence, a highwater overflow channel has been constructed from the Lineham mill pond to the river. The water carried off through this spillway does not pass the gauging station. During 1911, there was no flood and there was only an occasional flow through the spillway when the company raised the water in the pond to float logs.

Miscellaneous discharge measurements of this flow were made on the same day that Highwood River was measured. The flow through the Little Bow Ditch and Lineham's Spillway have both been added to the flow at the traffic bridge to obtain the total monthly flow in Highwood River.

Daily observations of the gauge at the regular station on Highwood River were made by W. E. M. Holmes during 1911.

### Discharge Measurements of Highwood River at High River, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 22 | H. C. Ritchie | 91 | 381 3 | 0 79 | 2 61 | 302 9 |
| June 17 | R. T. Sailman | 152 | 491 3 | 3 99 | 3 95 | 1962 0 |
| July 21 | L. R. Brereton | 123 | 296 9 | 1 62 | 2 86 | 480 3 |
| Aug. 29 | do | 130 | 293 8 | 1 85 | 2 85 | 544 8 |
| Oct. 4 | do | 131 | 293 6 | 1 84 | 2 87 | 540 2 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Highwood River at High River, Alta., for 1911

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 2.00 | 60 | 2.54 | 264 | 4.30 | 2620 |
| 2 | | | 2.00 | 60 | 2.57 | 282 | 4.34 | 2696 |
| 3 | | | 2.00 | 60 | 2.65 | 330 | 4.62 | 3250 |
| 4 | | | 2.00 | 60 | 2.70 | 360 | 4.15 | 2335 |
| 5 | | | 2.00 | 60 | 2.78 | 416 | 4.00 | 2050 |
| 6 | | | 2.00 | 60 | 3.00 | 600 | 3.85 | 1770 |
| 7 | | | 2.00 | 60 | 2.99 | 591 | 3.75 | 1595 |
| 8 | | | 2.00 | 60 | 2.87 | 486 | 3.69 | 1494 |
| 9 | | | 2.10 | 85 | 2.83 | 454 | 3.67 | 1462 |
| 10 | | | 2.16 | 103 | 2.82 | 446 | 3.87 | 1806 |
| 11 | | | 2.20 | 115 | 2.75 | 395 | 3.97 | 1993 |
| 12 | | | 2.15 | 100 | 2.70 | 360 | 4.05 | 2145 |
| 13 | | | 2.00 | 60 | 2.75 | 395 | 4.14 | 2316 |
| 14 | | | 1.88 | 42 | 2.80 | 430 | 4.33 | 2677 |
| 15 | | | 1.87 | 40 | 2.85 | 470 | 4.25 | 2525 |
| 16 | | | 2.06 | 75 | 3.84 | 1752 | 4.00 | 2050 |
| 17 | | | 2.18 | 109 | 4.10 | 2240 | 3.92 | 1898 |
| 18 | | | 2.07 | 78 | 3.72 | 1544 | 3.92 | 1898 |
| 19 | | | 2.15 | 100 | 3.44 | 1116 | 3.78 | 1646 |
| 20 | | | 2.25 | 133 | 3.23 | 846 | 3.66 | 1446 |
| 21 | | | 2.37 | 178 | 3.25 | 870 | 3.65 | 1430 |
| 22 | 2.10 | 85 | 2.60 | 300 | 3.24 | 858 | 3.60 | 1350 |
| 23 | 2.15 | 100 | 2.67 | 342 | 3.21 | 822 | 3.67 | 1462 |
| 24 | 2.25 | 133 | 2.72 | 374 | 3.13 | 733 | 3.59 | 1335 |
| 25 | 2.20 | 115 | 2.75 | 395 | 3.10 | 700 | 3.59 | 1335 |
| 26 | 2.10 | 85 | 2.80 | 430 | 3.04 | 640 | 3.55 | 1275 |
| 27 | 2.00 | 60 | 2.72 | 374 | 3.00 | 600 | 3.47 | 1158 |
| 28 | 2.11 | 88 | 2.72 | 374 | 3.04 | 640 | 3.51 | 1215 |
| 29 | 2.07 | 78 | 2.57 | 282 | 3.13 | 733 | 3.90 | 1116 |
| 30 | 2.05 | 72 | 2.60 | 300 | 3.44 | 1116 | 3.45 | 1130 |
| 31 | 2.00 | 60 | ... | ... | 3.88 | 1824 | .... | .. |

DAILY GAUGE-HEIGHT AND DISCHARGE of Highwood River at High River, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.58 | 1320 | 2.61 | 306 | 2.70 | 425 | 2.90 | 570 | 2.55 | 338 |
| 2 | 3.41 | 1074 | 2.67 | 342 | 2.69 | 419 | 2.90 | 570 | 2.62 | 377 |
| 3 | 3.34 | 982 | 2.85 | 470 | 3.12 | 770 | 2.92 | 587 | 2.50 | 310 |
| 4 | 3.31 | 913 | 3.13 | 733 | 3.76 | 1619 | 2.87 | 547 | 2.46 | 290 |
| 5 | 3.27 | 894 | 3.05 | 650 | 3.95 | 1955 | 2.83 | 517 | 2.41 | 265 |
| 6 | 3.17 | 777 | 3.11 | 720 | 3.84 | 1755 | 2.79 | 488 | 2.30 | 215 |
| 7 | 3.15 | 755 | 3.40 | 1070 | 3.80 | 1685 | 2.77 | 474 | 2.10 | 145 |
| 8 | 3.13 | 733 | 4.33 | 2700 | 3.74 | 1586 | 2.75 | 460 | 1.80 | 60 |
| 9 | 3.15 | 755 | 4.06 | 2180 | 3.65 | 1445 | 2.74 | 453 | 1.80 | 60 |
| 10 | 3.15 | 755 | 3.83 | 1760 | 3.60 | 1370 | 2.73 | 446 | 1.80 | 60 |
| 11 | 3.10 | 700 | 3.64 | 1450 | 3.55 | 1297 | 2.71 | 432 | 1.80 | 60 |
| 12 | 3.07 | 670 | 3.53 | 1280 | 3.50 | 1225 | 2.70 | 425 | 1.80 | 60 |
| 13 | 3.02 | 620 | 3.36 | 1040 | 3.45 | 1158 | 2.70 | 425 | 1.80 | 60 |
| 14 | 2.89 | 502 | 3.26 | 910 | 3.38 | 1065 | 2.68 | 413 | *2.30 | .... |
| 15 | 2.92 | 528 | 3.18 | 830 | 3.27 | 930 | 2.67 | 407 | 2.50 | .... |
| 16 | 2.86 | 478 | 3.30 | 980 | 3.23 | 884 | 2.66 | 401 | .... | .... |
| 17 | 2.87 | 486 | 3.15 | 800 | 3.19 | 840 | 2.63 | 383 | .... | .... |
| 18 | 2.92 | 528 | 3.05 | 703 | 3.15 | 800 | 2.61 | 371 | .... | .... |
| 19 | 2.91 | 519 | 3.00 | 655 | 3.13 | 780 | 2.50 | 310 | .... | .... |
| 20 | 2.89 | 502 | 2.98 | 638 | 3.11 | 760 | 2.51 | 316 | .... | .... |
| 21 | 2.88 | 494 | 2.95 | 612 | 3.08 | 731 | 2.53 | 326 | .... | .... |
| 22 | 2.86 | 478 | 2.93 | 596 | 3.05 | 703 | 2.53 | 326 | .... | .... |
| 23 | 2.83 | 454 | 2.90 | 570 | 3.00 | 655 | 2.53 | 326 | .... | .... |
| 24 | 2.75 | 395 | 2.85 | 533 | 2.98 | 638 | 2.59 | 360 | .... | .... |
| 25 | 2.72 | 374 | 2.80 | 495 | 2.98 | 638 | 2.53 | 326 | .... | .... |
| 26 | 2.74 | 388 | 3.03 | 683 | 2.96 | 621 | 2.50 | 310 | .... | .... |
| 27 | 2.71 | 367 | 2.98 | 638 | 2.99 | 646 | 2.50 | 310 | .... | .... |
| 28 | 2.69 | 354 | 2.89 | 563 | 2.99 | 646 | 2.50 | 310 | .... | .... |
| 29 | 2.62 | 312 | 2.85 | 533 | 2.95 | 612 | 2.50 | 310 | .... | .... |
| 30 | 2.55 | 270 | 2.77 | 474 | 2.90 | 570 | 2.52 | 321 | .... | .... |
| 31 | 2.55 | 270 | 2.74 | 453 | .... | .... | 2.53 | 326 | .... | .... |

* River freezing over.

MONTHLY DISCHARGE of Highwood River at High River, Alta., for 1911.

Drainage area, 756 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| March (22-31) | 150 | 72.6 | 105 | 0.139 | 0.05 | 2,083 |
| April | 464 | 51.3 | 182 | 0.241 | 0.27 | 10,830 |
| May | 2,301 | 290 | 790 | 1.045 | 1.20 | 48,575 |
| June | 3,345 | 1,130 | 1,844 | 2.439 | 2.72 | 109,726 |
| July | 1,339 | 276 | 612 | 0.810 | 0.93 | 37,630 |
| August | 2,728 | 312 | 860 | 1.138 | 1.31 | 52,879 |
| September | 1,975 | 426 | 984 | 1.302 | 1.45 | 58,552 |
| October | 594 | 316 | 412 | 0.545 | 0.63 | 25,333 |
| November (1-13) | 384 | 67.8 | 186 | 0.246 | 0.12 | 4,796 |
| The period | | | | | 8.68 | 350,404 |

NOTE.—The flow through Little Bow Ditch and Lineham's Spillway have been added to the flow at the traffic bridge to obtain the total monthly flow of Highwood River.

## Highwood River near Aldersyde, Alta.

This station was established October 3, 1911, by L. R. Brereton. It is located at the traffic bridge on the surveyed trail about one mile east of Aldersyde, in the N.W. 1/4 Sec. 17, Tp. 20, Rge. 28, W. 4th Mer.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the stream face of the north, or left abutment.

The channel is straight for 1000 feet above and 150 feet below the station. Both banks are high, clear of brush and not liable to overflow. The bed is of coarse gravel with a scattering of large stones and boulders in and near the section. The latter affect the velocity observations to some extent. The current is swift.

The gauge which is a plain staff graduated to feet and hundredths is nailed near the upstream end of the left, or north face of the centre pier. The zero (elev., 90.64) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the left bank, near the north end of the bridge.

The gauge was read once daily by L. W. Barrett, a farmer living within 100 yards of the bridge; but as only one discharge measurement was made after the gauge was installed, daily discharges could not be computed.

Discharge Measurements of Highwood River near Aldersyde, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 25 | R. T. Sailman | 160 | 282 4 | 2 63 | .... | 742 2 |
| June 16 | do | 214 | 519 2 | 4 13 | .... | 2146 0 |
| July 24 | L. R. Brereton | 144 | 236 3 | 2 06 | .... | 486 7 |
| Aug. 28 | do | 159 | 260 5 | 2 10 | | 548 5 |
| Oct. 3 | do | 159 | 268 0 | 2 20 | 1 84 | 589.3 |

Daily Gauge-height in feet of Highwood River near Aldersyde, Alta., for 1911.

| Day. | October. | November. |
|---|---|---|
| 1 | .... | 1 35 |
| 2 | .... | 1 60 |
| 3 | 1 85 | 1 60 |
| 4 | 1 80 | 1 55 |
| 5 | 1 80 | 1.40 |
| 6 | 1 73 | 1 30 |
| 7 | .... | 1 30 |
| 8 | 1 70 | 1 35 |
| 9 | 1 68 | 1 00 |
| 10 | 1 68 | 0 95 |
| 11 | 1 65 | 0 95 |
| 12 | 1 62 | 1.35 |
| 13 | 1 62 | 1.30 |
| 14 | 1 60 | 1 35 |
| 15 | 1 60 | 1 40 |
| 16 | 1 58 | .... |
| 17 | 1 55 | .... |
| 18 | 1 50 | .... |
| 19 | 1 48 | .... |
| 20 | 1 48 | .... |
| 21 | 1 50 | .... |
| 22 | 1 45 | .... |
| 23 | 1 48 | .... |
| 24 | 1 48 | .... |
| 25 | 1 48 | .... |
| 26 | 1 45 | .... |
| 27 | 1 20 | .... |
| 28 | 1 32 | .... |
| 29 | 0 95 | .... |
| 30 | 1 60 | .... |
| 31 | 1 60 | .... |

Note.—Gauge-heights after Oct. 27 are affected by ice.

## Bow River near Bassano, Alta.

This station was established August 20, 1909, by the irrigation department of the Canadian Pacific Railway Company. It is located at the Horseshoe bend in Bow River, near the east boundary of the Blackfoot Indian reserve, and is about three miles southwest of Bassano, and one mile upstream from the site of the Canadian Pacific Railway Company's dam.

The stream flows in one channel at all stages. It gently curves for 600 feet above and 2000 feet below the station. The right bank is high, steep and sparsely covered with brush, and is composed of gravel. The left bank is high, composed of clay, and covered with brush near water's edge. The bed of the stream is composed of gravel, and during low water and ordinary stages of the stream there is a wide gravel beach at the left bank. The current has a moderate velocity.

Discharge measurements are made by means of a cable and car. The initial point for soundings is a stake on the left bank, and distances are marked at every twenty feet on the cable by white paint.

The gauge, which is a plain staff graduated to feet and tenths, is situated in the bed of the stream near the left bank. The zero is referred to the datum of the irrigation department of the Canadian Pacific Railway.

Copies of the records of the gauge-height observations and gaugings made by F. G. Cross during 1911, were given to us by A. S. Dawson, Chief Engineer of the Natural Resources Department of the Canadian Pacific Railway Caompny.

### Discharge Measurements of Bow River near Bassano, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 19 | H. C. Ritchie | 332 | 2,192 | 1 12 | ... | 2,463 |
| May 3 | F. G. Cross | | 1,612 | 1 00 | 2,519 86 | 1,620 |
| May 5 | H. R. Carscallen | 330 | 2,173 | 0 99 | 2,520 01 | 2,153 |
| May 9 | F. G. Cross | . . | 2,398 | 1 35 | 2,520 81 | 3,224 |
| May 18 | do | ... | 3,273 | 2 33 | 2,522 83 | 7,638 |
| May 19 | H C. Ritchie | 390 | 2,984 | 2 14 | 2,522 26 | 6,392 |
| May 20 | F. G. Cross | ... | 2,969 | 2 00 | 2,522 06 | 5,928 |
| June 2 | do | | 3,368 | 2 52 | 2,523 71 | 8,837 |
| June 3 | H. R. Carscallen | 402 5 | 3,609 | 3 29 | 2,523 97 | 11,882 |
| June 11 | F. G. Cross | . . | 4,331 | 3 82 | 2,525 10 | 16,561 |
| June 30 | H. R. Carscallen | 405 | 4,097 | 3 79 | 2,524 90 | 15,535 |
| July 6 | F. G. Cross | | 3,900 | 2 82 | 2,524 40 | 11,402 |
| July 15 | do | . . | 3,309 | 2 48 | 2,523 05 | 8,190 |
| July 27 | H. R. Carscallen | 395 | 3,396 | 2 65 | 2,523 15 | 8,993 |
| Aug. 9 | F. G. Cross | ... | 5,065 | 4 52 | 2,526 53 | 22,878 |
| Aug. 29 | do | ... | 3,143 | 2 04 | 2,522 52 | 6,431 |
| Sept. 7 | do | . | 3,522 | 2 63 | 2,523 40 | 9,265 |
| Sept. 10 | J. C. Keith | 390 | 3,248 | 2 35 | 2,522 75 | 7,643 |
| Sept. 27 | F. G. Cross | . . | 2,570 | 1 59 | 2,521 15 | 4,096 |
| Nov. 3 | do | . . | 2,156 | 1 06 | 2,519 90 | 2,282 |

Daily Gauge-height and Discharge of Bow River near Bassano, Alta., for 1911.

| Day. | May. | | June. | | July. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height | Dis-charge. | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 19.90 | 2,000 | 22.83 | 7,950 | 25.10 | 16,400 |
| 2 | 19.90 | 2,000 | 23.58 | 10,428 | 25.35 | 17,500 |
| 3 | 19.82 | 1,920 | 23.98 | 11,904 | 25.15 | 16,620 |
| 4 | 19.91 | 2,014 | 24.69 | 14,680 | 24.95 | 15,750 |
| 5 | 20.01 | 2,154 | 24.64 | 14,480 | 24.75 | 14,920 |
| 6 | 20.18 | 2,392 | 24.24 | 12,892 | 24.42 | 13,600 |
| 7 | †20.49 | 2,864 | 23.84 | 11,372 | 24.03 | 12,094 |
| 8 | 20.80 | 3,360 | 23.52 | 10,212 | 23.85 | 11,410 |
| 9 | 20.81 | 3,378 | 23.42 | 9,852 | 24.03 | 12,094 |
| 10 | 20.62 | 3,072 | 23.27 | 9,344 | 23.95 | 11,790 |
| 11 | 20.62 | 3,072 | 23.23 | 9,216 | 23.70 | 10,860 |
| 12 | 20.58 | 3,008 | 23.34 | 9,576 | 23.45 | 9,960 |
| 13 | 20.56 | 2,976 | 24.10 | 12,360 | 23.27 | 9,344 |
| 14 | 20.71 | 3,216 | 25.40 | 17,720 | 23.17 | 9,024 |
| 15 | 20.91 | 3,558 | 25.77 | 19,362 | 23.05 | 8,640 |
| 16 | 20.98 | 3,684 | 25.75 | 19,270 | 23.00 | 8,480 |
| 17 | 21.82 | 5,328 | 25.72 | 19,132 | 23.25 | 9,280 |
| 18 | 22.83 | 7,950 | 25.45 | 17,940 | 23.33 | 9,542 |
| 19 | 22.41 | 6,766 | 25.35 | 17,500 | 23.37 | 9,678 |
| 20 | 22.05 | 5,880 | 25.23 | 16,972 | 23.45 | 9,960 |
| 21 | 21.76 | 5,192 | 25.00 | 15,960 | 23.35 | 9,610 |
| 22 | 21.68 | 5,016 | 24.77 | 15,000 | 23.20 | 9,120 |
| 23 | 21.78 | 5,236 | 24.70 | 14,720 | 23.22 | 9,184 |
| 24 | 21.88 | 5,472 | 25.20 | 16,840 | 23.30 | 9,440 |
| 25 | 21.71 | 5,082 | 25.54 | 18,336 | 23.25 | 9,280 |
| 26 | 21.58 | 4,800 | 25.95 | 20,190 | 23.10 | 8,800 |
| 27 | 21.61 | 4,862 | 25.68 | 18,952 | 23.20 | 9,120 |
| 28 | 21.51 | 4,660 | 25.20 | 16,840 | 23.25 | 9,280 |
| 29 | 21.51 | 4,660 | 24.90 | 15,540 | 22.95 | 8,320 |
| 30 | 21.51 | 4,660 | 24.90 | 15,540 | 23.03 | 8,576 |
| 31 | 21.96 | 5,664 | ........ | ........ | 22.90 | 8,160 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Bow River near Bassano, Alta., for 1911.—*Continued.*

| Day. | August. Gauge Height | August. Dis-charge | September. Gauge Height | September. Dis-charge | October. Gauge Height | October. Dis-charge | November. Gauge Height | November. Dis-charge. |
|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* |
| 1 | 22 93 | 8,256 | 22 34 | 6,584 | 21 25 | 4,170 | 20 05 | 2,210 |
| 2 | 22 90 | 8,160 | 22 32 | 6,532 | 21 25 | 4,170 | 19 95 | 2,070 |
| 3 | 22 83 | 7,950 | 23 36 | 9,644 | 21 10 | 3,900 | 19 95 | 2,070 |
| 4 | 23 07 | 8,704 | 22 40 | 6,740 | 21 25 | 4,170 | 20 30 | 2,560 |
| 5 | 23 27 | 9,344 | 22 46 | 6,896 | 21 15 | 3,990 | 20 40 | 2,720 |
| 6 | 23 45 | 9,960 | 23 70 | 10,860 | 21 15 | 3,990 | 20 18 | 2,392 |
| 7 | 23 53 | 10,248 | 23 40 | 9,780 | 21 05 | 3,810 | ‡ | |
| 8 | 25 00 | 15,960 | 23 10 | 8,800 | 21 05 | 3,810 | | |
| 9 | 26 50 | 22,780 | 23 05 | 8,640 | 21 00 | 3,720 | | |
| 10 | 25 75 | 19,270 | 22 85 | 8,010 | 20 95 | 3,630 | | |
| 11 | 25 10 | 16,400 | 22 75 | 7,710 | 20 85 | 3,450 | | |
| 12 | 24 60 | 14,320 | 22 65 | 7,420 | 20 80 | 3,360 | | |
| 13 | 24 20 | 12,740 | 22 50 | 7,000 | 20 85 | 3,450 | | |
| 14 | 23 55 | 10,320 | 22 35 | 6,610 | 20 80 | 3,360 | | |
| 15 | 23 40 | 9,780 | 22 15 | 6,120 | 20 75 | 3,280 | | |
| 16 | 23 35 | 9,610 | 22 05 | 5,880 | 20 75 | 3,280 | | |
| 17 | 23 43 | 9,888 | 22 00 | 5,760 | 20 80 | 3,360 | | |
| 18 | 23 20 | 9,120 | 22 05 | 5,880 | 20 70 | 3,200 | | |
| 19 | 22 89 | 8,1[illegible]0 | 21 90 | 5,520 | 20 65 | 3,120 | | |
| 20 | 22 80 | 7,860 | 21 72 | 5,104 | 20 55 | 2,960 | | |
| 21 | 22 70 | 7,560 | 21 65 | 4,950 | 20 60 | 3,040 | | |
| 22 | 22 55 | 7,140 | 21 55 | 4,740 | 20 55 | 2,960 | | |
| 23 | 22 30 | 6,480 | 21 60 | 4,840 | 20 45 | 2,800 | | |
| 24 | 22 20 | 6,240 | 21 65 | 4,950 | 20 45 | 2,800 | | |
| 25 | 22 05 | 5,880 | 21 45 | 4,540 | 20 45 | 2,800 | | |
| 26 | 21 90 | 5,520 | 21 35 | 4,350 | 20 40 | 2,720 | | |
| 27 | 21 85 | 5,400 | 21 20 | 4,080 | 20 25 | 2,490 | | |
| 28 | 21 70 | 5,060 | 21 25 | 4,170 | 20 25 | 2,490 | | |
| 29 | 22 07 | 5,928 | 21 40 | 4,440 | 20 25 | 2,490 | | |
| 30 | 22 17 | 6,168 | 21 35 | 4,350 | 20 25 | 2,490 | | |
| 31 | 22 25 | 6,360 | | | 20 20 | 2,420 | | |

† No observation, gauge height interpolated. ‡ Gauge frozen, observations discontinued.

NOTE.—All gauge-heights have been converted into elevation above mean sea level, using C. P. R. I. D. datum, but for convenience in printing the table 2,500 feet has been deducted from each.

MONTHLY DISCHARGE of Bow River near Bassano, Alta., for 1911.

(Drainage area, 8000 square miles.)

| Month. | Discharge in Second-Feet. Maximum. | Minimum | Mean. | Per square mile. | Run-Off. Depth in inches on Drainage area. | Total in acre-feet. |
|---|---|---|---|---|---|---|
| May | 7,950 | 1,920 | 4,061 | 0 508 | 0 59 | 249,701 |
| June | 20,190 | 7,950 | 14,669 | 1 834 | 2 05 | 872,866 |
| July | 17,500 | 8,160 | 10,833 | 1 354 | 1 56 | 666,095 |
| August | 22,780 | 5,060 | 9,566 | 1 196 | 1 38 | 588,190 |
| September | 10,860 | 4,080 | 6,363 | 0 795 | 0 89 | 378,625 |
| October | 4,170 | 2,420 | 3,286 | 0 411 | 0 47 | 202,048 |
| November (1-6) | 2,720 | 2,070 | 2,337 | 0 292 | 0 07 | 27,812 |
| The period | | | | | 7 01 | 2,985,337 |

## Miscellaneous Discharge Measurements in Bow River Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Square-ft.* | *Ft. per Sec.* | *Sec-ft.* |
| Sept. 20 | H. Brown. | Bath Creek | N.E. 32-28-16-5 | 36.5 | 26.90 | 2.62 | 70.50 |
| Oct. 17 | J. A. Newhall | do | do | 35.2 | 20.38 | 1.715 | 34.94 |
| Nov. 2 | do | do | do | 34.5 | 16.93 | 1.624 | 27.50 |
| Nov. 21 | do | do | do | 34.5 | 14.28 | 1.48 | 22.90 |
| Dec. 6 | do | do | do | 33.0 | 13.12 | 1.506 | 19.76 |
| Dec. 18 | do | do | do | 34.0 | 12.20 | 1.105 | 13.99 |
| May 3 | H. C. Ritchie | Beaupre Creek | Sec. 15-26-5-5 | | ... | ... | Dry. |
| July 14 | L. R. Brereton | do | do | 5.5 | 2.23 | 0.31 | 0.69 |
| Aug. 18 | do | do | do | 8.30 | 3.95 | 0.65 | 2.56 |
| Sept. 19 | do | do | do | 7.50 | 2.32 | 0.22 | 0.51 |
| Oct. 20 | do | do | do | * | | | |
| May 3 | H. C. Ritchie | Bighill Creek | Sec. 10-26-4-5 | 11.00 | 6.04 | 0.97 | 5.88 |
| July 14 | L. R. Brereton | do | do | 11.40 | 6.82 | 1.05 | 7.18 |
| Aug. 18 | do | do | do | 12.3 | 9.50 | 1.30 | 12.50 |
| Sept. 19 | do | do | do | 11.3 | 6.40 | 1.00 | 6.43 |
| Oct. 20 | do | do | do | 11.4 | 7.97 | 0.46 | 3.71 |
| Jan. 7 | H. R. Carcallen | Elbow River | S.E. 25-23-2-5 | 55.0 | 82.00 | 1.097 | 89.98 |
| Feb. 7 | do | do | do | 50.0 | 85.70 | 1.123 | 96.22 |
| Mar. 13 | G. H. Whyte & (L. J. Gleeson) | do | S.E. 15-22-6-5 | 44.0 | 50.80 | 2.230 | 113.45 |
| Mar. 14 | do | do | Sec. 15-22-6-5 Below mouth of Canyon Creek | 45.0 | 55.55 | 2.044 | 113.51 |
| Mar. 14 | do | do | Sec. 15-22-6-5 Above mouth of Canyon Creek | 51.0 | 70.85 | 1.306 | 92.56 |
| Mar. 14 | H. R. Carscallen | do | Sec. 15-22-6-5 Above mouth o Canyon Creek | 45.00 | 94.35 | 1.200 | 113.22 |
| July 27 | L. R. Brereton | do | do | 96.0 | 228.57 | 2.58 | 589.59 |
| Sept. 4 | do | do | do | 107.5 | 380.67 | 3.83 | 1459.56 |
| Sept. 25 | do | do | do | 74.0 | 208.71 | 2.04 | 425.28 |
| Apr. 26 | H. R. Carscallen | Fish Creek N. Br. | Sec. 22-22-3-5 | 19.5 | 10.63 | 0.882 | 9.38 |
| July 18 | L. R. Brereton | do | N.E. do | 16.0 | 10.84 | 0.63 | 6.85 |
| July 18 | do | Fish Creek, S. Br. | S.E. do | 23.0 | 26.82 | 0.78 | 20.80 |
| Aug. 23 | do | do | S.E. do | 36.0 | 38.82 | 1.03 | 39.98 |
| do | do | Fish Creek, N. Br | Sec. 22-22-3-5 | 17.2 | 14.07 | 1.20 | 16.85 |
| Sept. 27 | do | do | N.E. do | 19.7 | 24.41 | 0.93 | 22.81 |
| do | do | do S. Br. | S.E. do | 36.7 | 41.67 | 1.05 | 43.79 |
| May 3 | H. C. Ritchie | Grand Valley Crk | Sec. 24-26-5-5 | x | ... | ... | 1.5 |
| July 14 | L. R. Brereton | do | do | 9.7 | 5.43 | 0.97 | 5.28 |
| Aug. 18 | L. R. Brereton | Grand Valley Crk. | Sec. 13-26-5-5 | 10.2 | 9.95 | 1.39 | 13.81 |
| Sept. 19 | do | do | Sec. 24-26-5-5 | 9.6 | 5.88 | 0.97 | 5.73 |
| Oct. 20 | do | do | do | 5.7 | 2.46 | 0.89 | 2.19 |
| Sept 1 | do | Highwood River | Sec. 16-18-2-5 | 143.5 | 159.93 | 2.59 | 401.99 |
| Oct. 7 | do | do | S.W. 16-18-2-5 | 143.5 | 151.47 | 2.49 | 376.98 |
| May 3 | H. C. Ritchie | Horse Creek | Sec. 8-26-4-5 | ... | ... | ... | ‡ |
| July 14 | L. R. Brereton | do | do | 1.5 | 0.60 | 0.60 | 0.36 |
| Aug. 18 | do | do | do | 9.7 | 2.81 | 0.43 | 1.22 |
| Sept. 19 | do | do | do | 5.0 | 0.98 | 0.18 | 0.18 |
| Oct. 20 | do | do | do | 4.0 | 0.74 | 0.14 | 0.10 |
| June 17 | do | Lineham Spillway | N.W. 6-19-28-4 | 6.4 | 3.66 | 1.11 | 3.7 |
| July 22 | do | do | do | 9.0 | 6.30 | 1.49 | 9.40 |
| Aug. 29 | do | do | do | 7.80 | 4.16 | 1.63 | 6.79 |
| Oct. 4 | do | do | do | 7.90 | 5.40 | 1.68 | 9.05 |
| May 3 | H. C. Ritchie | Spencer Creek | Sec. 17-26-5-5 | ... | ... | ... | x1.00 |
| July 14 | L. R. Brereton | do | do | 7.60 | 4.87 | 0.55 | 2.67 |
| Aug. 18 | do | do | do | 9.80 | 7.70 | 0.91 | 7.59 |
| Sept. 19 | do | do | do | 9.70 | 7.35 | 0.64 | 4.72 |
| Oct. 20 | do | do | do | 9.80 | 7.19 | 0.61 | 4.40 |
| Aug. 31 | do | Stimson Creek | Sec. 14-17-2-5 | 27.0 | 26.65 | 0.49 | 13.03 |
| July 24 | L. R. Brereton | Tongue Flag Crk | S.W. 19-19-28-4 | 8.7 | 2.64 | 0.96 | 2.55 |
| Aug. 29 | do | do | do | 10.6 | 3.34 | 1.30 | 4.35 |
| Oct. 3 | do | do | do | 10.9 | 4.19 | 1.575 | 6.60 |

* Creek frozen solid. x Approximate. ‡ Too small to gauge.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Mineral Water Springs near Banff, Alta., in 1911.

| DATE. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Discharge. |
|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Sec. Feet.* |
| July 13.. | P. M. Sauder.. | Kidney Spring.... | Banff, Alta. | * | | 0 078 |
| July 13.. | do | Middle Spring. | do | * | | 0 256 |
| July 14.... | do | Over Flow From (Cave) | do | * | | 0 293 |
| Aug. 24.. | do | Upper Hot (Spring) | do | ** | | 0 350 |

* Discharge measured with a 9 in. weir. ** Discharge measured with two 9 in. weirs.

TEMPERATURES of Mineral Water Springs near Banff, Alta., in 1911.

| Date. | NAME. | LOCALITY. | Hydrographer. | Temperature |
|---|---|---|---|---|
| July 8 ....... | Overflow from upper Hot Spring ....... | Banff, Alta | P. M. Sauder. ........ | 114°. F |
| July 11....... | do ....... | do | do | 114 5° F. |
| July 12....... | Feed pipe for swimming Pool Upper Hot Springs........... | do | do ......... | 114°. F. |
| July 12 ...... | In well at Upper Hot Spring ........... | do | do ........ | 114 25° F |
| July 12....... | Kidney Spring. ................... | do | do ....... | 100 4° F. |
| July 15 .... | Swimming Basin near Cave ......... | do | do ........ | 93° F. |
| July 15.. .... | Sulphur Spring above Cave ........... | do | do ....... | 88°. F. |
| July 15.. .... | Iron Spring above Cave ............ | do | do ....... | 88°. F. |
| July 15....... | Spring in Cave ................ .... | do | do ....... | 86 .5° F. |
| July 15....... | Middle Spring (Upper)............. | do | do ........ | 94°. F. |
| July 15....... | Middle Spring (Lower) ............. | do | do ....... | 94° F. |
| July 15....... | Kidney Springs. ..................... | do | do ....... | 100 .5° F. |

## LITTLE BOW RIVER DRAINAGE BASIN.

*General Description.*

The source of Little Bow river is a spring in the Town of High River in Sec. 6, Tp. 19, Rge. 28, W. 4th Mer. From here it flows in a southeasterly direction for one hundred miles and empties into Belly river. In the first few miles, the natural flow is dependent entirely on a number of small springs and coulees which are dry most of the year, but later is augmented by the flow from Mosquito Creek, which drains the south and westerly part of the drainage basin.

There is a comparatively large flow in this stream during the spring freshets, but during summer it would under natural conditions dry up. There are a large number of ranchers and settlers on this stream, and it is very important that there should be a good flow for domestic and stock-watering purposes. For this reason, the Provincial Government has constructed a canal and diverts water from Highwood River into Little Bow River whenever required.

### MOSQUITO CREEK NEAR NANTON, ALTA.

This station was established August 1, 1908, by H. C. Ritchie. It is located at a traffic bridge, about four miles from Nanton, on the road from Nanton to Cayley. The bridge is on a road diversion on Sec. 30, Tp. 16, Rge. 28, W. 4th Mer.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed in a stilling box in the left bank, a few yards upstream from the bridge. It is referred to two spike-heads in the south side of the bridge pier at the right bank of the stream; elevation, 11.47.

The channel is straight for about 175 feet below the station, then curves to the left. Above the station the channel curves slightly to the left for about 500 feet, then it turns sharply to the left. The right bank is low near the water's edge, but is high a few feet from it. Sand and mud are deposited on this bank in high water. The left bank is high, and is of solid clay with a few boulders. There is only one channel at low water. The bridge piers divide the stream into three channels at flood stage.

Discharge measurements are made from the bridge at high-water and flood stages. The initial point for soundings is the north end of the bridge. The current is very sluggish at the bridge during low water, and during this stage discharge measurements are made at wading sections, some distance above or below the bridge.

During 1911, the gauge was read daily by G. S. Caspell, who lives about 1,200 feet north of the bridge.

DISCHARGE MEASUREMENTS of Mosquito Creek near Nanton, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| Apr. 19 | J. E. Degnan | 15.0 | 10.03 | 0.591 | 2.78 | 5.93 |
| May 8 | do | 14.0 | 3.81 | 0.755 | 2.38 | 2.88 |
| June 1 | A. W. P. Lowrie | 14.8 | 6.94 | 1.03 | 2.61 | 7.18 |
| June 19 | do | 13.6 | 3.10 | 0.38 | 2.30 | 1.17 |
| July 8 | do | 14.0 | 4.59 | 0.76 | 2.45 | 3.48 |
| July 25 | do | 10.7 | 2.20 | 0.69 | 2.34 | 1.52 |
| Aug. 14 | do | 25.3 | 21.81 | 0.52 | 2.66 | 11.30 |
| Aug. 30 | do | 24.3 | 17.70 | 0.34 | 2.56 | 5.97 |
| Sept. 27 | do | 25.4 | 21.69 | 0.58 | 2.71 | 12.65 |
| Oct. 24 | N. M. Sutherland | 24.3 | 19.26 | 0.50 | 2.64 | 9.66 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Mosquito Creek near Nanton, Alta., for 1911.

| DAY. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | 2.23 | 0.4 | 2.35 | 1.8 | 2.46 | 3.9 | 2.71 | 14.0 |
| 2 | 2.23 | 0.4 | 2.32 | 1.3 | 2.46 | 3.9 | 2.65 | 10.0 |
| 3 | 2.23 | 0.4 | 2.30 | 1.0 | 2.46 | 3.9 | 2.50 | 4.7 |
| 4 | 2.33 | 0.4 | 2.30 | 1.0 | 2.46 | 3.9 | 2.45 | 3.6 |
| 5 | 2.23 | 0.4 | 2.30 | 1.0 | 2.46 | 3.9 | 2.45 | 3.6 |
| 6 | 2.23 | 0.4 | 2.25 | 0.6 | 2.45 | 3.6 | 2.45 | 3.6 |
| 7 | 2.23 | 0.4 | 2.25 | 0.6 | 2.43 | 3.2 | 2.39 | 2.4 |
| 8 | 2.66 | 8.1 | 2.25 | 0.6 | 2.42 | 3.0 | 2.34 | 1.6 |
| 9 | 2.76 | 17.0 | 2.24 | 0.5 | 2.42 | 3.0 | 2.37 | 2.1 |
| 10 | 2.85 | 26.0 | 2.24 | 0.5 | 2.34 | 1.6 | 2.39 | 2.4 |
| 11 | 2.85 | 26.0 | 2.24 | 0.5 | 2.26 | 0.7 | 2.46 | 3.9 |
| 12 | 2.75 | 16.0 | 2.24 | 0.5 | 2.20 | 0.2 | 2.44 | 3.4 |
| 13 | 2.65 | 10.0 | 3.06 | 57.0 | 2.34 | 1.6 | 2.43 | 3.2 |
| 14 | 2.65 | 10.0 | 3.02 | 50.0 | 2.36 | 2.0 | 2.42 | 3.0 |
| 15 | 2.70 | 13.0 | 2.54 | 5.9 | 2.36 | 2.0 | 2.42 | 3.0 |
| 16 | 2.60 | 7.8 | 2.54 | 5.9 | 2.34 | 1.6 | 2.41 | 2.8 |
| 17 | 2.57 | 6.9 | 2.75 | 16.5 | 2.34 | 1.6 | 2.42 | 3.0 |
| 18 | 2.62 | 8.8 | 2.59 | 7.5 | 2.15 | 0.2 | 2.35 | 1.8 |
| 19 | 2.57 | 6.9 | 2.52 | 5.3 | 2.14 | 0.1 | 2.44 | 3.4 |
| 20 | 2.57 | 6.9 | 2.46 | 3.9 | 2.12 | 0.1 | 2.42 | 3.0 |
| 21 | 2.54 | 5.9 | 2.47 | 4.1 | 2.10 | 0.1 | 2.38 | 2.3 |
| 22 | 2.54 | 5.9 | 2.49 | 4.5 | 2.15 | 0.2 | 2.35 | 1.8 |
| 23 | 2.50 | 4.7 | 2.67 | 11.4 | 2.33 | 1.5 | 2.30 | 1.0 |
| 24 | 2.50 | 4.7 | 2.70 | 13.0 | 2.30 | 1.0 | 2.25 | 0.6 |
| 25 | 2.48 | 4.3 | 2.70 | 13.0 | 2.32 | 1.3 | 2.22 | 0.4 |
| 26 | 2.47 | 4.1 | 2.52 | 5.3 | 2.35 | 1.8 | 2.20 | 0.2 |
| 27 | 2.51 | 5.0 | 2.57 | 6.9 | 2.40 | 2.6 | 2.17 | 0.2 |
| 28 | 2.51 | 5.0 | 2.60 | 7.8 | 2.42 | 3.0 | 2.14 | 0.2 |
| 29 | 2.46 | 3.9 | 2.62 | 8.8 | 2.46 | 3.9 | 2.11 | 0.1 |
| 30 | 2.44 | 3.4 | 2.64 | 9.9 | 3.05 | 5.5 | 2.15 | 0.2 |
| 31 | ...... | ...... | 2.60 | 7.8 | ...... | ...... | 2.21 | 0.3 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Mosquito Creek near Nanton, Alta., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* |
| 1 | 2.25 | 0.6 | 2.35 | 1.8 | 2.50 | 4.7 | 2.50 | 4.7 |
| 2 | 2.28 | 0.8 | 2.34 | 1.6 | 2.56 | 6.6 | 2.52 | 5.3 |
| 3 | 2.27 | 0.8 | 2.39 | 2.4 | 2.58 | 7.2 | 2.53 | 5.6 |
| 4 | 2.25 | 0.6 | 2.49 | 4.5 | 2.60 | 7.8 | 2.53 | 5.6 |
| 5 | 2.30 | 1.0 | 2.68 | 12.0 | 2.61 | 8.3 | 2.54 | 5.9 |
| 6 | 2.70 | 13.0 | 2.81 | 21.0 | 2.57 | 6.9 | 2.55 | 6.2 |
| 7 | 2.80 | 20.0 | 2.76 | 17.0 | 2.55 | 6.2 | 2.60 | 7.8 |
| 8 | 2.85 | 26.0 | 2.79 | 19.0 | 2.55 | 6.2 | 2.66 | 10.9 |
| 9 | 2.91 | 32.5 | 2.68 | 12.0 | 2.54 | 5.9 | 2.69 | 12.5 |
| 10 | 2.90 | 31.0 | 2.59 | 7.5 | 2.54 | 5.9 | 2.66 | 10.9 |
| 11 | 2.87 | 28.0 | 2.55 | 6.2 | 2.53 | 5.6 | 2.64 | 9.9 |
| 12 | 2.84 | 24.0 | 2.51 | 5.0 | 2.52 | 5.3 | 2.64 | 9.9 |
| 13 | 2.74 | 16.0 | 2.48 | 4.3 | 2.51 | 5.0 | 2.64 | 9.9 |
| 14 | 2.61 | 8.3 | 2.46 | 3.9 | 2.50 | 4.7 | 2.64 | 9.9 |
| 15 | 2.57 | 6.9 | 2.44 | 3.4 | 2.50 | 4.7 | 2.64 | 9.9 |
| 16 | 2.55 | 6.2 | 2.42 | 3.0 | 2.45 | 3.6 | ... | ... |
| 17 | 2.53 | 5.6 | 2.47 | 4.1 | 2.45 | 3.6 | ... | ... |
| 18 | 2.52 | 5.3 | 2.47 | 4.1 | 2.46 | 3.9 | ... | ... |
| 19 | 2.51 | 5.0 | 2.47 | 4.1 | 2.45 | 3.6 | ... | ... |
| 20 | 2.49 | 4.5 | 2.50 | 4.7 | 2.46 | 3.9 | ... | ... |
| 21 | 2.48 | 4.3 | 2.50 | 4.7 | 2.46 | 3.9 | ... | ... |
| 22 | 2.47 | 4.1 | 2.50 | 4.7 | 2.46 | 3.9 | ... | ... |
| 23 | 2.46 | 3.9 | 2.55 | 6.2 | 2.47 | 4.1 | ... | ... |
| 24 | 2.45 | 3.6 | 2.57 | 6.9 | 2.51 | 5.0 | ... | ... |
| 25 | 2.40 | 2.6 | 2.55 | 6.2 | 2.54 | 5.9 | ... | ... |
| 26 | 2.42 | 3.0 | 2.55 | 6.2 | 2.38 | 2.3 | ... | ... |
| 27 | 2.44 | 3.4 | 2.55 | 6.2 | 2.44 | 3.4 | ... | ... |
| 28 | 2.46 | 3.9 | 2.55 | 6.2 | 2.46 | 3.9 | ... | ... |
| 29 | 2.43 | 3.2 | 2.53 | 5.6 | 2.48 | 4.3 | ... | ... |
| 30 | 2.40 | 2.6 | 2.50 | 4.7 | 2.50 | 4.7 | ... | ... |
| 31 | 2.45 | 3.6 | ... | ... | 2.50 | 4.7 | ... | ... |

MONTHLY DISCHARGE of Mosquito Creek near Nanton, Alta., for 1911.

(Drainage area, 183 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| April | 26.0 | 0.4 | 7.10 | .039 | .04 | 422 |
| May | 57.0 | 0.5 | 8.21 | .045 | .05 | 505 |
| June | 5.5 | 0.1 | 2.16 | .012 | .01 | 129 |
| July | 14.0 | 0.1 | 2.77 | .015 | .02 | 170 |
| August | 32.5 | 0.6 | 8.85 | .048 | .06 | 544 |
| September | 21.0 | 1.6 | 6.34 | .035 | .04 | 377 |
| October | 8.3 | 2.3 | 5.02 | .027 | .03 | 309 |
| November (1-15) | 12.5 | 4.7 | 8.33 | .046 | .03 | 239 |
| The period | ... | ... | ... | ... | ... | 2,695 |

## NANTON CREEK NEAR NANTON, ALTA.

This station was established August 3, 1908, by P. M. Sauder. It is located at George Topper's farm, near Nanton. It is on Sec. 20, Tp. 16, Rge. 28, W. 4th Mer., and almost directly west of Mr. Topper's stable.

The gauge, which is a plain staff graduated to feet and hundredths, is driven vertically into the bed of the stream, at the left bank. It is attached by braces to posts in the bank. The bench-mark is the top of a hub (wood stake with iron cap) on the right bank, about 75 feet south-east from the gauge; elevation 17.82 above the zero of the gauge.

This stream follows a very crooked course, but the channel is nearly straight for about 125 feet above and about 75 feet below the gauge. The banks are well defined but not high, and may overflow in excessive floods. They are composed of clay and covered with tough sod. The bed of the stream is composed of gravel, not liable to shift, and free from vegetation.

Discharge measurements are made by wading at or near the gauge. At flood stage, discharge measurements may be made at Mr. Topper's bridge, about 1,000 feet downstream from the gauge.

During 1911, the gauge was read by Mr. George Topper.

DISCHARGE MEASUREMENTS of Nanton Creek, near Nanton, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 19 | J. E. Degnan | 6.0 | 1.90 | 0.437 | 5.18 | 0.83 |
| May 8 | do | 3.8 | 1.85 | 0.383 | 5.13 | 0.71 |
| June 1 | A. W. P. Lowrie | 8.0 | 6.31 | 0.63 | 5.54 | 3.97 |
| June 19 | do | 7.4 | 3.48 | 0.33 | 5.18 | 1.13 |
| July 8 | do | 7.6 | 5.08 | 0.61 | 5.42 | 3.11 |
| July 25 | do | 7.6 | 4.26 | 0.46 | 5.24 | 1.98 |
| Aug. 14 | do | 7.5 | 7.66 | 1.12 | 5.91 | 8.60 |
| Aug. 30 | do | 7.0 | 6.50 | 0.88 | 5.73 | 5.71 |
| Sept. 27 | do | 7.4 | 8.36 | 1.02 | 5.85 | 8.49 |
| Oct. 24 | N. M. Sutherland | 7.0 | 7.97 | 0.90 | 5.77 | 7.16 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Nanton Creek near Nanton, Alta., for 1911.

| DAY. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5.05 | 0.30 | 5.00 | 0.05 | 5.50 | 3.50 | 5.70 | 5.90 |
| 2 | 5.20 | 1.10 | 5.00 | 0.05 | 5.40 | 2.55 | 5.90 | 8.75 |
| 3 | 5.20 | 1.10 | 5.00 | 0.05 | 5.43 | 2.84 | 5.55 | 4.08 |
| 4 | 5.15 | 0.82 | 5.00 | 0.05 | 5.30 | 1.75 | 5.45 | 3.02 |
| 5 | 5.10 | 0.55 | 5.00 | 0.05 | 5.30 | 1.75 | 5.45 | 3.02 |
| 6 | 5.02 | 0.15 | 5.00 | 0.05 | 5.30 | 1.75 | 5.40 | 2.55 |
| 7 | 5.02 | 0.15 | 5.00 | 0.05 | 5.30 | 1.75 | 5.35 | 2.15 |
| 8 | 5.02 | 0.15 | 5.00 | 0.05 | 5.25 | 1.42 | 5.25 | 1.42 |
| 9 | 5.20 | 1.10 | 5.00 | 0.05 | 5.25 | 1.42 | 5.25 | 1.42 |
| 10 | 5.30 | 1.75 | 5.00 | 0.05 | 5.25 | 1.42 | 5.25 | 1.42 |
| 11 | 5.40 | 2.55 | 5.00 | 0.05 | 5.20 | 1.10 | 5.25 | 1.42 |
| 12 | 5.30 | 1.75 | 5.00 | 0.05 | 5.20 | 1.10 | 5.25 | 1.42 |
| 13 | 5.03 | 0.20 | 5.05 | 0.30 | 5.30 | 1.75 | 5.25 | 1.42 |
| 14 | 5.05 | 0.30 | 5.75 | 6.60 | 5.40 | 2.55 | 5.25 | 1.42 |
| 15 | 5.05 | 0.30 | 5.45 | 3.02 | 5.40 | 2.55 | 5.20 | 1.10 |
| 16 | 5.09 | 0.50 | 6.05 | 10.9 | 5.30 | 1.75 | 5.20 | 1.10 |
| 17 | 5.09 | 0.50 | 5.40 | 2.55 | 5.20 | 1.10 | 5.20 | 1.10 |
| 18 | 5.09 | 0.50 | 5.30 | 1.75 | 5.05 | 0.30 | 5.20 | 1.10 |
| 19 | 5.10 | 0.55 | 5.20 | 1.10 | 5.05 | 0.30 | 5.20 | 1.10 |
| 20 | 5.09 | 0.50 | 5.15 | 0.82 | 5.05 | 0.30 | 5.30 | 1.75 |
| 21 | 5.09 | 0.50 | 5.05 | 0.30 | 5.10 | 0.55 | 5.30 | 1.75 |
| 22 | 5.10 | 0.55 | 5.05 | 0.30 | 5.15 | 0.82 | 5.25 | 1.42 |
| 23 | 5.09 | 0.50 | 5.40 | 2.55 | 5.20 | 1.10 | 5.25 | 1.42 |
| 24 | 5.08 | 0.45 | 5.60 | 4.65 | 5.20 | 1.10 | 5.25 | 1.42 |
| 25 | 5.10 | 0.55 | 5.70 | 5.90 | 5.55 | 4.08 | 5.28 | 1.62 |
| 26 | 5.09 | 0.50 | 5.80 | 7.30 | 5.40 | 2.55 | 5.25 | 1.42 |
| 27 | 5.00 | 0.05 | 5.84 | 7.88 | 5.35 | 2.15 | 5.30 | 1.75 |
| 28 | 5.05 | 0.30 | 5.88 | 8.46 | 5.98 | 9.91 | 5.30 | 1.75 |
| 29 | 5.06 | 0.35 | 5.85 | 8.02 | 6.55 | 18.3 | 5.30 | 1.75 |
| 30 | 5.03 | 0.20 | 5.65 | 5.27 | 5.85 | 8.02 | 5.30 | 1.75 |
| 31 | ... | | 5.60 | 4.65 | ..... | ..... | 5.30 | 1.75 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Nanton Creek near Nanton, Alta., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge. | Gauge Height | Dis-charge | Gauge Height | Dis-charge. | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5.32 | 1.91 | 5.69 | 5.78 | 5.75 | 6.60 | 6.06 | 11.1 |
| 2 | 5.33 | 1.99 | 5.68 | 5.65 | 6.93 | 24.00 | 6.06 | 11.1 |
| 3 | 5.35 | 2.15 | 5.73 | 6.32 | 6.05 | 10.9 | 5.98 | 9.91 |
| 4 | 5.35 | 2.15 | 6.65 | 19.8 | 5.95 | 9.47 | 5.95 | 9.47 |
| 5 | 5.60 | 4.65 | 6.60 | 19.0 | 5.83 | 7.74 | 5.95 | 9.47 |
| 6 | 5.95 | 9.47 | 6.55 | 18.3 | 5.83 | 7.74 | 5.95 | 9.47 |
| 7 | 6.90 | 23.3 | 6.35 | 15.3 | 5.80 | 7.30 | 5.65 | 5.27 |
| 8 | 7.50 | 32.5 | 6.05 | 10.9 | 5.75 | 6.60 | 5.67 | 5.52 |
| 9 | 6.65 | 19.8 | 5.95 | 9.47 | 5.75 | 6.60 | 5.67 | 5.52 |
| 10 | 6.30 | 14.6 | 5.93 | 9.18 | 5.75 | 6.60 | 5.67 | 5.52 |
| 11 | 6.15 | 12.4 | 5.86 | 8.17 | 5.75 | 6.60 | 5.67 | 5.52 |
| 12 | 6.05 | 10.9 | 5.83 | 7.74 | 5.75 | 6.60 | 5.69 | 5.78 |
| 13 | 6.00 | 10.2 | 5.80 | 7.30 | 5.75 | 6.60 | 5.69 | 5.78 |
| 14 | 5.94 | 9.33 | 5.75 | 6.60 | 5.75 | 6.60 | 5.69 | 5.78 |
| 15 | 5.90 | 8.75 | 5.74 | 6.46 | 5.71 | 6.04 | 5.69 | 5.78 |
| 16 | 6.00 | 10.2 | 5.73 | 6.32 | 5.71 | 6.04 | | |
| 17 | 5.90 | 8.75 | 5.91 | 8.89 | 5.71 | 6.04 | | |
| 18 | 5.90 | 8.75 | 5.92 | 9.04 | 5.72 | 6.18 | | |
| 19 | 5.85 | 8.02 | 5.82 | 7.59 | 5.72 | 6.18 | | |
| 20 | 5.85 | 8.02 | 5.80 | 7.30 | 5.72 | 6.18 | | |
| 21 | 6.00 | 10.2 | 5.84 | 7.88 | 5.73 | 6.32 | | |
| 22 | 5.95 | 9.47 | 5.88 | 8.46 | 5.73 | 6.32 | | |
| 23 | 5.85 | 8.02 | 5.91 | 8.89 | 5.73 | 6.32 | | |
| 24 | 5.83 | 7.74 | 5.95 | 9.47 | 5.75 | 6.60 | | |
| 25 | 5.85 | 8.02 | 5.95 | 9.47 | 5.62 | 4.90 | | |
| 26 | 6.20 | 13.1 | 5.93 | 9.18 | 5.85 | 8.02 | | |
| 27 | 5.90 | 8.75 | 5.85 | 8.02 | 6.02 | 10.5 | | |
| 28 | 5.87 | 8.32 | 5.82 | 7.59 | 6.02 | 10.5 | | |
| 29 | 5.75 | 6.60 | 5.78 | 7.02 | 6.10 | 11.7 | | |
| 30 | 5.70 | 5.90 | 5.75 | 6.60 | 6.10 | 11.7 | | |
| 31 | 5.65 | 5.27 | | | 6.10 | 11.7 | | |

MONTHLY DISCHARGE of Nanton Creek near Nanton, Alta., for 1911.

(Drainage area, 44 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| April | 2.55 | 0.20 | 0.627 | 0.014 | 0.02 | 37 |
| May | 10.90 | 0.05 | 2.67 | 0.061 | 0.07 | 164 |
| June | 18.30 | 0.30 | 2.71 | 0.062 | 0.07 | 161 |
| July | 8.75 | 1.10 | 2.08 | 0.047 | 0.05 | 128 |
| August | 32.50 | 1.91 | 9.65 | 0.219 | 0.25 | 593 |
| September | 19.80 | 5.65 | 5.92 | 0.134 | 0.15 | 352 |
| October | 24.00 | 4.90 | 8.10 | 0.184 | 0.21 | 498 |
| November (1-15) | 11.10 | 5.52 | 7.40 | 0.168 | 0.10 | 220 |
| The period | | | | | | |

MISCELLANEOUS DISCHARGE MEASUREMENTS in Little Bow River drainage basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Ft. per Sec.* | *Sec. Feet.* |
| June 28 | J. C. Milligan | Mosquito Creek | N.E. 8-16-1-5 | x | | | 0.78 |
| do | do | Snake Creek | N.E. 17-16-1-5 | x | | | 0.454 |

x Weir measurement.

## OLDMAN RIVER DRAINAGE BASIN

*General Description.*

Oldman river, one of the principal tributaries of the South Saskatchewan River, is formed in the Livingstone range of the Rocky mountains by the junction of four small rivers, viz., Livingstone, Northwest Branch, West Branch and Racehorse Creek, and flows in a southeasterly direction to near Cowley, where it is joined by the Crowsnest and Southfork rivers. Between Cowley and Kipp, where it empties into the Belly River, the Oldman river is augmented by numerous small rivers and creeks, its course being easterly and northerly. It drains the area bounded on the north by the parallel of latitude through 50° 20', on the south by the parallel through 49° 20', and on the west by the Great Divide, this area being estimated to contain about 2, 235 square miles, with topography varying from mountainous to rolling prairie.

The bed of the river is of rock and gravel, and has a large fall with consequent swift water, interspersed with falls and rapids, but it changes to quicksand and mud after reaching the prairie region where the current is more sluggish.

The flow of this river, draining as it does mountain ranges with peaks extending above the snow line, is subject to great changes, caused by melting snow and heavy summer rains in the mountains. Floods occur regularly in both May and June, the one in June generally rising higher and lasting longer. From this time on, however, the flow is normally steady, but gradually decreases until the minimum is reached during January and February.

The precipitation throughout the basin, consequently, is quite large. Though almost entirely under cultivation, where practicable, this area has little need of irrigation. Owing to the depth of the valley and its steep rocky banks irrigation from this river would be enormously expensive, if not altogether impossible, but there are many excellent power-sites at its falls and rapids. Up to the present, no power has been developed on this river, but investigations with that end in view are being made.

DISCHARGE MEASUREMENTS of Burton Ditch, at N.W. 36-11-1-5, (Alta.), in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| Oct. 13 | J. C. Milligan | .... | .... | .... | 0'-1¼" | 0.0689* |
| Oct. 13 | do | .... | .... | .... | 0'-2¾" | 0.224 * |
| Oct. 13 | do | .... | .... | .... | 0'-3 " | 0.2714* |
| Oct. 13 | do | .... | .... | .... | 0'-3¼" | 0.3226* |

* Weir measurement.

DISCHARGE MEASUREMENTS of Burton Ditch River at S.W. 1-12-1-5(Alta.), in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| Oct. 13 | J. C. Milligan | .... | .... | .... | 0'-1" | 0.033* |
| Oct. 13 | do | .... | .... | .... | 0'-2½" | 0.260* |
| Oct. 13 | do | .... | .... | .... | 0'-3½" | 0.414* |
| Oct. 13 | do | .... | .... | .... | 0'-3¾" | 0.530* |

* Weir measurement.

### TROUT CREEK AT STEVENSON'S FARM.

This station was established May 14, 1909, by H. C. Ritchie. It is located at the traffic bridge on the road allowance east of the S.E. ¼ Sec. 12, Tp. 12, Rge. 28, W. 4th Mer., and is about seven miles southwest of Claresholm.

The gauge, which is a plain staff graduated to feet and hundredths, is fastened to the left abutment of the bridge. It is referred to a bench-mark on top of the outer, downstream pile of the same abutment. (elevation, 7.99 feet above the zero of the gauge).

PLATE No. 16.


Looking East into "The Gap" on Oldman River. Taken by F. H. Peters.

PLATE No. 17.

Dam Site on Oldman River near "The Gap", looking down stream. Taken by F. H. Peters.

The channel is straight for sixty feet above and fifty feet below the station. Both banks are low, wooded, and liable to overflow during high water. The bed of the stream is sand and gravel. The current is fairly swift.

Discharge measurements are made from the bridge during high water, the initial point for soundings being on line with the inner face of the left abutment. During low water the stream is waded at the same section.

During 1911, the gauge was read by Mr. John Stevenson.

DISCHARGE MEASUREMENTS of Trout Creek at Stevenson's Farm, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 18 | J. E. Degnan | 28.2 | 15.75 | 0.698 | 0.95 | 11.02 |
| May 5 | do | 28.2 | 12.78 | 0.611 | 0.83 | 7.81 |
| May 31 | A. W. P. Lowrie | .... | 31.02 | 1.72 | 1.50 | 53.42 |
| June 17 | do | 28.5 | 21.39 | 1.14 | 1.20 | 24.50 |
| July 7 | do | 28.4 | 19.71 | 0.92 | 1.13 | 18.27 |
| Sept. 23 | do | 28.3 | 45.97 | 2.01 | 1.98 | 92.21 |
| Oct. 20 | N. M. Sutherland | 28.5 | 32.19 | 1.48 | 1.48 | 47.64 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Trout Creek at Stevenson's Farm, Alta., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis. charge. | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | *1.02 | 14.8 | * .82 | 6.2 | *1.57 | 55.3 |
| 2 | ..... | ..... | *1.05 | 16.7 | .80 | 5.2 | 1.60 | 57.8 |
| 3 | ..... | ..... | *1.08 | 18.6 | * .83 | 6.2 | 1.55 | 53.7 |
| 4 | ..... | ..... | 1.10 | 19.2 | .85 | 6.9 | *1.55 | 53.7 |
| 5 | ..... | ..... | *1.05 | 16.7 | * .85 | 6.9 | 1.55 | 53.7 |
| 6 | ..... | ..... | 1.00 | 13.6 | .85 | 6.9 | 1.52 | 51.2 |
| 7 | ..... | ..... | * .95 | 11.1 | * .85 | 6.9 | 1.50 | 49.6 |
| 8 | ..... | ..... | .90 | 8.6 | * .85 | 6.9 | *1.47 | 47.1 |
| 9 | ..... | ..... | * .95 | 11.1 | .85 | 6.9 | 1.44 | 44.7 |
| 10 | ..... | ..... | 1.00 | 13.6 | .85 | 6.9 | 1.40 | 41.4 |
| 11 | ..... | ..... | *1.00 | 13.6 | * .85 | 6.9 | *1.37 | 39.1 |
| 12 | ..... | ..... | 1.00 | 13.6 | .85 | 6.9 | 1.35 | 37.5 |
| 13 | ..... | ..... | * .96 | 11.6 | 1.05 | 6.7 | *1.33 | 35.9 |
| 14 | ..... | ..... | * .93 | 10.1 | 1.18 | 25.1 | 1.30 | 33.6 |
| 15 | ..... | ..... | .90 | 8.6 | *1.40 | 41.4 | *1.26 | 30.7 |
| 16 | ..... | ..... | * .92 | 9.6 | 1.63 | 60.4 | *1.23 | 28.6 |
| 17 | ..... | ..... | * .94 | 10.6 | 1.45 | 45.5 | 1.20 | 26.4 |
| 18 | ..... | ..... | .95 | 11.1 | *1.37 | 39.1 | *1.16 | 23.8 |
| 19 | ..... | ..... | * .97 | 12.1 | 1.30 | 33.6 | 1.12 | 21.1 |
| 20 | ..... | ..... | 1.00 | 13.6 | 1.28 | 32.2 | *1.12 | 21.1 |
| 21 | ..... | ..... | *1.02 | 14.8 | 1.22 | 27.8 | *1.11 | 20.5 |
| 22 | ..... | ..... | 1.04 | 16.1 | *1.26 | 30.7 | 1.11 | 20.5 |
| 23 | ..... | ..... | *1.01 | 14.2 | 1.31 | 34.4 | 1.11 | 20.5 |
| 24 | ..... | ..... | * .98 | 12.6 | 1.34 | 36.7 | 1.34 | 33.6 |
| 25 | ..... | ..... | .95 | 11.1 | 1.40 | 41.4 | 1.40 | 41.4 |
| 26 | ..... | ..... | .95 | 11.1 | *1.43 | 43.9 | 1.30 | 33.6 |
| 27 | 1.00 | 13.6 | * .94 | 10.6 | 1.45 | 45.5 | 1.20 | 26.4 |
| 28 | 1.00 | 13.6 | * .92 | 9.6 | *1.39 | 40.6 | 1.20 | 26.4 |
| 29 | *1.00 | 13.6 | .90 | 8.6 | 1.34 | 36.7 | *1.20 | 26.4 |
| 30 | *1.00 | 13.6 | * .86 | 7.2 | *1.43 | 43.9 | 1.21 | 27.1 |
| 31 | 1.00 | 13.6 | ..... | ..... | 1.53 | 52.1 | ..... | ..... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Trout Creek at Stevenson's Farm, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | *1.24 | 28.6 | 1.23 | 28.6 | 1.35 | 37.5 | *1.74 | 70.1 |
| 2 | 1.25 | 30.0 | 1.20 | 26.4 | 1.35 | 37.5 | *1.75 | 71.0 |
| 3 | 1.18 | 25.1 | 1.12 | 21.1 | *1.82 | 77.4 | 1.75 | 71.0 |
| 4 | 1.16 | 23.8 | 1.12 | 21.1 | 2.30 | 123. | *1.74 | 70.1 |
| 5 | 1.20 | 26.4 | 1.23 | 28.6 | 2.10 | 104 | *1.72 | 68.3 |
| 6 | *1.17 | 24.4 | *1.81 | 76.4 | 2.55 | 146 | 1.70 | 66.5 |
| 7 | 1.13 | 21.8 | 2.40 | 132 | 2.65 | 156 | *1.65 | 62.1 |
| 8 | *1.12 | 21.1 | *2.40 | 132 | 2.50 | 142. | 1.60 | 57.8 |
| 9 | *1.11 | 20.5 | 2.40 | 132 | 2.60 | 151. | *1.60 | 57.8 |
| 10 | 1.11 | 20.5 | 2.30 | 123. | *2.65 | 156. | *1.60 | 57.8 |
| 11 | 1.13 | 21.8 | *2.25 | 118 | 2.70 | 161. | *1.60 | 57.8 |
| 12 | 1.13 | 21.8 | 2.20 | 113 | 2.60 | 151 | *1.60 | 57.8 |
| 13 | 1.11 | 20.5 | *2.14 | 107 | *2.50 | 142. | 1.60 | 57.8 |
| 14 | *1.09 | 19.2 | 2.09 | 103 | 2.40 | 132. | *1.57 | 55.3 |
| 15 | 1.07 | 17.9 | 2.12 | 106 | *2.36 | 128. | 1.55 | 53.7 |
| 16 | *1.07 | 17.9 | *2.04 | 97.9 | *2.32 | 124 | *1.53 | 52.1 |
| 17 | 1.07 | 17.9 | *1.97 | 91.3 | *2.28 | 121. | 1.50 | 49.6 |
| 18 | *1.06 | 17.3 | 1.90 | 84.8 | *2.24 | 117. | *1.49 | 48.8 |
| 19 | 1.05 | 16.7 | 1.70 | 66.5 | 2.20 | 113. | *1.48 | 48.0 |
| 20 | *1.04 | 16.1 | *1.66 | 63.0 | *2.15 | 108 | 1.47 | 47.1 |
| 21 | *1.03 | 15.5 | *1.63 | 60.4 | *2.10 | 104 | *1.48 | 48.0 |
| 22 | 1.02 | 14.8 | 1.60 | 57.8 | *2.05 | 98.8 | 1.50 | 49.6 |
| 23 | *1.02 | 14.8 | *1.57 | 55.3 | 2.00 | 94.1 | 1.46 | 46.3 |
| 24 | 1.03 | 15.5 | 1.53 | 52.1 | *2.00 | 94.1 | *1.43 | 43.9 |
| 25 | *1.02 | 14.8 | *1.56 | 54.5 | 2.00 | 94.1 | *1.40 | 41.4 |
| 26 | 1.01 | 14.2 | 1.59 | 57.0 | *1.95 | 89.4 | 1.37 | 39.1 |
| 27 | 1.00 | 13.6 | *1.55 | 53.7 | 1.90 | 84.8 | *1.40 | 41.4 |
| 28 | 1.00 | 13.6 | 1.52 | 51.2 | 1.90 | 84.8 | *1.43 | 43.9 |
| 29 | *1.05 | 16.7 | *1.47 | 47.1 | *1.82 | 77.4 | *1.45 | 45.5 |
| 30 | 1.10 | 19.8 | *1.42 | 43.0 | 1.74 | 70.1 | 1.48 | 48.0 |
| 31 | 1.10 | 19.8 | 1.37 | 39.1 | ........ | ........ | 1.38 | 39.8 |

* No observation. Gauge-height interpolated.

MONTHLY DISCHARGE of Trout Creek at Stevenson's Farm, Alta., for 1911.

(Drainage area, 168 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| March | 13.6 | 13.6 | 13.6 | .081 | .02 | 135 |
| April | 19.2 | 7.2 | 12.5 | .074 | .08 | 744 |
| May | 60.4 | 5.2 | 25.7 | .153 | .17 | 1,580 |
| June | 57.8 | 20.5 | 36.1 | .215 | .24 | 2,148 |
| July | 30.0 | 13.6 | 19.4 | .116 | .13 | 1,193 |
| August | 132.0 | 21.1 | 72.4 | .431 | .50 | 4,452 |
| September | 161.0 | 37.5 | 111.0 | .661 | .74 | 6,605 |
| October | 71.0 | 39.1 | 53.8 | .320 | .37 | 3,308 |
| The period | | | | | | 20,165 |

## Trout Creek at Lockwood's Ranche.

This station was established on July 7, 1911, by A. W. P. Lowrie. It is located on Sec. 33, Tp. 11, Rge. 28, W. 4th Mer., and is about 180 feet from Mr. Lockwood's house.

The gauge, which is a plain staff graduated to feet and hundredths, is fastened to the stump of a tree on the right bank. The zero of the gauge (elev., 90.30) is referred to a notch in a tree about seventy feet downstream (assumed elev., 100.00).

The channel is straight for eighty feet above and seventy feet below the gauge. The right bank is wooded and may overflow during high water. The left bank is wooded and low. The bed of the channel is stony, and not liable to shift.

Discharge measurements are made by wading about twenty feet upstream from the gauge. The initial point for soundings is a post on the left bank.

The gauge was read by Mr. Barr, who lives on Mr. Lockwood's ranche. Tables of daily and monthly discharge for 1911 have not yet been computed. These will be finished during 1912 and published with the records for that year.

Discharge Measurements of Trout Creek at Lockwood's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 24 | A. W. P. Lowrie | 29 20 | 24 98 | 0 64 | 3 45 | 16 10 |
| Aug. 12 | do | 41 90 | 51 70 | 2 24 | 4 65 | 115 81 |
| Aug 29 | do | 30 30 | 37 39 | 1 04 | 3 90 | 39 09 |
| Sept 25 | do | 41 0 | 44 26 | 2 03 | 4 45 | 89 98* |
| Oct. 20 | N. M. Sutherland | 28 0 | 39 92 | 1 14 | 4 00 | 45 50 |

* Gauged 600 ft. below regular station.

## Muddypound Creek at Hart's Ranche.

This gauging station, located on the S.W. 1/4 Sec. 27, Tp. 11, Rge. 28, W. 4th Mer., at the foot-bridge on L. O. Hart's ranche, was established July 27, 1908, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed at the left bank fifteen feet upstream from the bridge. It is referred to a bench-mark on an iron iron pin near a post 35 feet northeast of the gauge; elevation 8.94.

The channel is straight for 30 feet above and 110 feet below the station. Both banks are high, clayey, and liable to overflow in extreme floods. The bed is of clean gravel. The current is fairly swift.

Discharge measurements are made from the bridge in high water, the initial point for soundings being marked at the left end of the bridge. In low stages the creek is waded about 100 feet upstream.

During 1911, the gauge was read by Mrs. M. E. Hart.

Discharge Measurements of Muddypound Creek at Hart's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 6 | J. E. Degnan | 13 80 | 10 00 | 0 359 | 2 18 | 3 59 |
| May 18 | do | 14 0 | 10 41 | 0 415 | 2 20 | 4 32 |
| May 30 | A. W. P. Lowrie | 13 30 | 11 48 | 0.58 | 2 29 | 6 70 |
| June 17 | do | 13 90 | 9 53 | 0 32 | 2 15 | 3 08 |
| July 7 | do | 7 00 | 1 99 | 0 79 | 2 13 | 1 58* |
| July 24 | do | 6 40 | 1 51 | 1 01 | 2 10 | 1 53 |
| Aug. 12 | do | 14 00 | 14 33 | 0.97 | 2 55 | 13 92 |
| Aug. 29 | do | 13 80 | 11 30 | 0 70 | 2 32 | 7 86 |
| Sept. 25 | *do | 14 00 | 17 44 | 1 31 | 2 81 | 22 80 |
| Oct. 20 | N. M. Sutherland | 14 00 | 13 6 | 0.84 | 2 44 | 11 38 |

* 25 yards above gauge rod.

DAILY GAUGE-HEIGHT AND DISCHARGE of Muddypound Creek at Hart's Ranche, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | ...... | ...... | 2 30 | 7 20 | 2 13 | 2.35 | 2.15 | 2.89 |
| 2 | ...... | ...... | 2 30 | 7 20 | 2 13 | 2.35 | 2.15 | 2.89 |
| 3 | ...... | ...... | 2 20 | 4 25 | 2 12 | 2.07 | 2.16 | 3.16 |
| 4 | ...... | ...... | 2 20 | 4.25 | 2.10 | 1.53 | 2.16 | 3.16 |
| 5 | ...... | ...... | 2 20 | 4 25 | 2.10 | 1.53 | 2 15 | 2.89 |
| 6 | ...... | ...... | 2.20 | 4.25 | 2 10 | 1.53 | 2.15 | 2 89 |
| 7 | ...... | ...... | 2.10 | 1.53 | 2.08 | 1.32 | 2.15 | 2.89 |
| 8 | ...... | ...... | 2 10 | 1.53 | 2.05 | 1.02 | 2.15 | 2.89 |
| 9 | ...... | ...... | 2.10 | 1 53 | 2 05 | 1.02 | 2.15 | 2.89 |
| 10 | ...... | ...... | 2 10 | 1.53 | 2 05 | 1 02 | 2.15 | 2.89 |
| 11 | ...... | ...... | 2 10 | 1.53 | 2.05 | 1.02 | 2 12 | 2.07 |
| 12 | ...... | ...... | 2.10 | 1.53 | 2 05 | 1.02 | 2.12 | 2.07 |
| 13 | ...... | ...... | 2 10 | 1.53 | 2.20 | 4.25 | 2 10 | 1.53 |
| 14 | ...... | ...... | 2 10 | 1.53 | 2.30 | 7.20 | 2.10 | 1.53 |
| 15 | ...... | ...... | 2.10 | 1.53 | 2.50 | 13 20 | 2.06 | 1.12 |
| 16 | ...... | ...... | 2 10 | 1.53 | 3 00 | 28.90 | 2.05 | 1.02 |
| 17 | ...... | ...... | 2 10 | 1.53 | 2.65 | 17 70 | 2 07 | 1 22 |
| 18 | ...... | ...... | 2 12 | 2 07 | 2.30 | 7 20 | 2 07 | 1 22 |
| 19 | ...... | ...... | 2 12 | 2 07 | 2.25 | 5.72 | 2.06 | 1.12 |
| 20 | 2 55 | 14 70 | 2.13 | 2.35 | 2.25 | 5.72 | 2.06 | 1.12 |
| 21 | 2 55 | 14 70 | 2.13 | 2.35 | 2.20 | 4.25 | 2.05 | 1 02 |
| 22 | 2.30 | 7.20 | 2.13 | 2.35 | 2.15 | 2.89 | 2.05 | 1.02 |
| 23 | 2.30 | 7 20 | 2.15 | 2.89 | 2.12 | 2.07 | 2.20 | 1.02 |
| 24 | 2.30 | 7 20 | 2.15 | 2.89 | 2.30 | 7.20 | 2 25 | 5.72 |
| 25 | 2 30 | 7.20 | 2.20 | 4 25 | 2.30 | 7 20 | 2.25 | 5.72 |
| 26 | 2 30 | 7 20 | 2.30 | 7 20 | 2 30 | 7 20 | 2.06 | 1.02 |
| 27 | 2.30 | 7 20 | 2.30 | 7 20 | 2 27 | 6 31 | 2.06 | 1.02 |
| 28 | 2 25 | 5.72 | 2.20 | 4.25 | 2.25 | 5.72 | 2.08 | 1.32 |
| 29 | 2 25 | 5.72 | 2.15 | 2 89 | 2 25 | 5.72 | 2 20 | 4 25 |
| 30 | 2.25 | 5 72 | 2 14 | 2 62 | 2 21 | 4 54 | 2.17 | 3 43 |
| 31 | 2 30 | 7.20 | ...... | ...... | 2.15 | 2 89 | ...... | ...... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Muddypound Creek at Hart's Ranche, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis charge |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.20 | 4.25 | 1.99 | 0.48 | 2.24 | 5.43 | 2.50 | 13.20 | 2.31 | 7.50 |
| 2 | 2.09 | 1.43 | 2.04 | 0.91 | 2.24 | 5.43 | 2.52 | 13.80 | 2.31 | 7.50 |
| 3 | 2.08 | 1.32 | 2.00 | 0.50 | 2.23 | 5.14 | 2.50 | 13.20 | 2.30 | 7.20 |
| 4 | 2.08 | 1.32 | 1.99 | 0.48 | 2.23 | 5.14 | 2.50 | 13.20 | 2.30 | 7.20 |
| 5 | 2.06 | 1.12 | 1.96 | 0.40 | *3.65 | 50.35 | 2.50 | 13.20 | 2.28 | 6.61 |
| 6 | 2.05 | 1.02 | 2.05 | 1.02 | 2.85 | 24.00 | 2.49 | 12.90 | 2.28 | 6.61 |
| 7 | 2.05 | 1.02 | 2.64 | 17.4 | *3.22 | 36.16 | 2.46 | 12.00 | 2.28 | 6.61 |
| 8 | 2.05 | 1.02 | 2.70 | 19.2 | 3.20 | 35.50 | 2.45 | 11.70 | 2.27 | 6.31 |
| 9 | 2.04 | 0.91 | 2.55 | 14.7 | 3.00 | 28.90 | 2.45 | 11.70 | 2.27 | 6.31 |
| 10 | 2.04 | 0.91 | 2.53 | 14.1 | 3.00 | 28.90 | 2.44 | 11.40 | 2.27 | 6.31 |
| 11 | 2.03 | 0.81 | 2.52 | 13.8 | 3.00 | 28.90 | 2.44 | 11.40 | 2.27 | 6.31 |
| 12 | 2.02 | 0.71 | 2.50 | 13.2 | 3.00 | 28.90 | 2.42 | 10.80 | | |
| 13 | 2.00 | 0.50 | 2.50 | 13.2 | 3.00 | 28.90 | 2.40 | 10.20 | | |
| 14 | 2.00 | 0.50 | 2.50 | 13.2 | 3.00 | 28.90 | 2.40 | 10.20 | | |
| 15 | 2.00 | 0.50 | 2.50 | 13.2 | 2.98 | 28.24 | 2.40 | 10.20 | | |
| 16 | 1.98 | 0.45 | 2.50 | 13.2 | 2.95 | 27.20 | 2.40 | 10.20 | | |
| 17 | 1.98 | 0.45 | 2.50 | 13.2 | 2.92 | 26.26 | 2.40 | 10.20 | | |
| 18 | 1.98 | 0.45 | 2.50 | 13.2 | 2.90 | 25.60 | 2.39 | 9.90 | | |
| 19 | 1.98 | 0.45 | 2.40 | 10.2 | 2.87 | 24.64 | 2.39 | 9.90 | | |
| 20 | 1.98 | 0.45 | 2.40 | 10.2 | 2.85 | 24.00 | 2.38 | 9.60 | | |
| 21 | 1.98 | 0.45 | 2.40 | 10.2 | 2.85 | 24.00 | 2.36 | 9.00 | | |
| 22 | 1.98 | 0.45 | 2.35 | 8.70 | 2.85 | 24.00 | 2.36 | 9.00 | | |
| 23 | 2.00 | 0.50 | 2.35 | 8.70 | 2.80 | 22.40 | 2.35 | 8.70 | | |
| 24 | 1.98 | 0.45 | 2.30 | 7.20 | 2.78 | 21.76 | 2.35 | 8.70 | | |
| 25 | 1.97 | 0.42 | 2.30 | 7.20 | 2.76 | 21.12 | 2.34 | 8.40 | | |
| 26 | 1.97 | 0.42 | 2.30 | 7.20 | 2.73 | 20.16 | 2.34 | 8.40 | | |
| 27 | 1.97 | 0.42 | 2.28 | 6.61 | 2.71 | 19.52 | 2.33 | 8.10 | | |
| 28 | 1.97 | 0.42 | 2.28 | 6.61 | 2.70 | 19.20 | 2.33 | 8.10 | | |
| 29 | 1.96 | 0.40 | 2.25 | 5.72 | 2.65 | 17.70 | 2.33 | 8.10 | | |
| 30 | 1.97 | 0.42 | 2.24 | 5.43 | 2.60 | 16.20 | 2.32 | 7.80 | | |
| 31 | 1.97 | 0.42 | 2.24 | 5.43 | ... | .... | 2.32 | 7.80 | | ... |

* Heavy rain.

MONTHLY DISCHARGE of Muddypound Creek at Hart's Ranche, Alta., for 1911.

(Drainage area, 43 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| March (20-21) | 14.7 | 5.72 | 8.08 | 0.19 | 0.08 | 192.0 |
| April | 7.2 | 1.53 | 3.12 | 0.73 | 0.81 | 185.6 |
| May | 28.9 | 1.02 | 5.28 | 0.12 | 0.14 | 325.0 |
| June | 5.72 | 1.02 | 2.30 | 0.053 | 0.59 | 137.0 |
| July | 4.25 | 0.40 | 0.79 | 0.018 | 0.21 | 49.0 |
| August | 19.2 | 0.40 | 8.86 | 0.206 | 0.24 | 545.0 |
| September | 50.35 | 5.14 | 24.4 | 0.567 | 0.63 | 1,452.0 |
| October | 13.8 | 7.8 | 10.4 | 0.242 | 0.28 | 640.0 |
| November (1-11) | 7.5 | 6.31 | 6.77 | 0.157 | 0.06 | 148.0 |
| The period | | | | | | 3673.6 |

## WILLOW CREEK NEAR MACLEOD.

This station was established July 1, 1909, by H. C. Ritchie. It is located at the traffic bridge on the S.W. 1/4 Sec. 25, Tp. 9, Rge. 26, W. 4th Mer.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed in a stilling box about 300 yards upstream from the bridge and near Mr. McLean's stable. It is referred to a bench-mark on a post 150 feet north of the gauge; elevation, 8.41.

The channel is straight for about 600 feet above and below the station. The right bank is high and wooded. The left bank is low, wooded, and liable to overflow in high-water stages. The bed of the stream is of clean gravel. The slope is uniform and the current swift.

Discharge measurements are made from the bridge during high stages, the initial point for soundings being marked on the downstream hand-rail on a line with the face of the north abutment. During low stages the river is waded at the same section and when very low, at the gauge.

During 1911, the gauge was read daily by Jas. R. McLean.

DISCHARGE MEASUREMENTS of Willow Creek near Macleod, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 13 | J. E. Degnan | 64.0 | 104.21 | 1.092 | 2.12 | 113.88 |
| May 2 | do | 61.0 | 96.30 | 1.067 | 2.05 | 102.77 |
| May 26 | A. W. P. Lowrie | 98.5 | 166.45 | 1.900 | 2.70 | 314.77 |
| June 12 | do | 80.6 | 134.21 | 1.550 | 2.45 | 209.05 |
| July 4 | do | 75.8 | 121.92 | 1.230 | 2.30 | 150.59 |
| July 20 | do | 55.0 | 78.75 | 0.800 | 1.89 | 63.39 |
| Aug. 5 | do | 68.0 | 100.9 | 1.180 | 2.11 | 119.53 |
| Aug. 28 | do | 98.6 | 149.59 | 1.630 | 2.40 | 243.21 |
| Sept. 19 | do | 105.2 | 221.10 | 2.220 | 3.06 | 490.67 |
| Oct. 19 | N. M. Sutherland | 76.0 | 116.9 | 1.440 | 2.34 | 168.65 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Willow Creek near Macleod, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.70 | 48.0 | 1.95 | 81.0 | 3.00 | 460 |
| 2 | | | 1.60 | 37.0 | 1.87 | 69.1 | 2.95 | 434 |
| 3 | | | 1.55 | 33.5 | 1.85 | 66.5 | 2.95 | 434 |
| 4 | | | 1.65 | 42.5 | 1.83 | 63.9 | 2.85 | 385 |
| 5 | | | 1.70 | 48.6 | 1.84 | 65.2 | 2.75 | 338 |
| 6 | | | 1.65 | 42.5 | 1.83 | 63.9 | 2.66 | 297 |
| 7 | | | 1.60 | 37.0 | 1.84 | 65.2 | 2.60 | 269 |
| 8 | | | 1.90 | 73.0 | 1.87 | 69.1 | 2.53 | 246 |
| 9 | | | 1.97 | 84.2 | 1.90 | 73.1 | 2.50 | 228 |
| 10 | | | 2.01 | 90.9 | 1.87 | 69.1 | 2.45 | 209 |
| 11 | | | 2.00 | 89.5 | 1.85 | 66.5 | 2.38 | 184 |
| 12 | | | 2.10 | 108.0 | 1.84 | 65.2 | 2.30 | 158 |
| 13 | | | 1.96 | 82.6 | 1.92 | 76.2 | 2.28 | 153 |
| 14 | | | 1.90 | 73.0 | 2.00 | 89.0 | 2.40 | 190 |
| 15 | | | 1.86 | 67.8 | 2.20 | 131.0 | 2.25 | 144 |
| 16 | | | 1.86 | 67.8 | 2.24 | 142.0 | 2.22 | 136 |
| 17 | | | 1.85 | 66.5 | 3.10 | 513.0 | 2.20 | 131 |
| 18 | | | 1.84 | 65.2 | 3.70 | 881.0 | 2.13 | 115 |
| 19 | | | 1.87 | 69.1 | 2.90 | 409.0 | 2.08 | 104 |
| 20 | | | 1.85 | 66.5 | 2.90 | 409.0 | 2.04 | 96.6 |
| 21 | | | 1.82 | 62.6 | 2.70 | 315.0 | 2.04 | 96.6 |
| 22 | 2.65 | 292 | 1.96 | 82.6 | 2.50 | 228.0 | 2.02 | 92.8 |
| 23 | 2.65 | 292 | 2.01 | 90.9 | 2.55 | 248.0 | 2.02 | 92.8 |
| 24 | 2.60 | 269 | 2.05 | 98.5 | 2.56 | 253.0 | 2.20 | 131 |
| 25 | 2.55 | 248 | 2.07 | 102.3 | 2.58 | 261.0 | 2.20 | 131 |
| 26 | 2.40 | 190 | 2.10 | 108.0 | 2.58 | 261.0 | 2.25 | 144 |
| 27 | 2.40 | 190 | 2.17 | 124.0 | 2.55 | 248.0 | 2.25 | 144 |
| 28 | 2.25 | 144 | 2.20 | 131.0 | 2.66 | 297.0 | 2.23 | 139 |
| 29 | 2.00 | 89.0 | 2.12 | 113.0 | 2.66 | 297.0 | 2.25 | 144 |
| 30 | 1.90 | 73.0 | 2.06 | 100.0 | 2.66 | 297.0 | 2.26 | 147 |
| 31 | 1.80 | 65.0 | ...... | ..... | 2.80 | 361.0 | ...... | ...... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Willow Creek near Macleod, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge. | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge | Gauge Height | Dis-chrage |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.25 | 144 | 1.70 | 48.0 | 2.16 | 122 | 2.56 | 253 | 1.95 | 81.0 |
| 2 | 2.25 | 144 | 1.75 | 54.0 | 2.15 | 120 | 2.53 | 240 | 1.96 | 82.6 |
| 3 | 2.23 | 139 | 1.85 | 66.5 | 2.12 | 113 | 2.50 | 228 | 2.04 | 96.6 |
| 4 | 2.20 | 131 | 1.90 | 73.0 | 2.35 | 174 | 2.50 | 228 | 2.05 | 98.5 |
| 5 | 2.15 | 120 | 1.96 | 82.6 | 4.60 | 148 | 2.45 | 209 | 2.20 | 131. |
| 6 | 2.10 | 108 | 2.25 | 144 | 4.50 | 1413 | 2.40 | 190 | 2.20 | 131. |
| 7 | 2.05 | 98.5 | 2.45 | 209 | 4.50 | 1413 | 2.35 | 174 | 2.23 | 139. |
| 8 | 1.95 | 81.0 | 3.10 | 513 | 4.15 | 1178 | 2.30 | 158 | 2.25 | 144 |
| 9 | 1.95 | 81.0 | 4.35 | 1312 | 4.05 | 1114 | 2.30 | 158 | 2.25 | 144. |
| 10 | 1.94 | 79.4 | 4.00 | 1078 | 3.92 | 1024 | 2.30 | 158 | 2.27 | 150. |
| 11 | 1.93 | 77.8 | 3.70 | 881 | 3.75 | 914 | 2.27 | 150 | 2.30 | 158. |
| 12 | 1.87 | 69.1 | 3.40 | 689 | 3.65 | 848 | 2.27 | 150 | 2.33 | 168. |
| 13 | 1.84 | 65.2 | 3.10 | 513 | 3.44 | 714 | 2.25 | 144 | 2.35 | 174 |
| 14 | 1.82 | 62.6 | 2.90 | 409 | 3.20 | 570 | 2.23 | 139 | 2.35 | 174 |
| 15 | 1.78 | 57.6 | 2.70 | 315 | 3.10 | 513 | 2.20 | 131 | 2.35 | 174 |
| 16 | 1.75 | 54.0 | 2.70 | 315 | 3.00 | 460 | 2.18 | 126 | | |
| 17 | 1.72 | 50.4 | 2.85 | 385 | 3.00 | 460 | 2.16 | 122 | | |
| 18 | 1.74 | 52.8 | 2.70 | 315 | 2.90 | 409 | 2.14 | 117 | | |
| 19 | 1.75 | 54.0 | 2.55 | 248 | 2.83 | 375 | 2.10 | 108 | | |
| 20 | 1.74 | 52.8 | 2.50 | 228 | 2.75 | 338 | 2.10 | 108 | | |
| 21 | 1.74 | 52.8 | 2.45 | 209 | 2.73 | 329 | 2.10 | 108 | | |
| 22 | 1.73 | 51.6 | 2.40 | 190 | 2.70 | 315 | 2.10 | 108 | | |
| 23 | 1.72 | 50.4 | 2.35 | 174 | 2.75 | 338 | 2.08 | 104 | | |
| 24 | 1.72 | 50.4 | 2.30 | 158 | 2.72 | 324 | 2.08 | 104 | | |
| 25 | 1.70 | 48.0 | 2.25 | 144 | 2.70 | 315 | 2.05 | 98.5 | | |
| 26 | 1.70 | 48.0 | 2.23 | 139 | 2.67 | 301 | 2.03 | 94.7 | | |
| 27 | 1.68 | 45.8 | 2.20 | 131 | 2.65 | 292 | 1.70 | 48.0 | | |
| 28 | 1.67 | 44.7 | 2.26 | 147 | 2.63 | 283 | 1.75 | 54.0 | | |
| 29 | 1.65 | 42.5 | 2.24 | 142 | 2.60 | 269 | 1.80 | 60.0 | | |
| 30 | 1.68 | 45.8 | 2.20 | 131 | 2.56 | 253 | 1.90 | 73.0 | | |
| 31 | 1.68 | 45.8 | 2.18 | 126 | | | 1.95 | 81.0 | | |

MONTHLY DISCHARGE of Willow Creek near Macleod, Alta., for 1911.

(Drainage area, 1005 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile | Depth in inches on Drainage area. | Total in acre-feet. |
| March (22-31) | 292 | 65 | 185 | .184 | .07 | 3,669 |
| April | 131 | 33.5 | 76.9 | .076 | .08 | 4,576 |
| May | 881 | 63.9 | 211 | .209 | .24 | 12,974 |
| June | 460 | 92.8 | 199 | .198 | .22 | 11,841 |
| July | 144 | 42.5 | 72.5 | .072 | .08 | 4,458 |
| August | 1,312 | 48 | 309 | .305 | .35 | 1,900 |
| September | 1,413 | 113 | 515 | .512 | .57 | 30,645 |
| October | 253 | 48 | 136 | .135 | .16 | 8,362 |
| November (1-15) | 174 | 81 | 136 | .135 | .08 | 4,047 |
| The period | | | | | | 82,472 |

OLDMAN RIVER NEAR MACLEOD, ALTA.

This station was established on July 12, 1910, by H. C. Ritchie. It is located at the traffic bridge on the N.W. ¼ Sec. 10, Tp. 9, Rge. 26, W. 4th Mer.

The gauge is a plain staff graduated to feet and hundredths, fastened to a crib protecting the pier near the right bank. It is referred to a bench-mark on spikes in a wooden bent, 93 feet east of the gauge; elevation, 11.96.

The channel is straight for 400 feet above and 1000 feet below the station. Both banks are low, wooded and liable to overflow in extreme high water. The bed is composed of clean gravel, and shifts during high-water stages. The current is swift, especially during high water.

Discharge measurements are made from the bridge, the initial point for soundings being at the left end of the hand-rail on the downstream side.

During 1911 the gauge was read by Mrs. Walter Jackson. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912, and published with the records for that year.

Discharge Measurements of Oldman River, near Macleod, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 4 | J. E. Degnan | 273.5 | 819.36 | 3.087 | 5.56 | 3,119.37 |
| May 15 | do | 80.0 | 252.80 | 2.251 | 3.19 | 5,960.50 |
| May 26 | A. W. Lowrie | 293.0 | 1,041.57 | 4.890 | 5.94 | 5,096.96 |
| June 13 | do | 402.0 | 1,715.89 | 5.690 | 7.60 | 9,769.70 |
| July 3 | do | 260.0 | 768.11 | 4.330 | 5.34 | 3,325.86 |
| July 19 | do | 180.0 | 401.75 | 4.140 | 4.15 | 1,665.03 |
| Aug. 5 | do | 106.6 | 395.10 | 4.060 | 4.10 | 1,603.42 |
| Aug. 28 | do | 104.5 | 363.63 | 3.620 | 3.85 | 1,314.70 |
| Sept. 19 | N. M. Sutherland | 117.5 | 492.53 | 5.460 | 5.01 | 2,689.86 |
| Oct. 18 | do | 102.0 | 357.10 | 3.190 | 3.77 | 1,140.86 |
| Dec. 11 | do | 102.0 | 322.70 | 1.780 | 3.54 | 573.65 |

Mean Daily Gauge-height, in feet, of Oldman River near Macleod, Alta., for 1911.

| Day. | March. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ...... | 3.55 | 5.25 | 8.25 | 5.45 | 3.85 | 3.53 | 4.56 | 3.20 | 3.55 |
| 2 | ...... | 3.52 | 5.22 | 8.35 | 5.42 | 3.89 | 3.50 | 4.40 | 3.20 | 4.07 |
| 3 | ...... | 3.50 | 5.22 | 8.55 | 5.45 | 3.89 | 3.46 | 4.37 | 3.20 | 4.10 |
| 4 | ...... | 3.42 | 5.45 | 8.35 | 5.32 | 3.89 | 4.92 | 4.32 | 3.20 | 4.15 |
| 5 | ...... | 3.36 | 5.80 | 8.20 | 5.25 | 4.08 | 7.60 | 4.29 | 3.20 | 4.13 |
| 6 | ...... | 3.30 | 6.45 | 8.16 | 5.15 | 4.19 | 7.50 | 4.25 | 3.22 | 4.10 |
| 7 | ...... | 3.25 | 6.35 | 7.88 | 5.04 | 4.25 | 7.35 | 4.20 | 3.25 | 4.07 |
| 8 | ...... | 3.20 | 6.15 | 7.85 | 4.15 | 5.25 | 6.89 | 4.15 | 3.25 | 4.02 |
| 9 | ...... | 3.20 | 5.75 | 7.80 | 4.35 | 6.55 | 6.70 | 4.10 | 3.25 | 3.95 |
| 10 | ...... | 3.30 | 5.65 | 7.16 | 4.55 | 6.20 | 6.55 | 4.05 | 3.25 | 3.85 |
| 11 | ...... | 3.40 | 5.50 | 7.25 | 4.45 | 5.67 | 6.50 | 4.01 | 3.25 | 3.77 |
| 12 | ...... | 3.30 | 5.55 | 7.53 | 4.37 | 5.35 | 6.45 | 3.95 | 3.25 | 3.70 |
| 13 | ...... | 3.25 | 5.65 | 7.80 | 4.30 | 5.15 | 6.28 | 3.95 | 3.25 | 3.60 |
| 14 | ...... | 3.20 | 5.80 | 7.90 | 4.20 | 4.87 | 5.90 | 3.90 | 3.25 | 3.59 |
| 15 | ...... | 3.19 | 7.20 | 7.65 | 4.20 | 4.75 | 5.75 | 3.87 | 4.75 | 3.56 |
| 16 | ...... | 3.17 | 9.40 | 7.35 | 4.20 | 4.53 | 5.65 | 3.80 | 4.85 | 3.51 |
| 17 | ...... | 3.25 | 8.75 | 7.20 | 4.19 | 4.45 | 5.50 | 3.77 | 5.15 | 3.45 |
| 18 | ...... | 3.50 | 7.69 | 7.02 | 4.19 | 4.36 | 5.30 | 3.75 | 5.36 | 3.39 |
| 19 | ...... | 3.90 | 7.02 | 6.65 | 4.15 | 4.29 | 5.04 | 3.69 | 4.50 | 3.35 |
| 20 | ...... | 4.25 | 6.10 | 6.32 | 4.13 | 4.25 | 5.01 | 3.64 | 4.42 | 3.35 |
| 21 | ...... | 4.60 | 6.40 | 6.14 | 4.10 | 4.12 | 4.99 | 3.59 | 4.35 | 3.55 |
| 22 | 3.69 | 4.80 | 6.37 | 6.12 | 4.08 | 4.05 | 4.97 | 3.55 | 4.29 | 3.80 |
| 23 | 3.67 | 5.20 | 6.32 | 6.12 | 4.06 | 4.01 | 4.95 | 3.51 | 4.19 | 4.20 |
| 24 | 3.65 | 5.40 | 6.23 | 6.30 | 4.03 | 3.95 | 4.90 | 3.48 | 4.15 | 4.20 |
| 25 | 3.60 | 5.41 | 6.10 | 6.80 | 4.00 | 3.87 | 4.79 | 3.45 | 4.10 | 4.21 |
| 26 | 3.58 | 5.85 | 5.85 | 6.45 | 3.95 | 3.80 | 4.70 | 3.40 | 4.05 | 4.21 |
| 27 | 3.55 | 6.05 | 5.80 | 6.20 | 3.85 | 3.89 | 4.62 | 3.36 | 4.03 | 4.50 |
| 28 | 3.50 | 5.60 | 5.91 | 5.12 | 3.83 | 3.85 | 4.58 | 3.25 | 3.92 | 4.70 |
| 29 | 3.48 | 5.35 | 6.10 | 5.25 | 3.82 | 3.79 | 4.55 | 3.22 | 3.79 | 4.89 |
| 30 | 3.65 | 5.30 | 6.55 | 5.40 | 3.80 | 3.69 | 4.51 | 3.20 | 3.55 | 5.10 |
| 31 | 3.61 | .... | 7.17 | ...... | 3.82 | 3.58 | | 3.20 | ..... | 5.20 |

## Pincher Creek at Pincher Creek.

Under the direction of Arthur O. Wheeler, a regular gauging station was established on Pincher Creek at Pincher Creek, in the spring of 1898. On August 13, 1906, J. F. Hamilton replaced the old gauge by a new one. Owing to local improvements the gauge has since been changed, but the station remains in practically the same place as established by Mr. Wheeler.

The gauge is a plain staff graduated to feet and hundredths, securely fastened to the breakwater on the right bank, about twenty feet below the traffic bridge. It is referred to benchmarks on the north abutment and a low pile underneath the north end of the bridge (elevations 7.75 and 3.40 feet, respectively, above the zero of the gauge). It is read by P. Bertles, who lives on the north side of the creek.

During high water, discharge measurements are made from the downstream side of the bridge. At low stages, the creek is waded 450 yards upstream.

The channel is straight for about 200 yards above and 300 yards below the bridge. Both banks are high, the right being well cribbed; neither is liable to overflow. The bed is rock and free from vegetation. At the wading section, the channel is straight for about 500 yards above and 70 yards below. Both banks are high, clean and not liable to overflow. The bed is gravel, mixed with heavy gumbo clay.

The town of Pincher Creek has a gravity waterworks system which diverts water from the creek at a point about three and one quarter miles above the bridge and the records at this station do not include the water used by the town.

The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912, and published with the records for that year.

Discharge Measurements of Pincher Creek, at Pincher Creek, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| Apr. 22 | J. E. Degnan | 35 50 | 30.93 | 2 641 | 2.15 | 81 69* |
| May 12 | A. W. P. Lowrie | 34.50 | 24.85 | 2.320 | 2.02 | 57.70‡‡ |
| June 3 | do | 45 40 | 88.86 | 3.970 | 3.00 | 352.90‡ |
| June 3 | do | 76.00 | 77.30 | 4 310 | 3 00 | 333 30x |
| June 20 | do | 40.70 | 37 23 | 2.420 | 2 49 | 90 32 |
| July 11 | do | 36.16 | 21 53 | 1.820 | 2 17 | 39 29 |
| July 27 | do | 13.80 | 13 27 | 1.430 | 2.00 | 19.07 |
| Aug. 19 | do | 39.00 | 24.42 | 1.610 | 2.24 | 39.40 |
| Sept. 2 | do | 19 00 | 14 66 | 1.860 | 2.10 | 27.13 |
| Sept. 7 | do | 81.00 | 116.05 | 4.720 | 3.65 | 547 77 |
| Oct. 10 | | 34 20 | 40 22 | 1.700 | 2.67 | 68.31 |
| Oct. 30 | do | 33.00 | 35.35 | 1.300 | 2 55 | 45.79‡ |

* 3 point method.
‡‡ At foot bridge near regular station.
x Gauged at highway bridge.
‡ Gauged 75′ ft. below footbridge.

MEAN DAILY GAUGE-HEIGHT, in feet, of Pincher Creek, at Pincher Creek, Alta., for 1911.

| Day. | March. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ....... | 1.78 | 2.03 | 3.00 | 2.70 | 2.07 | 2.15 | 2.90 | 2.49 |
| 2 | ... | 1.69 | 1.98 | 3.18 | 2.67 | 2.15 | 2.10 | 2.95 | 2.47 |
| 3 | ... | 1.65 | 2.02 | 3.02 | 2.65 | 2.10 | 2.10 | 3.00 | 2.47 |
| 4 | | 1.91 | 2.05 | 3.00 | 2.60 | 2.06 | 4.60 | 3.00 | 2.45 |
| 5 | ... | 1.90 | 2.04 | 2.87 | 2.54 | 2.02 | 4.00 | 2.98 | 2.45 |
| 6 | | 1.85 | 2.08 | 2.82 | 2.50 | 2.30 | 4.00 | 2.94 | 2.44 |
| 7 | ... | 1.87 | 2.10 | 2.80 | 2.46 | 3.85 | 3.90 | 2.91 | 2.45 |
| 8 | . | 1.85 | 2.10 | 2.89 | 2.42 | 2.25 | 3.73 | 2.90 | 2.45 |
| 9 | | 1.83 | 2.09 | 2.90 | 2.38 | 2.20 | 3.64 | 2.90 | 2.47 |
| 10 | | 2.02 | 2.00 | 2.92 | 2.35 | 2.12 | 3.60 | 2.88 | 2.47 |
| 11 | ... | 2.05 | 1.97 | 2.90 | 2.30 | 2.03 | 3.50 | 2.84 | 2.50 |
| 12 | | 1.93 | 1.97 | 2.90 | 2.24 | 1.97 | 3.34 | 2.81 | 2.50 |
| 13 | | 1.90 | 2.38 | 2.95 | 2.20 | 2.70 | 3.27 | 2.76 | 2.48 |
| 14 | | 1.81 | 2.22 | 2.96 | 2.17 | 2.50 | 3.30 | 2.70 | 2.48 |
| 15 | . | 1.75 | 3.55 | 2.91 | 2.12 | 2.57 | 3.17 | 2.70 | 2.50 |
| 16 | | 1.77 | 3.60 | 2.88 | 2.10 | 2.60 | 3.10 | 2.74 | ....... |
| 17 | | 1.77 | 3.37 | 2.80 | 2.10 | 2.56 | 3.05 | 2.71 | ....... |
| 18 | . | 1.90 | 2.84 | 2.76 | 2.08 | 2.54 | 3.00 | 2.69 | ....... |
| 19 | 2.12 | 1.90 | 2.81 | 2.75 | 2.08 | 2.51 | 3.00 | 2.69 | ....... |
| 20 | 2.04 | 1.85 | 2.80 | 2.70 | 2.05 | 2.50 | 2.95 | 2.68 | ....... |
| 21 | 1.94 | 1.90 | 2.78 | 2.67 | 2.00 | 2.44 | 3.00 | 2.68 | ....... |
| 22 | 1.90 | 2.02 | 3.02 | 2.60 | 2.06 | 2.40 | 3.00 | 2.68 | ....... |
| 23 | 1.86 | 2.30 | 2.80 | 2.54 | 2.06 | 2.35 | 3.00 | 2.66 | ....... |
| 24 | 1.80 | 1.97 | 2.75 | 3.62 | 2.00 | 2.30 | 3.00 | 2.56 | ....... |
| 25 | 1.82 | 1.97 | 2.70 | 3.18 | 2.00 | 2.22 | 3.00 | 2.52 | ....... |
| 26 | 1.80 | 1.97 | 2.77 | 2.88 | 2.03 | 2.20 | 3.00 | 2.52 | ....... |
| 27 | 1.76 | 1.96 | 3.00 | 2.80 | 2.00 | 2.20 | 2.97 | 2.54 | ....... |
| 28 | 1.81 | 1.96 | 3.05 | 2.77 | 2.00 | 2.22 | 2.97 | 2.54 | ....... |
| 29 | 1.89 | 1.95 | 3.02 | 2.74 | 2.03 | 2.20 | 2.94 | 2.53 | ....... |
| 30 | 2.00 | 1.95 | 2.97 | 2.64 | 2.04 | 2.20 | 2.90 | 2.50 | ....... |
| 31 | 1.80 | . | 3.06 | ....... | 2.02 | 2.17 | ....... | 2.50 | ....... |

## SOUTHFORK RIVER NEAR COWLEY.

This gauging station, located at the traffic bridge between Cowley and Pincher on the S.E. ¼ Sec. 2, Tp. 7, Rge. 1, W. 5th Mer., was established by H. C. Ritchie on August 5, 1909.

The gauge is a plain staff, graduated to feet and hundredths. It was first fastened to the second pier of the bridge from the left bank, but, owing to this section changing during floods, was moved to a point about half a mile downstream and securely fastened by braces to supports on the bank. In its present position it is about five minutes walk from the house of Mr. G. W. Buchanan, who reads it daily. It is referenced by a bench-mark on a tree within twenty feet; elevation 8.33.

Above the bridge an island divides the river into two channels, this island being submerged during high-water stages. These two channels join about fifty feet upstream from section, but the stream is again divided into three by the piers of the bridge. Owing to the protection of the piers, gravel-bars are formed downstream from the section.

The bed of the river is quite rough, requiring extreme care in determining the area of the section. The current is swift, except through the east channel during low stages, when it becomes very sluggish.

Discharge measurements are made from the downstream side of the bridge during both high and low water, the initial point for sounding being marked on the superstructure in line with the face of the abutment on the left bank.

The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

Discharge Measurements of Southfork River, near Cowley, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Feb. 20 | W. H. Green | 77.0 | 88.00 | 1.010 | 3.33 | 89.16 |
| Feb. 27 | do | | 358.65 | 0.610 | 3.51 | 219.71 |
| Mar. 21 | J. E. Degnan | 78.0 | 157.75 | 1.353 | 2.95 | 212.78 |
| Apr. 7 | do | 81.0 | 161.13 | 1.190 | 2.28 | 191.77 |
| Apr. 27 | do | 205.0 | 415.14 | 3.818 | 3.70 | 1,584.82 |
| June 5 | do | 248.0 | 738.10 | 5.910 | 5.10 | 4,367.76 |
| June 21 | A. W. P. Lowrie | 221.8 | 539.60 | 4.890 | 4.15 | 2,640.76 |
| July 12 | do | 181.0 | 299.35 | 3.220 | 3.09 | 964.94 |
| July 28 | do | 100.0 | 222.05 | 2.480 | 2.62 | 551.69 |
| Aug. 21 | do | 108.2 | 242.58 | 2.370 | 2.74 | 575.49 |
| Sept. 12 | do | 235.0 | 571.85 | 4.850 | 4.30 | 2,776.27 |
| Oct. 11 | N. M. Sutherland | 109.0 | 234.69 | 2.390 | 2.76 | 561.33 |
| Nov. 4 | do | 97.0 | 173.17 | 1.900 | 2.37 | 329.84 |
| Nov. 30 | do | 40.0 | 111.50 | 2.010 | 3.45 | 224.68 |
| Dec. 14 | do | 54.0 | 111.41 | 1.710 | 3.125 | 190.39 |

Mean Daily Gauge-height, in feet, of Southfork River near Cowley, Alta., for 1911.

| Day. | Jan. | Feb. | March | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.43 | 3.30 | 3.55 | 2.40 | 3.07 | 4.40 | 3.85 | 2.69 | 2.46 | 3.05 | 2.45 | 3.40 |
| 2 | 2.35 | 3.20 | 3.60 | 2.85 | 3.06 | 5.00 | 3.70 | 2.75 | 2.45 | 3.03 | 2.45 | 3.35 |
| 3 | 2.05 | 3.05 | 3.55 | 2.45 | 3.11 | 5.40 | 3.60 | 2.70 | 2.45 | 3.00 | 2.40 | 3.28 |
| 4 | 3.57 | 3.45 | 3.60 | 2.38 | 3.30 | 5.40 | 3.55 | 2.70 | 6.00 | 2.95 | 2.36 | 3.12 |
| 5 | 3.10 | 3.45 | 3.50 | 2.40 | 3.50 | 5.05 | 3.45 | 2.68 | 5.20 | 2.90 | 2.33 | 3.15 |
| 6 | 3.30 | 3.47 | 3.60 | 2.45 | 3.85 | 4.70 | 3.45 | 2.74 | 4.90 | 2.90 | 2.30 | 3.13 |
| 7 | 3.15 | 3.45 | 3.65 | 2.28 | 3.70 | 4.65 | 3.35 | 3.55 | 4.50 | 2.85 | 2.30 | 3.15 |
| 8 | 3.00 | 3.47 | 3.65 | 2.26 | 3.60 | 4.80 | 3.30 | 3.75 | 4.45 | 2.80 | 5.15 | 3.15 |
| 9 | 2.87 | 3.45 | 3.65 | 2.30 | 3.45 | 4.70 | 3.30 | 3.65 | 4.50 | 2.80 | 5.10 | 3.10 |
| 10 | 2.70 | 3.45 | 3.58 | 2.34 | 3.35 | 4.80 | 3.20 | 3.55 | 4.30 | 2.83 | 5.10 | 2.97 |
| 11 | 2.83 | 3.45 | 3.50 | 2.35 | 3.30 | 5.00 | 3.10 | 3.45 | 4.30 | 2.85 | 4.20 | 2.60 |
| 12 | 3.25 | 3.45 | 3.50 | 2.35 | 3.25 | 5.30 | 3.90 | 3.25 | 4.30 | 2.80 | 4.20 | 3.17 |
| 13 | 3.35 | 3.45 | 3.55 | 2.28 | 3.40 | 5.40 | 3.05 | 3.00 | 4.20 | 2.75 | 4.25 | 3.20 |
| 14 | 3.40 | 3.47 | 3.43 | 2.25 | 3.40 | 5.30 | 3.05 | 3.15 | 4.15 | 2.70 | 3.89 | 3.05 |
| 15 | 3.40 | 3.45 | 3.52 | 2.25 | 3.40 | 5.30 | 3.05 | 3.05 | 3.95 | 2.67 | 4.20 | 3.08 |
| 16 | 3.40 | 3.45 | 3.45 | 2.35 | 5.25 | 5.10 | 3.08 | 2.94 | 3.70 | 2.65 | 4.30 | 3.10 |
| 17 | 3.35 | 3.56 | 3.45 | 2.52 | 4.50 | 4.95 | 3.03 | 2.85 | 3.55 | 2.65 | 4.25 | 3.05 |
| 18 | 3.30 | 3.50 | 3.38 | 2.55 | 4.30 | 4.70 | 3.00 | 2.80 | 3.50 | 2.63 | 4.30 | 3.20 |
| 19 | 3.25 | 3.45 | 3.25 | 2.68 | 4.10 | 4.50 | 2.95 | 2.75 | 3.40 | 2.60 | 4.10 | 3.00 |
| 20 | 3.13 | 3.26 | 3.10 | 2.86 | 3.90 | 4.35 | 2.90 | 2.70 | 3.30 | 2.60 | 3.90 | 3.50 |
| 21 | 3.30 | 3.50 | 2.87 | 3.10 | 3.60 | 4.15 | 2.80 | 2.74 | 3.30 | 2.55 | 3.80 | 3.50 |
| 22 | 3.25 | 3.45 | 2.75 | 3.15 | 3.60 | 4.15 | 2.75 | 2.70 | 3.25 | 2.50 | 3.65 | 3.50 |
| 23 | 3.10 | 3.55 | 2.67 | 3.30 | 3.55 | 4.10 | 2.80 | 2.64 | 3.25 | 2.40 | 3.50 | 3.40 |
| 24 | 3.20 | 3.49 | 2.55 | 3.40 | 3.40 | 4.50 | 2.70 | 2.69 | 3.25 | 2.40 | 3.55 | 3.45 |
| 25 | 3.30 | 3.55 | 2.45 | 3.70 | 3.30 | 4.85 | 2.68 | 2.60 | 3.25 | 2.42 | 3.50 | 3.40 |
| 26 | 3.25 | 3.50 | 2.35 | 3.30 | 3.20 | 4.50 | 2.65 | 2.60 | 3.25 | 2.42 | 3.40 | 3.37 |
| 27 | 3.20 | 3.44 | 2.38 | 3.30 | 3.20 | 4.25 | 2.60 | 2.65 | 3.22 | 2.45 | 3.30 | 3.20 |
| 28 | 3.35 | 3.45 | 2.40 | 3.20 | 3.20 | 4.10 | 2.62 | 2.55 | 3.22 | 2.44 | 3.25 | 3.18 |
| 29 | 3.35 | .... | 2.40 | 3.07 | 3.30 | 3.95 | 2.55 | 2.50 | 3.10 | 2.42 | 3.33 | 3.20 |
| 30 | 3.30 | .... | 2.40 | 3.03 | 3.80 | 3.90 | 2.70 | 2.50 | 3.05 | 2.43 | 3.50 | 3.15 |
| 31 | 3.30 | .... | 2.38 | .... | 4.10 | .... | 2.65 | 2.48 | | 2.44 | | 3.10 |

## Mill Creek near Mountain Mill.

This gauging station, located on the S.W. ¼ Sec. 18, Tp. 6, Rge. 1, W. 5th Mer., at the abandoned site of the old Government mill nine and a half miles west of Pincher Creek post office, was established July 7, 1910, by H. C. Ritchie.

The gauge is a plain staff graduated to feet and hundredths, placed at the left bank. It is referred to a bench-mark on a spike at the northeast corner of the mill (elevation 10.97).

The channel is straight for 200 feet above and 300 feet below the station. Both banks are high, clean, rocky and will not overflow. The bed of the stream is of gravel, giving a stable cross-section. The current is swift.

Discharge measurements in flood stages are made from the bridge. In normal and low-water stages the creek is waded fifty feet upstream from the gauge, the initial point for soundings being a stake on the left bank.

During 1911, the gauge was read by Mrs. J. McIlquham. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS of Mill Creek near Mountain Mill, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 21 | J. E. Degnan | 49 0 | 42 37 | 3 211 | 2.57 | 136.05* |
| May 11 | A. W. P. Lowrie | 45 5 | 64.36 | 2.380 | 2.66 | 153.32* |
| June 28 | do | 65 5 | 105 17 | 3 260 | 2.75 | 342.74† |
| July 10 | do | 46 8 | 40.01 | 2 520 | 2 25 | 100.98 |
| July 26 | do | 36 7 | 27 95 | 1.920 | 2 01 | 53.66* |
| Aug. 18 | do | 48 0 | 36.92 | 2 730 | 2.30 | 100.85* |
| Sept. 13 | do | 68 6 | 137.29 | 4 670 | 3.30 | 641.80† |
| Oct. 9 | N. M. Sutherland | 40 0 | 36.25 | 2 670 | 2.07 | 96.71 |
| Nov. 1 | do | 35 5 | 32.76 | 2 040 | 1 96 | 66.78- |

* 3 point method.
† Gauged at bridge.
\- Slush Ice.

MEAN DAILY GAUGE-HEIGHT, in feet, of Mill Creek, at Mountain Mill, Alta., for 1911.

| Day. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 20 | 2 58 | 3 60 | 2 75 | 2 50 | 2 02 | 2.25 | 2.05 |
| 2 | 2 20 | 2 60 | 3 65 | 2 67 | 3 05 | 2.02 | 2.30 | 2.00 |
| 3 | 2 18 | 2 60 | 3 60 | 2 65 | 2 85 | 2 40 | 2 25 | 1.95 |
| 4 | 2 10 | 2 65 | 3 40 | 2 65 | 2 60 | 4 60 | 2 20 | 1.95 |
| 5 | 2 20 | 2 70 | 3 00 | 2.50 | 2 20 | 3.70 | 2 20 | 1.95 |
| 6 | 2.10 | 3 00 | 3 00 | 2.40 | 2.30 | 2 80 | 2.15 | 1.95 |
| 7 | 2 18 | 3 05 | 3 00 | 2.40 | 3 27 | 2.90 | 2.15 | 2 00 |
| 8 | 2.18 | 2.85 | 3 05 | 2.40 | 3 20 | 3 40 | 2 10 | 2.05 |
| 9 | 2 20 | 2.85 | 3 10 | 2 35 | 3.05 | 3.40 | 2 10 | 2.10 |
| 10 | 2.20 | 2 75 | 3.10 | 2.30 | 3 05 | 3.30 | 2 10 | 2.30 |
| 11 | 2.20 | 2 70 | 3 40 | 2.30 | 2 70 | 3 39 | 2 10 | 2 35 |
| 12 | 2.18 | 2 70 | 3 22 | 2 20 | 2 60 | 3.35 | 2 10 | 2.50 |
| 13 | 2 30 | 2 86 | 3 15 | 2 20 | 2 50 | 3.30 | 2 10 | 2 95 |
| 14 | 2 20 | 2 80 | 3 15 | 2 15 | 2 45 | 3.20 | 2 05 | 3.10 |
| 15 | 2.35 | 3 00 | 3 10 | 2 10 | 2 40 | 3.15 | 2.05 | 3.30 |
| 16 | 2 30 | 4 15 | 3 10 | 2 10 | 2 38 | 3.10 | 2.05 | ........ |
| 17 | 2.35 | 3 50 | 2.95 | 2.10 | 2.38 | 2 80 | 2 05 | ........ |
| 18 | 2.37 | 3 31 | 2.95 | 2.10 | 2 30 | 2 70 | 2 10 | ........ |
| 19 | 2.45 | 3 15 | 2.90 | 2.18 | 2 22 | 2.60 | 2 05 | ........ |
| 20 | 2 58 | 3 10 | 2.00 | 2.16 | 2 19 | 2 49 | 2.05 | ........ |
| 21 | 2.80 | 3 10 | 2 00 | 2 16 | 2 22 | 2.49 | 2.00 | ........ |
| 22 | 2.70 | 3 50 | 2 10 | 2.10 | 2 18 | 2 50 | 2.00 | ........ |
| 23 | 2 65 | 3 00 | 2.10 | 2.15 | 2 18 | 2 50 | 1 95 | ........ |
| 24 | 2 80 | 2 82 | 2 20 | 2.12 | 2 16 | 2 50 | 1.95 | ........ |
| 25 | 2.85 | 2 80 | 2 20 | 2.12 | 2.20 | 2 50 | 1.95 | ........ |
| 26 | 2 82 | 2 75 | 2.40 | 2.01 | 2.20 | 2.30 | 2 00 | ........ |
| 27 | 2.70 | 2 65 | 2.40 | 2.02 | 2 20 | 2.30 | 2.00 | ........ |
| 28 | 2 60 | 2.65 | 2.60 | 2 05 | 2.10 | 2.30 | 2.00 | ........ |
| 29 | 2 63 | 2 75 | 2 80 | 2.05 | 2 00 | 2.30 | 2 00 | ........ |
| 30 | 2.58 | 3.40 | 2 80 | 2.20 | 2 00 | 2.20 | 2 00 | ........ |
| 31 | ........ | 3 44 | ........ | 2 30 | 2 00 | ........ | 2 05 | ........ |

## CANYON CREEK NEAR MOUNTAIN MILL.

This gauging station, located on the N.E. 1/4 Sec. 14, Tp. 6, Rge. 2, W. 5th Mer. near G. Biron's ranche, was established July 6, 1910, by H. C. Ritchie.

The gauge is a plain staff graduated to feet and hundredths, placed at the left bank within 75 feet of Mr. Biron's corral. It is referred to a bench-mark on a spike in a tree within fifteen feet; elevation 14.49.

The channel is straight for 150 feet above and 30 feet below the station. Both banks are high, wooded and will not overflow. The bed of the stream is as clean gravel and rock. The current is very swift and turbulent. On this account discharge measurements are made about half a mile upstream at the traffic bridge on the road allowance to the Beaver coal mines.

Discharge measurements are made from the bridge during high-water stages, the initial point for soundings being on a line with the face of the left abutment. At ordinary stages the stream is waded about 100 yards downstream, the initial point for soundings being marked by a hub on the left bank.

During 1911, the gauge was read by Mr. G. Biron. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS of Canyon Creek, near Mountain Mill, in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 21 | J. E. Degnan | 18.0 | 28.59 | 1.913 | 5.27 | 54.68 |
| May 11 | A. W. P. Lowrie | 18.5 | 19.78 | 1.88 | 4.98 | 37.28 |
| June 28 | do | 18.20 | 16.52 | 1.88 | 4.92 | 30.08 |
| July 10 | do | 17.50 | 10.20 | 1.07 | 4.55 | 10.98 |
| July 26 | do | 17.00 | 8.09 | 0.93 | 4.37 | 7.59 |
| Aug. 18 | do | 17.80 | 8.94 | 1.00 | 4.50 | 8.93 |
| Sept. 13 | do | 18.4 | 33.59 | 2.78 | 5.50 | 93.51 |
| Oct. 9 | N. M. Sutherland | 18.8 | 14.87 | 1.70 | 4.85 | 25.22 |
| Nov. 1 | do | 18.0 | 13.89 | 1.12 | 4.72 | 15.60 |

MEAN DAILY GAUGE-HEIGHT, in feet, of Canyon Creek near Mountain Mill, for 1911.

| DAY. | April. | May. | June. | July. | August | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 5.14 | 5.90 | 4.83 | 4.40 | 4.39 | 4.94 | 4.70 |
| 2 | | 5.14 | 5.75 | 4.78 | 4.54 | 4.40 | 4.94 | 4.67 |
| 3 | | 5.12 | 5.60 | 4.74 | 4.53 | 4.49 | 4.95 | 4.61 |
| 4 | | 5.19 | 5.40 | 4.72 | 4.46 | 6.05 | 4.91 | 4.61 |
| 5 | | 5.20 | 5.33 | 4.68 | 4.46 | 6.40 | 4.9[illegible] | 4.60 |
| 6 | | 5.23 | 5.30 | 4.66 | 4.45 | 6.10 | 4.86 | 4.58 |
| 7 | | 5.20 | 5.35 | 4.62 | 5.00 | 6.20 | 4.85 | 4.60 |
| 8 | | 5.10 | 5.25 | 4.60 | 5.14 | 6.25 | 4.84 | 4.95 |
| 9 | | 5.04 | 5.20 | 4.58 | 5.02 | 6.15 | 4.83 | 5.72 |
| 10 | 4.54 | 5.01 | 5.15 | 4.57 | 4.94 | 5.80 | 4.82 | 5.92* |
| 11 | 4.60 | 4.96 | 5.15 | 4.54 | 4.82 | 5.78 | 4.78 | 5.92* |
| 12 | 4.61 | 4.95 | 5.10 | 4.54 | 4.73 | 5.60 | 4.77 | 5.92* |
| 13 | 4.63 | 5.15 | 5.05 | 4.52 | 4.64 | 5.50 | 4.77 | 5.92* |
| 14 | 4.54 | 5.24 | 5.10 | 4.51 | 4.60 | 5.40 | 4.76 | 5.92* |
| 15 | 4.55 | 5.58 | 5.03 | 4.49 | 4.56 | 5.34 | 4.75 | 5.92* |
| 16 | 4.64 | 6.90 | 5.00 | 4.46 | 4.55 | 5.30 | 4.74 | |
| 17 | 4.80 | 6.20 | 4.94 | 4.45 | 4.52 | 5.20 | 4.73 | |
| 18 | 4.94 | 5.90 | 4.90 | 4.44 | 4.50 | 5.15 | 4.72 | |
| 19 | 5.02 | 5.60 | 4.80 | 4.46 | 4.49 | 5.12 | 4.71 | |
| 20 | 5.10 | 5.50 | 4.79 | 4.45 | 4.45 | 5.10 | 4.70 | |
| 21 | 5.30 | 5.40 | 4.80 | 4.43 | 4.48 | 5.05 | 4.69 | |
| 22 | 5.45 | 5.34 | 4.80 | 4.43 | 4.48 | 5.10 | 4.69 | |
| 23 | 5.59 | 5.39 | 4.74 | 4.42 | 4.47 | 5.07 | 4.68 | |
| 24 | 5.35 | 5.34 | 4.80 | 4.44 | 4.43 | 5.14 | 4.70 | |
| 25 | 5.50 | 5.30 | 5.45 | 4.43 | 4.40 | 5.12 | 4.70 | |
| 26 | 5.51 | 5.30 | 5.10 | 4.35 | 4.43 | 5.10 | 4.72 | |
| 27 | 5.40 | 5.40 | 5.00 | 4.32 | 4.50 | 5.05 | 4.73 | |
| 28 | 5.24 | 5.60 | 4.94 | 4.32 | 4.45 | 5.00 | 4.74 | |
| 29 | 5.24 | 5.80 | 4.85 | 4.34 | 4.41 | 5.00 | 4.63 | |
| 30 | 5.20 | 6.08 | 4.84 | 4.47 | 4.40 | 4.97 | 4.63 | |
| 31 | | 6.10 | | 4.38 | 4.33 | | 4.65 | |

* Top of ice.

## Oldman River near Cowley.

This gauging station, located at a ford on the N.W. ¼ Sec. 34, Tp. 7, Rge. 1, W. 5th Mer., and approximately four miles northeast of Cowley, was established by H. C. Ritchie, on Sept. 15, 1908.

The gauge is a plain staff graduated to feet and hundredths. It is securely fastened to a post on the right bank and is connected with the channel by a ditch. It is referenced by two bench-marks, the first on a tree 20 feet upstream (elevation 9.63); the second on a stone 15 feet downstream (elevation 3.32).

The discharge measurements are made at the gauge, where a cable station has been erected for use during high-water stages. During low water the river is waded at the same section. The points for soundings are permanently marked by a tagged wire, stretched directly above the cable.

The channel is straight for about 900 feet above and 250 feet below the section. The bed is of rock and gravel and is free from vegetation. The current has considerable velocity, but flows smoothly to about 150 feet below the section, where it breaks into small rapids. Both banks are high and wooded, neither being liable to overflow.

During 1911, the gauge was read by Mr. Hugh W. Pettit. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

Discharge Measurements of Oldman River, near Cowley, in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 21 | W. H. Green | 158 | 116 7 | 0.993 | 2 46 | 116.82 |
| Feb. 16 | do | 140 | 74 95 | 1 14 | 2 95 | 85.80 |
| Feb. 28 | do | 140 | 79 25 | 1 22 | 2 91 | 96.54 |
| Mar. 20 | do | 159 | 159 82 | 1 46 | 2 60 | 234.02 |
| April 6 | J. E. Degnan | 36 | 113 70 | 1 186 | 1 03 | 134.87 |
| Apr. 26 | do | 194 | 335 05 | 3 514 | 2 26 | 1,177.24 |
| May 18 | A. W. P. Lowrie | 200 | 459 0 | 4 99 | 3 02 | 2,290.77 |
| June 6 | do | 197 0 | 439 66 | 4 80 | 2 95 | 2,108.08 |
| June 23 | do | 188 0 | 360 91 | 4 50 | 2 55 | 1,623.58 |
| July 13 | do | 187.0 | 238 33 | 2 72 | 1 85 | 649 19 |
| July 29 | do | 180 0 | 176 05 | 1 67 | 1 55 | 294 33 |
| Aug. 22 | do | 188 0 | 232 95 | 2 34 | 1 85 | 545.18 |
| Sept. 9 | do | 199 0 | 381 5 | 4 15 | 2 65 | 1,575 57 |
| Oct. 12 | N. M. Sutherland | 180 0 | 191 85 | 2 21 | 1 64 | 423.19 |
| Nov. 2 | do | 140 0 | 133 65 | 1 61 | 1 28 | 215 03* |
| Nov. 29 | do | 143 0 | 130 54 | 1 26 | 2 30 | 164.74 |
| Dec. 15 | do | 183.0 | 125 25 | 1 25 | 2 21 | 156.12 |

* Slush Ice.

## Todd Creek at Elton's Ranche.

This station was established by H. C. Ritchie on August 3, 1909. It is located seven miles northwest of Cowley, at a private foot-bridge about twenty feet from Cecil Elton's house on the S.W. ¼ Sec. 19, Tp. 8, Rge. 1, W. 5th Mer.

The gauge is a plain staff graduated to feet and hundredths, driven into the bed of the stream and securely braced to the left bank. It is referred to the top of a stake about ten feet east (elevation 6.70 above the zero of the gauge). It is read by Cecil Elton.

The channel is straight for about 55 feet above and 60 feet below the gauge. The right bank is high and wooded and liable to overflow in extreme high water. The left bank is wooded and liable to overflow for about five feet from edge, where it rises abruptly to about six feet. The bed lies in one channel and is composed of clean sand and gravel. The current is inclined to be swift at high stages, but quite sluggish at low.

Cecil Elton and Capt. Cardwell have irrigation ditches which divert water at points above this gauging station. Mr. Elton irrigates about 35 acres, and Capt. Cardwell about 90. Very little, if any, water was diverted during 1911.

The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS at regular stations of Todd Creek at Elton's Ranche, in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Apr. 8 | J. E. Degnan | 8 5 | 4 42 | 1 063 | 2 77 | 4 70 |
| April 24 | do | 18 5 | 19 87 | 1 734 | 3 15 | 34 47 |
| May 17 | A. W. P. Lowrie | 19 7 | 48 88 | 3 16 | 4 25 | 156 37 |
| June 8 | do | 19 30 | 32 80 | 1 92 | 3 39 | 63 10 |
| June 26 | do | 20.0 | 22 78 | 1 23 | 3 05 | 28 09 |
| July 14 | do | 20 4 | 17 68 | 1 49 | 2 75 | 11 90 |
| July 31 | do | 19 7 | 17 79 | 0 77 | 2 81 | 13 65 |
| Aug. 23 | do | 19 70 | 17 49 | 0 67 | 2 75 | 11 76 |
| Sept. 8 | do | 20 00 | 23 46 | 1 38 | 3 07 | 32 36 |
| Oct. 13 | N. M. Sutherland | 21 20 | 21 09 | 75 | 2 83 | 15 78 |

MEAN DAILY GAUGE-HEIGHT, in feet, of Todd Creek at Elton's Ranche, for 1911.

| Day. | March. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | 4 21 | 2 99 | 3 46 | 3 06 | 2 78 | 2 69 | 2 90 | 2 75 |
| 2 | | 3 28 | 2 98 | 3 48 | 2 94 | 2 76 | 2 69 | 2 90 | 2 76 |
| 3 | | 3 22 | 2 95 | 3 45 | 2 91 | 2 80 | 2 72 | 2 88 | 2 86 |
| 4 | | 3 21 | 2 98 | 3 42 | 2 89 | 2 84 | 3 03 | 2 88 | 2 86 |
| 5 | | 3 05 | 3 01 | 3 43 | 2 88 | 2 86 | 3 21 | 2 88 | 2 86 * |
| 6 | | 2 92 | 3 00 | 3 44 | 2 86 | 2 94 | 3 21 | 2 88 | 2 78 * |
| 7 | | 2 72 | 2 98 | 3 41 | 2 82 | 3 18 | 3 27 | 2 87 | 2 74 * |
| 8 | | 2 73 | 2 96 | 3 39 | 2 81 | 3 52 | 3 07 | 2 83 | 2 74 * |
| 9 | | 3 75 | 2 95 | 3 37 | 2 80 | 3 23 | 2 98 | 2 82 | |
| 10 | | 3 42 | 2 96 | 3 30 | 2 80 | 3 14 | 2 90 | 2 81 | |
| 11 | | 3 25 | 2 93 | 3 28 | 2 78 | 3 04 | 2 87 | 2 82 | |
| 12 | | 3 20 | 2 93 | 3 23 | 2 78 | 2 93 | 2 84 | 2 82 | |
| 13 | | 3 00 | 2 99 | 3 23 | 2 77 | 2 80 | 2 83 | 2 83 | |
| 14 | | 2 87 | 3 38 | 3 22 | 2 74 | 2 80 | 2 91 | 2 81 | |
| 15 | | 2 80 | 3 49 | 3 20 | 2 75 | 2 77 | 2 91 | 2 80 | |
| 16 | | 2 82 | 3 82 | 3 18 | 2 76 | 2 77 | 2 93 | 2 80 | |
| 17 | | 2 88 | 4 09 | 3 13 | 2 75 | 2 79 | 2 94 | 2 80 | |
| 18 | | 2 91 | 3 75 | 3 11 | 2 78 | 2 77 | 2 93 | 2 80 | |
| 19 | | 3 05 | 3 50 | 3 05 | 2 75 | 2 76 | 2 89 | 2 78 | |
| 20 | 7 35 | 3 07 | 3 44 | 3 04 | 2 76 | 2 75 | 2 90 | 2 78 | |
| 21 | 6 63 | 3 12 | 3 37 | 3 04 | 2 76 | 2 79 | 2 93 | 2 78 | |
| 22 | 6 50 | 3 14 | 3 32 | 3 03 | 2 77 | 2 76 | 2 89 | 2 79 | |
| 23 | 6 61 | 3 245 | 3 29 | 3 04 | 2 77 | 2 75 | 2 91 | 2 78 | |
| 24 | 6 22 | 3 14 | 3 34 | 3 04 | 2 76 | 2 73 | 2 95 | | |
| 25 | 6 20 | 3 15 | 3 36 | 3 02 | 2 74 | 2 74 | 2 92 | 2 71 | |
| 26 | 5 21 | 3 17 | 3 38 | 3 01 | 2 72 | 2 76 | 2 93 | 2 80 | |
| 27 | 5 71 | 3 09 | 3 40 | 3 04 | 2 70 | 2 74 | 2 94 | 2 74 | |
| 28 | 5 36 | 3 01 | 3 57 | 2 95 | 2 70 | 2 75 | 2 93 | 2 78 | |
| 29 | 5 10 | 2 99 | 3 56 | 2 94 | 2 70 | 2 74 | 2 91 | 2 89 | |
| 30 | 4 68 | 2 99 | 3 54 | 3 04 | 2 80 | 2 75 | 2 90 | 2 84 | |
| 31 | 4 38 | ...... | 3 45 | ...... | 2.80 | 2 72 | .. | 2 84 | |

*Creek frozen

## COW CREEK AT ROSS'S RANCHE.

A gauging station located on Sec. 12, Tp. 8, Rge. 2, W. 5th Mer., on Abel Brux's farm, was established August 2, 1909, by H. C. Ritchie. In the spring of 1910 Mr. Brux moved away, and, as no other observer was available, Mr. Ritchie established a new station, at John Ross's ranche on the N.E. ¼ Sec. 14, Tp. 8, Rge. 2, W. 5th Mer., on May 26, 1910.

The gauge is a plain staff graduated to feet and hundredths, placed at the right bank. It is referred to a bench-mark on the east side of the step at the door on the south side of John Ross's stable (elevation 13.71).

The channel is straight for 25 feet above and 40 feet below the station. Both banks are high, wooded and not liable to overflow. The bed is of clean sand and gravel.

Discharge measurements are made from a private bridge during high stages, the initial point for soundings being on the left bank. In low water the creek is waded.

During 1911, the gauge was read by Mr. John Ross. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS of Cow Creek, at Ross's Ranche, Alta., in 1911.

| Date. | Hydrographer | Width. | Area of Section. | Mean Velocity. | Gauge Height | Discharge |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 8 | J. E. Degnan | 6.50 | 4.00 | 0.845 | 2.34 | 3.38 |
| April 21 | do | 9.80 | 11.74 | 1.304 | 2.30 | 15.31 |
| May 17 | A. W. P. Lowrie | 10.00 | 18.70 | 2.520 | 3.05 | 47.11 |
| June 8 | do | 9.00 | 13.43 | 1.790 | 2.50 | 24.11 |
| June 26 | do | 9.00 | 9.42 | 1.040 | 2.05 | 9.77 |
| July 14 | do | 9.00 | 6.75 | 0.550 | 1.80 | 3.73 |
| July 31 | do | 9.20 | 7.32 | 0.580 | 1.85 | 4.24 |
| Aug. 23 | 'do | 8.70 | 7.21 | 0.760 | 1.90 | 5.48 |
| Sept. 8 | do | 9.00 | 10.19 | 1.320 | 2.23 | 13.49 |
| Oct. 13 | N. M. Sutherland | 9.00 | 9.51 | 0.850 | 2.04 | 8.06 |

MEAN DAILY GAUGE-HEIGHT, in feet, of Cow Creek at Ross's Ranche, Alta., for 1911.

| Day. | March. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| 1 | | 3.40 | 2.10 | 2.60 | 2.00 | 1.85 | 1.80 | 2.10 | 1.80 |
| 2 | | 3.25 | 2.10 | 2.60 | 2.00 | 1.90 | 1.80 | 2.10 | 1.80 |
| 3 | | 3.15 | 2.15 | 2.60 | 1.95 | 1.90 | 1.85 | 2.10 | 1.80 |
| 4 | | 3.05 | 2.15 | 2.65 | 1.85 | 2.00 | 2.50 | 2.10 | 1.80 |
| 5 | | 2.70 | 2.20 | 2.60 | 1.85 | 1.90 | 2.50 | 2.05 | 1.80 |
| 6 | | 2.55 | 2.30 | 2.55 | 1.80 | 2.00 | 2.55 | 2.05 | 1.80 |
| 7 | | 2.15 | 2.15 | 2.50 | 1.80 | 2.65 | 2.40 | 2.05 | 1.80 |
| 8 | | 2.05 | 2.15 | 2.50 | 1.75 | 2.30 | 2.30 | 2.05 | 1.75 |
| 9 | | 3.40 | 2.15 | 2.45 | 1.75 | 2.50 | 2.15 | 2.05 | 1.75 |
| 10 | | 3.35 | 2.15 | 2.40 | 1.70 | 2.70 | 2.15 | 2.05 | 1.75 |
| 11 | | 3.30 | 2.15 | 2.35 | 1.70 | 2.15 | 2.10 | 2.05 | 1.75 |
| 12 | | 2.50 | 2.10 | 2.30 | 1.70 | 2.10 | 2.10 | 2.05 | |
| 13 | | 2.07 | 2.35 | 2.30 | 1.70 | 2.00 | 2.10 | 2.05 | |
| 14 | | 2.00 | 2.65 | 2.30 | 1.70 | 2.00 | 2.10 | 2.05 | |
| 15 | | 1.95 | 2.70 | 2.30 | 1.70 | 2.00 | 2.05 | 2.05 | |
| 16 | | 2.20 | 5.00 | 2.25 | 1.70 | 2.00 | 2.05 | 2.05 | |
| 17 | | 2.15 | 3.15 | 2.20 | 1.70 | 2.00 | 2.05 | 2.05 | |
| 18 | | 2.85 | 2.90 | 2.15 | 1.70 | 1.90 | 2.05 | 2.05 | |
| 19 | | 2.85 | 2.80 | 2.10 | 1.70 | 1.90 | 2.05 | 2.05 | |
| 20 | | 2.20 | 2.70 | 2.10 | 1.70 | 1.80 | 2.05 | 2.05 | |
| 21 | 5.55 | 2.60 | 2.65 | 2.10 | 1.70 | 1.90 | 2.05 | 1.95 | |
| 22 | 5.15 | 2.70 | 2.65 | 2.05 | 1.70 | 1.90 | 2.05 | 1.95 | |
| 23 | 4.85 | 2.50 | 2.60 | 2.05 | 1.70 | 1.85 | 2.15 | 1.90 | |
| 24 | 4.80 | 2.30 | 2.70 | 2.05 | 1.70 | 1.85 | 2.15 | 1.90 | |
| 25 | 4.75 | 2.50 | 2.75 | 2.05 | 1.70 | 1.85 | 2.20 | 1.90 | |
| 26 | 4.75 | 2.45 | 2.75 | 2.05 | 1.70 | 1.85 | 2.20 | 1.90 | |
| 27 | 4.70 | 2.30 | 2.85 | 2.05 | 1.70 | 1.85 | 2.20 | 1.90 | |
| 28 | 4.90 | 2.15 | 3.00 | 2.00 | 1.70 | 1.85 | 2.20 | 1.85 | |
| 29 | 5.25 | 2.15 | 2.85 | 2.00 | 1.70 | 1.80 | 2.15 | 1.85 | |
| 30 | 4.30 | 2.15 | 2.70 | 2.00 | 1.90 | 1.80 | 2.10 | 1.85 | |
| 31 | 3.60 | | 2.60 | | 1.90 | 1.80 | | 1.85 | |

## CONNELLY CREEK NEAR LUNDBRECK, ALTA.

This station was established July 31, 1909, by H. C. Ritchie. It is located at a foot-bridge on the trail in S.E. 1/4 Sec. 36, Tp. 7, Rge. 2, W. 5th Mer., and about 100 feet from the mouth of the creek.

This stream has a very crooked channel, and it is very difficult to find a suitable place for gauging. For about twenty feet below and above the gauge the channel is practically straight. The right bank is low and liable to overflow at high stages of the stream; the left bank is comparatively high. Both banks are thickly wooded near the water's edge. The bed is composed of sand and gravel, and is free from vegetation.

During high stages, discharge measurements are made from the foot-bridge, the initial point for soundings being a stake on the right bank. During low stages, the current at this point is too sluggish for accurate results, and a wading section about 200 feet upstream is used.

As Mr. N. V. Holway, who read the gauge in 1909, was not available, the gauge was not read during 1911.

Discharge Measurements of Connelly Creek near Lundbreck, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 10 | J. E. Degnan | 11.20 | 7.54 | 0 671 | 2 60 | 5.06 |
| April 24 | do | 12.50 | 9.10 | 1 255 | 2 70 | 11 42 |
| May 17 | A. W. P. Lowrie | 13.15 | 11.70 | 2 401 | 3.22 | 28.10 |
| July 14 | do | 11 70 | 4 38 | 0 340 | 2.40 | 1 49 |
| July 31 | do | 12 60 | 5 21 | 0 650 | 2.45 | 3.36 |
| Aug. 23 | do | 12.40 | 5 00 | 0 590 | 2.42 | 2.93 |
| Sept. 8 | do | 13 30 | 5.83 | 0.860 | 2.57 | 5.88 |
| Nov. 4 | N. M. Sutherland | 7.80 | 3.82 | 1 060 | 2.59 | 4.07 |

## Crowsnest River near Lundbreck, Alta.

This gauging station, located on the N.W. ¼ Sec. 26, Tp. 7, Rge. 2, W. 5th Mer., at the traffic bridge just north of Lundbreck, was established September 7, 1907, by P. M. Sauder.

The gauge is a plain staff graduated to feet and hundredths, placed twenty feet downstream from the bridge and about six feet from the water's edge. It is connected with the channel by a ditch which is kept open by the hydrographer on his periodic trips. It is referred to a bench-mark on a notch in a tree about twenty yards north of the gauge (elevation, 9.74).

The channel is straight for 250 feet above and 1,500 feet below the station. The right bank is high, wooded and will not overflow. The left bank is low, wooded and liable to overflow in extreme high water. The bed of the stream is of rock, giving a stable cross-section. The current is swift and torrential.

Discharge measurements are made from the bridge, the initial point for soundings being marked on the lower downstream chord, on a line with the face of the left abutment.

During 1911, the gauge was read by C.C. Moore. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

Discharge Measurements of Crowsnest River near Lundbreck, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 24 | W. H. Green | 54 0 | 67 42 | 1 265 | 2.82 | 85.320 |
| Feb. 21 | do | 52 0 | 129 50 | 0 810 | 3.26 | 105 069 |
| Mar. 1 | do | 55 0 | 145 95 | 0.770 | 3 18 | 112.190 |
| Mar. 22 | J. E. Degnan | 53 5 | 76 83 | 1 760 | 1.65 | 135.760 |
| April 10 | do | 55.0 | 79 00 | 1 780 | 1 68 | 141.360 |
| May 19 | A. W. P. Lowrie | 74 3 | 234 34 | 5.710 | 3.90 | 1,337 960 |
| June 7 | do | 71 0 | 201 60 | 5 280 | 3.50 | 1,062 280 |
| June 29 | do | 67 5 | 155 00 | 4 030 | 2 83 | 625.790 |
| July 15 | do | 64 0 | 119 90 | 3 030 | 2.31 | 364 480 |
| Aug. 24 | do | 60 0 | 101 25 | 2 620 | 2.05 | 264 810 |
| Sept. 14 | do | 67 0 | 152 25 | 4 150 | 2 80 | 632 380 |
| Nov. 16 | N. M. Sutherland | 65 0 | 110 95 | 2 070 | 2.96 | 230 200 |

MEAN DAILY GAUGE-HEIGHT, IN FEET, of Crowsnest River, near Lundbreck, Alta., for 1911.

| Day. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.25 | 2.85 | 3.20 | 1.73 | 2.80 | 3.98 | 2.82 | 2.11 | 1.89 | 2.30 | 1.88 |
| 2 | 2.25 | 2.85 | 3.40 | 1.70 | 2.90 | 4.30 | 2.75 | 2.15 | 1.89 | 2.28 | 1.87 |
| 3 | 2.25 | 2.85 | 3.35 | 1.70 | 2.95 | 4.36 | 2.70 | 2.18 | 1.88 | 2.29 | 1.88 |
| 4 | 2.55 | 2.86 | 3.20 | 1.60 | 3.10 | 4.10 | 2.61 | 2.19 | 2.90 | 2.28 | 1.88 |
| 5 | 2.55 | 2.80 | 3.35 | 1.58 | 3.35 | 3.95 | 2.55 | 2.19 | 3.60 | 2.24 | 1.86 |
| 6 | 2.53 | 2.90 | 3.20 | 1.55 | 3.50 | 3.65 | 2.55 | 2.15 | 3.45 | 2.22 | 1.85 |
| 7 | 2.63 | 2.85 | 3.25 | 1.65 | 3.15 | 3.55 | 2.55 | 2.33 | 3.30 | 2.20 | 1.86 |
| 8 | 2.60 | 2.85 | 3.22 | 1.63 | 3.11 | 3.49 | 2.55 | 3.20 | 3.25 | 2.19 | 1.85 |
| 9 | 2.45 | 2.88 | 3.18 | 1.65 | 3.00 | 3.40 | 2.50 | 2.90 | 3.10 | 2.18 | 1.83 |
| 10 | 2.55 | 2.88 | 3.12 | 1.68 | 2.95 | 3.40 | 2.45 | 2.82 | 3.00 | 2.15 | 1.84 |
| 11 | 2.55 | 3.20 | 3.00x | 1.60 | 2.89 | 3.42 | 2.38 | 2.70 | 3.00 | 2.15 | 1.84 |
| 12 | 2.70 | 3.30 | 2.95x | 1.66 | 2.90 | 3.50 | 2.35 | 2.55 | 2.99 | 2.12 | 1.85 |
| 13 | 2.80 | 3.20 | 2.95x | 1.66 | 3.15 | 3.60 | 2.35 | 2.52 | 2.92 | 2.12 | 1.86 |
| 14 | 2.88 | 3.20 | 2.95x | 1.68 | 3.01 | 3.60 | 2.35 | 2.40 | 2.88 | 2.10 | .... |
| 15 | 2.89 | 3.20 | 2.90x | 1.67 | 3.50 | 3.50 | 2.31 | 2.32 | 2.74 | 2.10 | .... |
| 16 | 2.85 | 3.85 | 3.00x | 1.76 | 5.50 | 3.41 | 2.40 | 2.30 | 2.70 | 2.10 | .... |
| 17 | 2.86 | 3.85 | 3.00x | 1.95 | 4.81 | 3.35 | 2.35 | 2.25 | 2.60 | 2.09 | .... |
| 18 | 2.85 | 3.84 | 3.00x | 1.98 | 3.30 | 3.28 | 2.31 | 2.20 | 2.55 | 2.10 | .... |
| 19 | 2.85 | 3.80 | 2.85x | 2.10 | 3.95 | 3.20 | 2.35 | 2.17 | 2.50 | 2.08 | .... |
| 20 | 2.85 | 2.84 | 1.73 | 2.30 | 3.70 | 3.05 | 2.32 | 2.11 | 2.45 | 2.08 | .... |
| 21 | 2.86 | 2.87 | 1.73 | 2.60 | 3.51 | 3.00 | 2.25 | 2.18 | 2.40 | 2.05 | .. |
| 22 | 2.85 | 2.95 | 1.65 | 2.95 | 3.36 | 3.04 | 2.22 | 2.12 | 2.40 | 2.00 | .. |
| 23 | 2.85 | 3.40 | 1.70 | 2.76 | 3.40 | 3.00 | 2.25 | 2.10 | 2.38 | 1.98 | .. |
| 24 | 2.85 | 3.35 | 1.73 | 3.00 | 3.30 | 3.00 | 2.25 | 2.06 | 2.36 | 2.00 | .. |
| 25 | 2.85 | 3.31 | 1.70 | 3.20 | 3.19 | 3.10 | 2.20 | 2.05 | 2.35 | 1.95 | .... |
| 26 | 2.85 | 3.30 | 1.63 | 3.55 | 3.10 | 3.10 | 2.20 | 2.12 | 2.32 | 1.90 | .... |
| 27 | 2.82 | 3.20 | 1.64 | 3.25 | 3.10 | 3.00 | 2.20 | 2.10 | 2.31 | 1.90 | .... |
| 28 | 2.83 | 2.95 | 1.63 | 3.00 | 3.25 | 2.94 | 2.14 | 2.08 | 2.32 | 1.89 | .... |
| 29 | 2.85 | | 1.66 | 2.85 | 3.32 | 2.85 | 2.10 | 2.05 | 2.32 | 1.88 | .... |
| 30 | 2.85 | | 1.70 | 2.85 | 3.55 | 2.80 | 2.19 | 2.00 | 2.31 | 1.87 | .... |
| 31 | 2.84 | | 1.76 | . | 3.75 | . | 2.18 | 1.90 | ... | 1.87 | .... |

x Ice going out

## CROWSNEST RIVER NEAR FRANK, ALTA.

This gauging station, located at the traffic bridge on Sec. 36, Tp. 7 Rg. 4 W. 5th Mer., was established on July 28, 1910, by H. C. Ritchie.

The gauge consists of a plain staff graduated to feet and hundredths, placed at the left bank about twenty feet downstream. It is referenced by a bench-mark on spikes driven into a tree-stump within three feet of the gauge (elevation, 9.43).

The channel is straight for about 200 feet above the station and for 500 feet below, both banks being high, wooded and not liable to overflow. The bed of the stream is clean gravel.

The discharge measurements are made from the bridge during high-water stages, the points for soundings being painted on the lower chord. In low stages the river is waded at the same section.

During 1911, the gauge was read by Chas. Richardson.

DISCHARGE MEASUREMENTS of Crowsnest River near Frank, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section | Mean Velocity. | Gauge Height | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Jan. 2 | W. H. Greene | 48.0 | 35.30 | 1.046 | 3.77 | 36.94 |
| Jan. 25 | do | 50.8 | 42.87 | 1.197 | 3.95 | 51.30 |
| Feb. 22 | do | 47.6 | 36.70 | 1.190 | 3.85 | 43.69 |
| Mar. 2 | do | 48.1 | 36.32 | 1.150 | 3.86 | 41.72 |
| Mar. 23 | J. E. Degnan | 54.0 | 50.07 | 1.510 | 4.10 | 75.67 |
| April 11 | do | 53.0 | 51.64 | 1.440 | 4.13 | 74.37 |
| April 29 | do | 66.0 | 103.65 | 3.696 | 4.94 | 383.16 |
| May 20 | A. W. P. Lowrie | 71.2 | 150.54 | 4.960 | 5.75 | 747.85 |
| June 9 | do | 71.1 | 159.77 | 4.930 | 5.70 | 787.92 |
| June 30 | do | 70.4 | 125.31 | 4.020 | 5.25 | 503.78 |
| July 17 | do | 66.5 | 97.93 | 3.120 | 4.82 | 305.90 |
| Aug. 2 | do | 65.6 | 79.91 | 2.310 | 4.60 | 184.40 |
| Aug. 25 | do | 65.0 | 68.75 | 2.360 | 4.43 | 162.62 |
| Sept. 15 | do | 66.0 | 93.20 | 3.340 | 4.81 | 311.42 |
| Oct. 16 | N. McL. Sutherland | 62.0 | 65.17 | 2.020 | 4.38 | 113.64 |
| Nov. 9 | do | 50.2 | 39.84 | 1.380 | 3.96 | 55.01 |

SESSIONAL PAPER No. 25d

DAILY GAUGE-HEIGHT AND DISCHARGE of Crowsnest River, near Frank, Alta., for 1911.

| Day | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.78 | 37 | 3.92 | 48 | 3.86 | 43 | 4.20 | 92 | 4.94 | 358 | 6.38 | 1,264 |
| 2 | 3.80 | 38 | 3.93 | 50 | 3.86 | 43 | 4.22 | 97 | 4.97 | 373 | 6.55 | 1,385 |
| 3 | 3.82 | 40 | 3.93 | 50 | 3.86 | 43 | 4.18 | 88 | 5.05 | 413 | 6.50 | 1,349 |
| 4 | 3.82 | 40 | 3.93 | 50 | 3.86 | 43 | 4.14 | 80 | 5.26 | 524 | 6.35 | 1,243 |
| 5 | 3.83 | 40 | 3.93 | 50 | 3.85 | 42 | 4.11 | 74 | 5.60 | 724 | 6.10 | 1,065 |
| 6 | 3.86 | 43 | 3.93 | 50 | 3.85 | 42 | 4.10 | 72 | 5.58 | 711 | 6.00 | 994 |
| 7 | 3.90 | 46 | 3.92 | 48 | 3.85 | 42 | 4.08 | 69 | 5.33 | 562 | 5.90 | 924 |
| 8 | 3.95 | 52 | 3.92 | 48 | 3.85 | 42 | 4.06 | 66 | 5.26 | 524 | 5.77 | 834 |
| 9 | 3.89 | 45 | 3.91 | 47 | 3.86 | 43 | 4.06 | 66 | 5.15 | 465 | 5.77 | 834 |
| 10 | 3.93 | 50 | 3.91 | 47 | 3.86 | 43 | 4.10 | 72 | 5.11 | 443 | 5.79 | 847 |
| 11 | 3.95 | 52 | 3.90 | 46 | 3.86 | 43 | 4.13 | 78 | 4.98 | 378 | 5.85 | 889 |
| 12 | 3.95 | 52 | 3.90 | 46 | 3.82 | 40 | 4.12 | 76 | 5.06 | 418 | 5.98 | 980 |
| 13 | 3.95 | 52 | 3.90 | 46 | 3.81 | 39 | 4.11 | 74 | 5.18 | 481 | 5.98 | 980 |
| 14 | 3.98 | 56 | 3.90 | 46 | 3.81 | 39 | 4.10 | 72 | 5.20 | 492 | 5.96 | 966 |
| 15 | 3.99 | 57 | 3.90 | 46 | 3.85 | 42 | 4.12 | 76 | 5.50 | 660 | 5.90 | 924 |
| 16 | 4.00 | 58 | 3.91 | 47 | 3.89 | 45 | 4.25 | 104 | 5.90 | 924 | 5.90 | 924 |
| 17 | 4.00 | 58 | 3.91 | 47 | 3.92 | 48 | 4.31 | 119 | 5.80 | 854 | 5.89 | 917 |
| 18 | 4.00 | 58 | 3.91 | 47 | 3.97 | 54 | 4.45 | 161 | 5.78 | 841 | 5.81 | 861 |
| 19 | 3.99 | 57 | 3.91 | 47 | 3.97 | 54 | 4.50 | 178 | 5.74 | 814 | 5.68 | 775 |
| 20 | 3.98 | 56 | 3.91 | 47 | *4.03 | 62 | 4.75 | 273 | 5.65 | 776 | 5.52 | 673 |
| 21 | 3.98 | 56 | 3.89 | 45 | 4.10 | 72 | 5.20 | 492 | 5.70 | 788 | 5.39 | 596 |
| 22 | 3.97 | 54 | 3.85 | 42 | 4.10 | 72 | 5.00 | 388 | 5.60 | 724 | 5.47 | 643 |
| 23 | 3.96 | 53 | 3.85 | 42 | 4.09 | 71 | 5.10 | 438 | 5.51 | 666 | 5.38 | 591 |
| 24 | 3.95 | 52 | 3.84 | 41 | 4.16 | 84 | 5.26 | 524 | 5.32 | 557 | 5.51 | 666 |
| 25 | 3.95 | 52 | 3.84 | 41 | 4.16 | 84 | 5.47 | 643 | 5.16 | 470 | 5.59 | 718 |
| 26 | 3.95 | 52 | 3.85 | 42 | 4.16 | 84 | 5.36 | 580 | 5.97 | 973 | 5.47 | 643 |
| 27 | 3.95 | 52 | 3.86 | 43 | 4.17 | 86 | 5.25 | 519 | 5.72 | 801 | 5.38 | 591 |
| 28 | 3.95 | 52 | 3.86 | 43 | 4.17 | 86 | 4.97 | 373 | 5.56 | 698 | 5.30 | 546 |
| 29 | 3.95 | 52 | | | 4.18 | 88 | 4.98 | 378 | 5.70 | 788 | 5.22 | 503 |
| 30 | 3.92 | 48 | | | 4.18 | 88 | 4.99 | 383 | 5.70 | 788 | 5.25 | 519 |
| 31 | 3.92 | 48 | . . . | . . . | 4.21 | 94 | | | 5.90 | 924 | | . . . |

DAILY GAUGE-HEIGHT AND DISCHARGE of Crowsnest River, near Frank, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 5.20 | 492 | 4.59 | 209 | 4.35 | 130 | 4.51 | 181 | 4.23 | 99 | 4.09 | 71 |
| 2 | 5.15 | 465 | 4.60 | 212 | 4.35 | 130 | 4.50 | 178 | 4.21 | 94 | 4.05 | 65 |
| 3 | 5.08 | 428 | 4.60 | 212 | 4.36 | 133 | 4.50 | 178 | 4.21 | 94 | 4.06 | 66 |
| 4 | 5.00 | 388 | 4.59 | 209 | 5.80 | 854 | 4.49 | 175 | 4.20 | 92 | 4.08 | 69 |
| 5 | 4.91 | 343 | 4.58 | 205 | 5.58 | 711 | 4.49 | 175 | 4.20 | 92 | 4.10 | 72 |
| 6 | 4.98 | 378 | 4.59 | 209 | 5.31 | 552 | 4.49 | 175 | 4.20 | 92 | 4.12 | 76 |
| 7 | 5.00 | 388 | *4.80 | 294 | 5.25 | 519 | 4.48 | 171 | 4.20 | 92 | 4.14 | 80 |
| 8 | 4.94 | 358 | *5.00 | 388 | 5.10 | 438 | *4.47 | 168 | *4.10 | 72 | 4.15 | 82 |
| 9 | 4.90 | 338 | 5.18 | 481 | 5.00 | 388 | *4.45 | 161 | 3.96 | 53 | 4.15 | 82 |
| 10 | 4.85 | 316 | 5.00 | 388 | 5.00 | 388 | *4.43 | 154 | 3.86 | 43 | 4.12 | 76 |
| 11 | 4.81 | 298 | 4.91 | 343 | 5.00 | 388 | *4.42 | 150 | 3.84 | 41 | 4.10 | 72 |
| 12 | 4.79 | 290 | 4.79 | 290 | 4.99 | 383 | *4.42 | 150 | 3.81 | 39 | 4.09 | 71 |
| 13 | 4.79 | 290 | 4.75 | 273 | 4.96 | 368 | *4.44 | 157 | 3.77 | 36 | 4.08 | 69 |
| 14 | 4.77 | 281 | 4.68 | 244 | 4.86 | 320 | *4.42 | 150 | 3.79 | 37 | 4.08 | 69 |
| 15 | 4.79 | 290 | 4.67 | 240 | 4.82 | 303 | 4.40 | 144 | 3.85 | 42 | 4.09 | 71 |
| 16 | 4.82 | 303 | 4.60 | 212 | 4.77 | 281 | 4.39 | 141 | 3.89 | 45 | 4.04 | 64 |
| 17 | 4.82 | 303 | 4.58 | 205 | 4.70 | 252 | 4.37 | 136 | 3.92 | 48 | 4.00 | 58 |
| 18 | 4.80 | 294 | 4.50 | 178 | 4.67 | 240 | 4.36 | 133 | 3.96 | 55 | 3.97 | 54 |
| 19 | 4.78 | 286 | 4.49 | 175 | 4.61 | 216 | 4.35 | 130 | 4.02 | 61 | 3.95 | 52 |
| 20 | 4.75 | 273 | 4.50 | 178 | 4.60 | 212 | 4.33 | 124 | 4.05 | 65 | 3.97 | 54 |
| 21 | 4.71 | 256 | 4.50 | 178 | 4.60 | 212 | 4.32 | 122 | 4.09 | 71 | 3.98 | 56 |
| 22 | 4.69 | 248 | 4.46 | 161 | 4.59 | 209 | 4.31 | 119 | 4.14 | 80 | 3.99 | 57 |
| 23 | 4.67 | 240 | 4.43 | 154 | 4.57 | 202 | 4.30 | 116 | 4.16 | 84 | 4.03 | 62 |
| 24 | 4.62 | 220 | 4.43 | 154 | 4.56 | 198 | 4.29 | 114 | 4.18 | 88 | 3.98 | 56 |
| 25 | 4.62 | 220 | 4.43 | 154 | 4.55 | 195 | 4.28 | 111 | 4.18 | 88 | 3.95 | 52 |
| 26 | 4.59 | 209 | 4.45 | 161 | 4.55 | 195 | 4.26 | 106 | 4.14 | 80 | 3.96 | 53 |
| 27 | 4.56 | 198 | 4.43 | 154 | 4.54 | 192 | 4.26 | 106 | 4.09 | 71 | 3.99 | 57 |
| 28 | 4.57 | 202 | 4.40 | 144 | 4.55 | 195 | 4.25 | 104 | 4.05 | 65 | 3.96 | 53 |
| 29 | 4.57 | 202 | 4.38 | 138 | 4.54 | 192 | 4.24 | 102 | 4.05 | 65 | 3.94 | 51 |
| 30 | 4.60 | 212 | 4.37 | 136 | 4.53 | 188 | 4.24 | 102 | 4.09 | 71 | 3.92 | 48 |
| 31 | 4.55 | 195 | 4.35 | 130 | .... | ... | 4.23 | 99 | ... | .... | *3.91 | 47 |

* Gauge height interpolated.

MONTHLY DISCHARGE of Crowsnest River near Frank, Alta., for 1911.

Drainage area, 170 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square mile. | Depth in inches on Drainage area. | Total in acre-feet. |
| January | 58 | 37 | 50.3 | 0.296 | 0.34 | 3,093 |
| February | 50 | 41 | 46.1 | 0.271 | 0.28 | 2,560 |
| March | 94 | 39 | 58.1 | 0.342 | 0.39 | 3,572 |
| April | 643 | 66 | 224.0 | 1.340 | 1.50 | 13,329 |
| May | 973 | 358 | 642.0 | 3.780 | 4.36 | 39,475 |
| June | 1,385 | 503 | 85.5 | 5.030 | 5.61 | 50,876 |
| July | 492 | 195 | 297.0 | 1.750 | 2.02 | 18,262 |
| August | 481 | 130 | 220.0 | 1.390 | 1.60 | 13,527 |
| September | 519 | 130 | 306.0 | 1.800 | 2.01 | 18,208 |
| October | 181 | 99 | 135.7 | 0.798 | 0.92 | 8,344 |
| November | 99 | 36 | 68.5 | 0.403 | 0.45 | 4,076 |
| December | 82 | 47 | 63.4 | 0.373 | 0.43 | 3,898 |
| The year | ..... | ..... | ..... | ..... | ..... | 179,220 |

CROWSNEST RIVER NEAR COLEMAN, ALTA.

This gauging station, located on the S.W. ¼ Sec. 12, Tp. 8, Rge. 5, W. 5th Mer., at a private bridge about two and a half miles west of Coleman, was established July 28, 1910, by H. C. Ritchie.

The gauge is a plain staff graduated to feet and hundredths, placed at the left bank about 150 feet upstream from the bridge. It is referred to a bench-mark on top of a post thirty feet west of the gauge (elevation 10.16).

The channel is straight for 30 feet above and 300 feet below the station. Both banks are high, wooded, and will not overflow. The bed of the stream is of sand and gravel. The current is fairly swift.

Discharge measurements are made from the bridge during high-water stages, the initial point for soundings being on line with the face of the left abutment. In low stages the stream is waded three quarters of a mile downstream from the bridge.

The gauge is read by Prudent LeGal, whose house is about forty feet away. The tables of daily and monthly discharge for 1911 have not yet been prepared, but will be compiled during 1912 and published with the records for that year.

DISCHARGE MEASUREMENTS of Crowsnest River, near Coleman, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 11 | J. E. Degnan | 27.0 | 42.80 | 0.991 | 3.95 | 42.44 |
| May 1 | do | 30.0 | 58.73 | 2.015 | 4.71 | 118.35 |
| May 23 | A. W. P. Lowrie | 42.0 | 84.25 | 3.580 | 5.64 | 301.67 |
| June 12 | do | 39.0 | 121.80 | 4.200 | 7.11 | 512.02 |
| July 1 | do | 37.0 | 87.16 | 4.030 | 5.92 | 352.11 |
| July 18 | do | 36.0 | 79.00 | 2.740 | 5.42 | 216.29 |
| Aug. 3 | do | 35.0 | 68.85 | 2.250 | 5.10 | 154.80 |
| Aug. 26 | do | 44.0 | 42.11 | 2.030 | 4.72 | 85.38* |
| Sept. 18 | do | 44.0 | 44.46 | 2.260 | 4.89 | 100.28 |
| Oct. 15 | N. M. Sutherland | 33.0 | 78.70 | 0.600 | 4.80 | 47.24 |
| Oct. 17 | do | 43.0 | 37.70 | 2.450 | 4.80 | 92.22* |
| Dec. 4 | do | 31.5 | 24.23 | 1.790 | 4.08 | 43.40† |
| Dec. 18 | do | 28.0 | 22.48 | 1.420 | 4.45 | 31.90x |

*Gauged one mile below regular station.
xGauged one half mile below rod.
†Open water.

MEAN DAILY GAUGE-HEIGHT, IN FEET, of Crowsnest River, near Coleman, Alta., for 1911.

| Day. | March. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ... | 3.93 | 4.72 | 6.42 | 5.72 | 4.90 | 4.52 | 4.60 | 3.22 | 4.14 |
| 2 | ... | 3.82 | 4.73 | 6.70 | 5.72 | 5.02 | 4.52 | 4.60 | 3.22 | 4.13 |
| 3 | | 3.80 | 4.80 | 6.83 | 5.63 | 4.95 | 4.62 | 4.53 | 3.22 | 4.13 |
| 4 | | 3.81 | 4.82 | 6.72 | 5.54 | 4.90 | 5.53 | 4.52 | 3.22 | 4.13 |
| 5 | ... | 3.85 | 4.85 | 6.41 | 5.51 | 4.92 | 5.46 | 4.53 | 3.21 | 4.12 |
| 6 | ... | 3.80 | 4.90 | 6.10 | 5.52 | 5.00 | 5.43 | 4.52 | 3.20 | 4.10 |
| 7 | ... | 3.80 | 5.13 | 6.13 | 5.50 | 5.02 | 5.31 | 4.52 | 3.40 | 4.10 |
| 8 | ... | 3.81 | 5.14 | 6.10 | 5.51 | 5.35 | 5.10 | 4.45 | 3.50 | 4.10 |
| 9 | ... | 3.90 | 5.30 | 6.13 | 5.34 | 5.30 | 5.00 | 4.45 | 5.30 | 4.10 |
| 10 | ... | 3.90 | 5.10 | 6.10 | 5.30 | 5.11 | 5.06 | 4.43 | 5.45 | 4.10 |
| 11 | ... | 3.84 | 4.93 | 6.32 | 5.31 | 5.13 | 5.12 | 4.41 | 5.40 | 4.10 |
| 12 | ... | 3.80 | 4.91 | 6.93 | 5.30 | 5.12 | 5.20 | 4.40 | 5.10 | 4.11 |
| 13 | ... | 3.83 | 4.93 | 6.50 | 5.25 | 4.90 | 5.21 | 5.00 | 5.60 | 3.96 |
| 14 | | 3.82 | 4.93 | 6.73 | 5.32 | 4.93 | 5.10 | 4.40 | 5.80 | 3.96 |
| 15 | ... | 3.84 | 5.30 | 6.63 | 5.30 | 4.92 | 5.02 | 4.60 | 5.90 | 3.96 |
| 16 | ... | 3.85 | 6.12 | 6.52 | 5.31 | 4.83 | 4.95 | 4.30 | 5.70 | 3.96 |
| 17 | ... | 3.86 | 6.11 | 6.30 | 5.33 | 4.81 | 4.83 | 4.00 | 5.63 | 3.96 |
| 18 | ... | 3.90 | 6.00 | 6.21 | 5.22 | 4.75 | 4.81 | 4.10 | 5.63 | 4.45 |
| 19 | 3.51 | 3.92 | 5.80 | 6.20 | 5.20 | 4.72 | 4.73 | 4.00 | 5.60 | 4.70 |
| 20 | 3.62 | 3.95 | 5.70 | 6.13 | 5.10 | 4.73 | 4.72 | 3.35 | 5.55 | 4.40 |
| 21 | 3.70 | 4.15 | 5.72 | 6.10 | 5.12 | 4.72 | 4.72 | 3.32 | 5.50 | 4.03 |
| 22 | 3.74 | 4.13 | 5.70 | 6.12 | 5.10 | 4.70 | 4.70 | 3.32 | 4.00 | 4.06 |
| 23 | 3.90 | 4.23 | 5.63 | 6.10 | 5.12 | 4.64 | 4.71 | 3.32 | 3.00 | 4.05 |
| 24 | 3.96 | 4.33 | 5.43 | 6.10 | 5.11 | 4.62 | 4.71 | 3.32 | 3.50 | 3.95 |
| 25 | 4.05 | 4.50 | 5.20 | 6.21 | 5.11 | 4.61 | 4.65 | 3.32 | 4.00† | 3.00 |
| 26 | 3.80 | 4.56 | 5.43 | 6.12 | 5.10 | 4.55 | 4.65 | 3.32 | 4.40† | 3.04 |
| 27 | 3.80 | 4.62 | 5.45 | 5.93 | 5.02 | 4.60 | 4.62 | 3.30 | 4.40 | 3.06 |
| 28 | 3.92 | 4.63 | 5.42 | 5.83 | 5.00 | 4.53 | 4.61 | 3.30 | 4.63 | 3.09 |
| 29 | 4.00 | 4.65 | 5.42 | 5.75 | 4.93 | 4.53 | 4.61 | 3.30 | 4.70 | 4.05 |
| 30 | 3.85 | 4.70 | 5.51 | 5.75 | 4.90 | 4.53 | 4.61 | 3.25 | 4.24 | 4.10 |
| 31 | 3.81 | ... | 6.21 | .... | 4.93 | 4.52 | ... | 3.23 | . | 4.10 |

† Snow.

MISCELLANEOUS DISCHARGE MEASUREMENTS made in Oldman River, Alta., Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq.-ft.* | *Feet per second.* | *Sec.-ft.* |
| May 1 | J. E. Degnan | Blairmore Creek | Sec. 3-8-4-5 | 24.0 | 20.38 | 2.758 | 56.210 |
| May 20 | A. W. P. Lowrie | " | " 34-7-4-5 | 23.6 | 22.84 | 3.000 | 68.610 |
| June 9 | " | " | " 10-8-4-5 | 22.8 | 16.97 | 2.380 | 40.520 |
| July 1 | " | " | " 10-8-4-5 | 9.6 | 7.23 | 2.690 | 19.440 |
| July 17 | " | " | " 10-8-4-5 | 7.5 | 4.57 | 1.680 | 7.710 |
| Aug. 3 | " | " | " 10-8-4-5 | 7.6 | 5.08 | 1.530 | 7.880 |
| Aug. 25 | " | " | " 10-8-4-5 | 7.4 | 5.51 | 1.820 | 10.020 |
| Sept. 15 | " | " | " 10-8-4-5 | 23.0 | 15.26 | 1.600 | 24.460 |
| Aug. 25 | " | Callum Creek | N.E. 6-10-1-5 | 15.3 | 10.474 | 1.243 | 12.930 |
| Oct. 23 | " | Carmichall's Spring | S.E. 34-13-29-4 | x | | | 0.130 |
| June 26 | " | Elton's Ditch | Sec. 19-8-1-5 | 2.10 | 0.50 | 0.780 | 0.390 |
| Sept. 10 | " | Fortier's Spring* | " 17-7-1-5 | x | | | Nil. |
| Sept. 10 | " | " * | " 17-7-1-5 | x | | | 0.011 |
| Sept. 10 | " | " * | " 17-7-1-5 | x | | | 0.003 |
| Oct. 11 | N. M. Sutherland | Fortier's Spring East | " 17-7-1-5 | x | | | 0.008 |
| Oct. 11 | " | " West | " 17-7-1-5 | x | | | 0.011 |
| Nov. 3 | " | " | " 17-7-1-5 | x | | | 0.006 |
| Dec. 1 | " | " | " 17-7-1-5 | x | | | 0.002 |
| April 11 | J. E. Degnan | Gold Creek | " 31-7-3-5 | 21.0 | 12.48 | 1.054 | 13.16 |
| April 29 | " | " | " 31-7-3-5 | 22.9 | 21.21 | 2.382 | 50.530 |
| May 23 | A. W. P. Lowrie | " | " 30-7-3-5 | 24.0 | 29.13 | 2.900 | 85.000 |
| June 10 | " | " | " 30-7-3-5 | 24.0 | 26.06 | 2.770 | 71.940 |
| July 18 | A. W. P. Lowrie | Gold Creek | Sec. 30-7-3-5 | 21.80 | 16.39 | 1.740 | 28.59 |
| Aug. 4 | " | " | " 30-7-3-5 | 20.70 | 14.93 | 1.680 | 25.12 |
| Aug. 26 | " | " | " 30-7-3-5 | 21.20 | 15.40 | 1.580 | 24.30 |
| Sept. 18 | " | " | " 30-7-3-5 | 23.50 | 23.40 | 2.930 | 68.55 |
| Oct. 17 | N. M. Sutherland | " | " 30-7-3-5 | 21.10 | 20.38 | 1.850 | 37.68 |
| April 29 | J. E. Degnan | Lyon Creek | N.E. 35-7-4-5 | 20.60 | 18.50 | 2.718 | 50.30 |
| May 22 | A. W. P. Lowrie | " | Sec. 26-7-4-5 | 20.80 | 21.46 | 2.930 | 62.89 |
| June 9 | " | " | " 26-7-4-5 | 15.80 | 12.09 | 2.320 | 28.02 |
| June 30 | " | " | " 26-7-4-5 | 13.00 | 6.93 | 1.310 | 9.08 |
| Oct. 16 | N. M. Sutherland | " | " 26-7-4-5 | 10.70 | 6.72 | 1.480 | 9.92 |
| May 1 | J. E. Degnan | McGillivary Creek | S.E. 7-8-4-5 | 18.80 | 19.16 | 1.570 | 30.09 |
| June 10 | A. W. P. Lowrie | " | Sec. 7-8-4-5 | 20.20 | 25.01 | 2.000 | 50.12 |
| July 1 | " | " | " 7-8-4-5 | 17.40 | 18.09 | 1.170 | 21.11 |
| July 18 | " | " | N.E. 7-8-4-5 | 15.40 | 12.54 | 0.750 | 9.40 |
| Aug. 3 | " | " | Sec. 7-8-4-5 | 15.00 | 11.34 | 0.620 | 7.07 |
| Aug. 26 | " | " | N.E. 7-8-4-5 | 15.20 | 11.24 | 0.510 | 6.74 |
| Sept. 18 | " | " | " 7-8-4-5 | 15.80 | 13.53 | 0.694 | 9.39 |
| Oct. 17 | N. M. Sutherland | " | " 7-8-4-5 | 10.00 | 4.88 | 1.360 | 6.65 |
| Dec. 4 | " | " | " 7-8-4-5 | 5.20 | 1.78 | 0.890 | 1.58 |
| May 1 | J. E. Degnan | Nez Perce Creek | Sec. 17-8-4-5 | 14.10 | 12.54 | 2.184 | 27.39 |
| July 1 | A. W. P. Lowrie | " | " 17-8-4-5 | 12.60 | 8.84 | 0.890 | 7.89 |
| July 18 | " | " | " 17-8-4-5 | 12.20 | 6.87 | 0.60 | 4.130 |
| Sept. 18 | " | " | " 17-8-4-5 | 12.30 | 6.75 | 0.84 | 5.670 |
| Oct. 17 | N. M. Sutherland | " | " 17-8-4-5 | 10.00 | 4.40 | 0.96 | 4.240 |
| July 25 | J. C. Milligan | Sorrel Horse Creek | N.E. 26-13-30-4 | x | | | 0.028 |
| July 25 | " | " | " 26-13-30-4 | x | | | 0.039 |
| July 25 | " | Spring A | L.S. 14 Sec. 35-13-1-5 | x | | | 0.028 |
| July 25 | " | " | S.W. 2-14-1-5 | x | | | 0.010 |
| July 25 | " | " | L.S.13,Sec.35-13-1-5. | x | | | 0.018 |
| Oct. 20 | " | " | S.E. 21-14-1-5 | x | | | 0.069 |
| July 12 | " | Spring Creek | N.W.,Sec.31-14-1-5 | x | | | 0.010 |
| July 13 | " | " | N.E. 6-15-1-5 | x | | | 0.899 |
| July 14 | " | " | S.W. 5-15-1-5 | x | | | 0.018 |
| July 24 | " | " | N.E. 28-13-2-5 | x | | | 0.050 |
| July 25 | " | " | N.E. 27-13-1-5 | x | | | 0.018 |
| July 27 | " | " | S.E. 34-13-1-5 | x | | | 0.010 |
| Aug. 16 | " | " | N.W. 23-11-30-4 | x | | | 0.018 |
| Sept. 26 | A. W. P. Lowrie | " | S.E. 34-13-29-4 | x | | | 0.515 |
| Oct. 20 | J. C. Milligan | " | S.E. 21-14-1-5 | x | | | 0.590 |
| Sept. 16 | A. W. P. Lowrie | Summit Creek | S.W. 12-8-6-5 | 4.40 | 0.87 | 0.69 | 0.600 |
| Nov. 14 | N. M. Sutherland | " | S.W. 12-8-6-5 | 4.00 | 0.98 | 0.49 | 0.480 |
| April 18 | J. E. Degnan | Willow Creek | S.W. 36-12-28-4 | 24.00 | 30.80 | 2.57 | 79.110 |
| July 24 | A. W. P. Lowrie | " | S.W. 36-12-28-4 | 22.30 | 27.10 | 1.56 | 42.300 |

MISCELLANEOUS DISCHARGE MEASUREMENTS made in Oldman River, Alta., Drainage Basin, in 1911.—*Continued.*

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. ft.* | *Feet per Sec.* | *Sec.-ft.* |
| Oct. 21 | N. M. Sutherland... | Willow Creek | S.W. 36-12-28-4 | 87 00 | 108 60 | 1 00 | 108 800 |
| May 1 | J. E. Degnan | York Creek | N.W. 34-7-4-5 | 21 50 | 21 22 | 1 943 | 41 24 |
| May 20 | A. W. P. Lowrie... | " | " | 22 60 | 24 37 | 2 720 | 66 35 |
| June 9 | " | " | " | 23 80 | 24 81 | 3 040 | 75 44 |
| July 1 | " | " | " | 21 60 | 20 76 | 2 040 | 42 40 |
| July 17 | " | " | " | 19 00 | 15 12 | 1 140 | 17 30 |
| Aug. 3 | " | " | " | 20 00 | 14 04 | 1 090 | 15 26 |
| Aug. 25 | " | " | " | 20 00 | 11 50 | 0 970 | 11 12 |
| Sept. 15 | " | " | " | 20 07 | 15 23 | 1 370 | 20 82 |
| Oct. 17 | N. M. Sutherland. | " | " | 11 50 | 8 55 | 1 290 | 11 01 |

xWeir measurement.

## WATERTON RIVER DRAINAGE BASIN.

### *General Description.*

Waterton River rises in the northwestern portion of the state of Montana, in the eastern slope of the Rocky mountains. It flows in a northerly direction and passing through a chain of lakes near the International Boundary, known as Waterton lakes, it continues in a north and easterly direction and finally empties into Belly River near Stand Off, Alta.

The topography of the basin is of a varied character, ranging from the mountainous regions of Montana to the rolling prairie of Southern Alberta. The tributaries are situated mostly in the upper portion of the basin, near the International Boundary, and from the west side.

There is a large snow-fall in the upper portion of the basin, and the melting of this, combined with heavy rains, often causes big floods on this river in the early summer. Thereafter the river steadily decreases in volume, until the minimum is reached about mid-winter.

Waterton lakes offer a very favourable site for a storage reservoir, approximately 14 miles long and one mile wide. The steep rocky banks of the narrows make an ideal site for the construction of a dam. The flow could be more than doubled during the summer months and used for irrigation purposes, or a power project could easily be developed.

### WATERTON RIVER AT WATERTON MILLS.

This station was established on August 26, 1908, by P. M. Sauder. It is located on the N.E. ¼ Sec. 8, Tp. 2, Rge. 29, W. 4th Mer., about 250 feet below the river's outlet from the Lower Waterton Lake.

The gauge, which is a plain staff graduated to feet and hundredths, is placed in a stilling box at the right bank. The zero (elev., 90.51) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated within six feet of the gauge.

The channel is wide and straight for 250 feet above and 400 feet below the station. Both banks are high, slightly wooded, and will not overflow. The bed of the stream is rough and rocky with a stable cross-section. The current is always rather swift at mid-stream.

Discharge measurements are made from a cable car during high stages. In low water the stream can be waded almost all the way across, the deep channel in the centre being taken from the cable car. Measurements are often affected by the heavy winds, which frequently occur. The points for soundings are marked by a tagged wire stretched above the cable.

During 1911, the gauge was read by Mr. H. H. Hanson. The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken, and before it could be repaired the rating station was frozen up and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked.

### CROOKED CREEK NEAR WATERTON MILLS, ALTA.

This station was established on September 15, 1909, by H. C. Ritchie. It was at first located on the S.E. ¼ Sec. 22, Tp. 2, Rge. 29, W. 4th Mer., but as an observer could not be secured at this point it was moved on June 15, 1911, by L. J. Gleeson to a point about 250 feet from Ernest Allred's house on the S.W. ¼ Sec. 23, Tp. 2, Rge. 29, W. 4th Mer. It is now about 27 miles from Cardston and 3 miles from Waterton Mills Post Office.

The stream flows in one channel at all stages. It is straight for forty feet above and twenty feet below the station. The bank is high, covered with brush, and not liable to overflow. The right bank is low, clear at the station, and liable to overflow. The bed is composed of gravel, but is not liable to shift, except in flood stage.

Discharge measurements are made by wading thirty feet upstream from the gauge. The initial point for soundings is at a stump of a small tree on the left bank. During flood periods the stream cannot be waded at this point, but gaugings can be made at a bridge about one and a half miles downstream.

The gauge which is a plain staff graduated to feet and hundredths, is nailed to a corral post in the centre of the creek. The zero (elev., 91.86) is referred to two nail-heads in a post (assumed elev., 100.00), situated about ten feet south of the gauge.

During 1911, the gauge was read by Ernest Allred.

The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken, and before it could be repaired the rating station was frozen up and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked.

## BELLY RIVER DRAINAGE BASIN.

### *General Description.*

Belly River rises near Chief mountain in northern Montana. The main stream is augmented, on the United States side of the boundary line, by Middle Fork, and, on the Canadian side, by North Fork. From the junction with North Fork on Sec. 21, Tp. 1, Rge. 28, W. 4th Mer., the river flows in a winding, northeasterly course until it is joined by Oldman River in Sec. 27, Tp. 9, Rge. 23, W. 4th Mer., where it turns southeasterly, and, after making a loop, flows in a northeasterly direction until it joins Bow River in Sec. 27, Tp. 11, Rge. 13, W. 4th Mer., and forms South Saskatchewan River.

The topography of the basin is of the most varied character, ranging from the mountainous regions of Montana and the rolling prairie and foothills at the boundary, to the level prairie from Lethbridge to the junction with Bow River. The upper tributaries drain a forested region, but the main stream flows through a deep valley with many bluffs of large whitewood on its banks.

There is an abundant snow-fall in the upper portion of the basin, but the precipitation diminishes until semi-arid conditions are met near Lethbridge. At first Belly River is a comparatively clear stream, but soon after crossing the boundary line it becomes turbid, especially at times of high water. The greater portion of the sediment is caused by the washing away of banks and cutting of new channels. Freshets caused by melting snow and heavy rains are frequent in the summer. The maximum flow usually occurs in June or July, and after that the flow gradually decreases until it reaches the minimum in January or February.

As yet very little use has been made of the water in this basin. In the upper regions where water could easily be diverted it is not required for irrigation purposes, and further downstream it would be an expensive undertaking.

There a couple of small private irrigation schemes diverting water from Belly River, and the city of Lethridge will in the near future receive their domestic supply from the same source.

The Alberta Railway and Irrigation Company have located and may construct a canal from Belly river to supply their irrigation system, if St. Mary River is found deficient. There are also a number of sites in the upper regions where power can be developed and which will no doubt be developed when there is a market.

### Belly River near Mountain View, Alta.

This station was established on Nov. 1, 1911, by H. R. Carscallen. It is situated in the N.E. ¼ Sec. 5, Tp. 2, Rge. 23, W. 4th Mer., and is six miles southwest of Mountain View post office.

The channel is straight for 250 feet above the station and for 350 below. The bed is composed of gravel and sand. The right bank is high, slightly wooded and will not overflow except during extreme high water. The left bank is low, quite well wooded, and will overflow.

Discharge measurements are made by means of a cable-car, tagged wire, and stay wire. The initial point for soundings is a ship-spike driven into the downstream cable-support on the left bank, and is marked by red paint on the measuring wire.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to a post sunk in the stream bed at the right bank. The zero (elev., 88.16) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated beneath the centre of the cable support on the right bank.

The gauge was read by J. N. West, but as this station was established so late in the season there are not sufficient data to compute daily and monthly discharges, and the records for this station for 1911 will be completed during 1912, and published with the records for that year.

DISCHARGE MEASUREMENTS of Belly River near Mountain View, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Nov. 1 | L. J. Gleeson | 86.5 | 212.20 | 0.880 | 2.075 | 187.60 |
| Dec. 10 | D. D. Macleod | 83.0 | 168.86 | 0.603 | 2.010 | 101.82* |

* Ice conditions

## MAMI CREEK NEAR MOUNTAIN VIEW, ALTA.

This station was established on August 13, 1909, by H. C. Ritchie. It is located at the traffic bridge on the road allowance north of the N.E. ¼ Sec. 18, Tp. 2, Rge. 27, W. 4th Mer., and is just below the junction of the east and west branches.

The channel is curved for about 100 feet above the bridge and straight for 200 feet below. Both banks are high, clear of brush, rocky and liable to overflow in extreme high water. The bed of the stream is composed of stones covered with sand and gravel.

Discharge measurements are made during high water from the bridge. In low water the east branch dries up and the west branch is waded just above the junction.

The gauge is a plain staff graduated to feet and hundredths, fastened to a pile supporting the bridge at the left bank. The zero (elev., 90.70) is referred to nailheads (assumed elev. 100.00) on a pile on the right bank.

Gaugings were made at this station during 1911, but, as the flow of the stream is very small and records were of little value, no observer was employed. As two applications, one for irrigation and the other for domestic purposes, have recently been received, arrangements are being made to employ an observer during 1912. No water was diverted in 1911.

The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken, and, before it could be repaired, the rating station was frozen up and the meter could not be rated. The results of the gaugings are therefore withheld until the meter is rated, and the computations checked.

## CHRISTIANSON DITCH NEAR CALDWELL, ALTA.

This station was established on Sept. 14, 1911, by L. J. Gleeson. It is situated in the S.E. ¼ Sec. 12, Tp. 3, Rge. 8, W. 4th Mer., on Elias Christianson's irrigation ditch. It is six miles northwest of Mountain View and one quarter of a mile south of Big Bend police post.

The channel is straight for 300 feet above and 100 feet below the station. The main ditch is about 400 feet long and four feet wide, and has a good fall.

Discharge measurements have been made with a small Price meter, but a weir would give more satisfactory results.

The gauge is a plain staff graduated to feet and tenths. It is driven into the channel of the ditch, on the line of the gauging section. The zero of the gauge (elev., 96.30) is referred to a bench-mark (assumed elev., 100.00) situated on the left bank close to the gauge.

No water was diverted through this ditch during 1911 after the gauge was established, and therefore there are no records.

## BELLY RIVER NEAR STAND OFF, ALTA.

This station was established on May 27, 1909, by H. C. Ritchie. It is eighteen miles south of the town of Macleod, and is located on the S.E. ¼ Sec. 21, Tp. 6, Rge. 25, W. 4th Mer., 200 yards from George Pearson's house.

The gauge, which is a plain staff graduated to feet and hundredths, is secured by braces to the left bank. The zero (elev., 92.51) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated 35 feet upstream from the gauge.

Discharge measurements are made during the open season from the traffic bridge on the S.E. ¼ Sec. 21, Tp. 6, Rge. 25, W. 4th Mer., the points for soundings being painted on the lower chord of the superstructure. During the frozen period they are made at or near the gauge.

For a distance of 75 feet above and 60 feet below the section, the channel is straight. The current runs smooth with a moderate velocity over a bed of clean gravel. Both banks are low, free from brush, and liable to overflow during high stages of the river. Since the establishment of this station the cross-section has changed very little, if any, but owing to the sharp turns in the channel the river is liable to take a new course altogether in times of extreme flood.

During 1911, the gauge was read by George Pearson. The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken and before it could be repaired, the rating station was frozen up and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked. During the winters of 1910-11 and 1911-12 records of the flow under the ice were secured.

### Belly River near Lethbridge, Alta.

This station was established on August 31, 1911, by A. W. P. Lowrie. It is located at the traffic bridge on the N.W. ¼ Sec. 1, Tp. 19, Rge. 22, W. 4th Mer., and is about two and a half miles from Lethbridge post office.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to the second pier from the east end of the bridge. The zero of the gauge (elev., 87.82) is referred to a bench-mark on the west face of the east pier (assumed elev., 100.00).

The channel is straight for 800 feet above and 2000 feet below the station. The right bank is not very high and might overflow in flood stages of the stream. The left bark is low and is liable to overflow during very high water. The bed of the stream is composed of sand and gravel but is not liable to shift.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is near the west end of the bridge and distances are marked on the hand-rail with white paint.

Tables of daily and monthly discharge for 1911, have not been computed. These will be finished during 1912 and will be published with the records for that year.

Discharge Measurements of Belly River, near Lethbridge, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 6 | L. J. Gleeson | 243 6 | 1,080 5 | 1 25 | .... | 1,354 7 |
| May 9 | do | 476 6 | 2,844 0 | 2 92 | .. | 8,300 0 |
| May 27 | A. W. P. Lowrie | 458 9 | 2,993 7 | 3 27 | .. | 9,813 9 |
| June 15 | do | 573 6 | 3,947 3 | 4 96 | ... | 19,592.8 |
| July 5 | do | 449 0 | 2,960 4 | 2 90 | .. | 8,605 0 |
| July 21 | do | 372 0 | 2,014 1 | 2 01 | ... | 4,051 3 |
| Aug. 16 | do | 378 1 | 2,297 5 | 2 31 | . | 5,297.4 |
| Aug. 31 | do | 353 5 | 1,733 8 | 1 57 | 1 28 | 2,719 4 |
| Oct. 25 | N. Sutherland | 388 0 | 1,672 2 | 1 43 | 1 21 | 2,388.6 |
| Dec. 6 | D. D. MacLeod | 200 0 | 1,288 5 | 1 27 | 0 75 | 1,631.6 |

## ST. MARY RIVER DRAINAGE BASIN.

*General Description.*

St. Mary River, an important tributary of the Belly River and so indirectly of the South Saskatchewan River, heads in northern Montana on the eastern slope of the main range of the Rocky Mountains. It starts from the great Blackfoot glacier and receives affluents from numerous lesser glaciers. These streams unite within a short distance from their source and flow into Upper St. Mary lake. Below this lake, and in close proximity to it, is lower St. Mary lake, the aggregate lengths of the two being about 22 miles. The river flows out of the lower lake, at an elevation of 4460 feet above mean sea-level, and takes a northerly course through the foothills to the International Boundary. From the boundary it flows in a northeasterly direction, through a rolling country, finally emptying into the Belly River near Lethbridge, Alta.

The basin is bounded on the south by the Rocky mountains, on the west by the watershed between Belly and St. Mary rivers and on the east by the watershed between Milk and St. Mary rivers. The upper portion of the basin is heavily timbered and receives its precipitation mostly in the shape of snow-fall, but the lower and major portion is totally devoid of tree growth, and has a small precipitation.

The river flows through a very deep valley. It has steep banks and this makes the diversion of water from this stream for irrigation an expensive undertaking. In Canada, the Alberta Railway and Irrigation Company has water rights on this river. The head-gates of their canal are at Kimball, five miles north of the boundary, and they already have 231 miles of ditch constructed which irrigates land surrounding Lethbridge. Further construction is being planned and the works, when completed, will irrigate approximately 500,000 acres of land, at present semi-arid.

As this is an international river, discharge measurements are taken by the Hydrographic Surveys services of both the Canadian and American governments. It is expected that in the near future the hydrographers of both countries will use a common gauging station at a point as near the International Boundary as a suitable site can be found. It is hoped in this way to obtain results of high degree of accuracy and perfectly satisfactory to both countries.

## FIDLER BROTHERS' DITCH AT BOUNDARY CREEK, ALTA.

This station was established on Sept. 13, 1911, by L. J. Gleeson. It is situated in the S.E. ¼ Sec. 19, Tp. 1, Rge. 26, W. 4th Mer., on Fidler Brothers' irrigation ditch, one quarter of a mile southwest of Cardston.

The channel of the ditch is straight for a distance of thirty feet above and twenty feet below the gauge. The soil is clay with a little sand.

Discharge measurements can be made with a small Price meter, but on account of the small velocity a weir would be more suitable.

The gauge is placed in the centre of the ditch, 100 feet downstream from the head-gate. It is a plain staff graduated to feet and tenths. The zero of the gauge (elev., 93.62) is referred to a wooden bench-mark (assumed elev., 100.00) situated on the left bank, eight feet west of the gauge, and on the line of the gauging section.

As the ditch was not used after the gauge was established no records were secured at this station in 1911.

## ST. MARY RIVER AT KIMBALL, ALTA.

This station was established by the Alberta Railway and Irrigation Company in 1905. It is located on the S.W. ¼ Sec. 25, Tp. 1, Rge. 25, W. 4th Mer., about half a mile above the company's dam and head-gate.

The channel is straight for about 450 feet above and 400 feet below the station. Both banks are high and not liable to overflow. The right bank is partly covered with scrub above the station, but at and below the station it is clear. The bed of the stream is of gravel and is liable to slight changes. The current is quite uniform all the way across the stream.

Discharge measurements are made by means of a cable car, and tagged wire at high and ordinary stages. At low-water periods, the river can be waded. The initial point for soundings is the zero of the tagged wire, which is 44.8 feet from the inside edge of the cable support on the right bank.

The gauge, which is a plain staff graduated to feet and hundredths, is set in the right bank, a few feet upstream from the cable. A trench lined with plank connects a stilling box about the gauge with the channel in low water. The zero of the gauge (elevation 86.87) is referred to a permanent iron bench-mark (assumed elevation, 100.00) situated near the cable support on the right bank. In 1911, the gauge was read by J. M. Dunn, ditch rider for the A. R. & I. Co.

This station is not satisfactory during the frozen period and during the winter months gauge-heights and discharges are observed at a temporary gauging station located at the traffic bridge about two miles below the regular station.

### DISCHARGE MEASUREMENTS of St. Mary River at Kimball, in 1911.

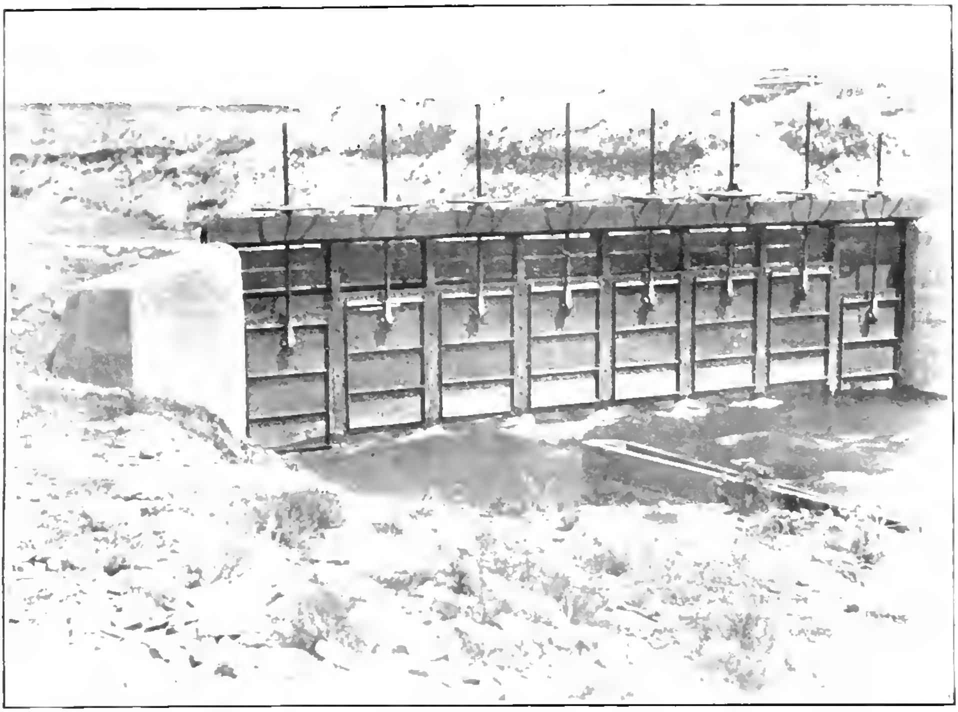
| DATE. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-feet.* | *Ft. per sec.* | *Feet.* | *Sec.-feet.* |
| Jan. 16 | W. H. Green | 100 7 | 173 9 | 1 21 | 6 26 | 210 2 |
| Feb. 3 | " | 66 0 | 100 3 | 2 02 | 5 53 | 202 4 |
| Mar. 16 | J. E. Degnan. | 68 0 | 82 1 | 1 73 | 4 95 | 141 6 |
| Mar. 29 | " | 150 0 | 224 6 | 1 60 | 4 63 | 360 3 |
| April 1 | " | 65 0 | 108 1 | 2 95 | 4 15 | 318 8 |
| April 8 | L. J. Gleeson. | 62 8 | 97 2 | 2 80 | 5 20 | 271 8 |
| April 21 | " | 220 8 | 376 5 | 1 42 | 2 82 | 536 2 |
| May 1 | " | 223 8 | 499 4 | 2 16 | 3 28 | 1076 2 |
| May 16 | " | 227 4 | 893 1 | 4 27 | 5 00 | 3812 0 |
| May 19 | " | 226 0 | 796 1 | 3 70 | 4 56 | 2945 3 |
| June 3 | " | 228 0 | 869 6 | 3 83 | 5 00 | 3330 3 |
| June 7 | " | 227 5 | 858 6 | 3 84 | 4 78 | 3298 6 |
| June 9 | " | 226 9 | 836 0 | 3 90 | 4 77 | 3261 3 |
| June 20 | " | 228 0 | 904 2 | 4 26 | 5 05 | 3855 4 |
| June 27 | " | 227 7 | 841 1 | 3 90 | 4 78 | 3284.0 |
| July 12 | " | 224 8 | 604 8 | 2 81 | 3 81 | 1702 0 |
| July 20 | " | 225 0 | 574 9 | 2 76 | 3 70 | 1584 9 |
| July 20 | " | 225 0 | 573 8 | 2 76 | 3 70 | 1582 1 |
| Aug. 3 | " | 222 5 | 513 7 | 2 28 | 3 41 | 1170 9 |
| Aug. 16 | " | 222 5 | 473 9 | 2 24 | 3 28 | 1059.5 |
| Aug. 16 | " | 222 0 | 473 9 | 2 28 | 3 28 | 1082 8 |
| Aug. 29 | " | 222 4 | 415 0 | 1 78 | 2 97 | 736 9 |
| Sept. 7 | " | 225 0 | 598 4 | 2 74 | 3 77 | 1639 7 |
| Sept. 23 | " | 224 5 | 575 5 | 2 48 | 3 65 | 1428 5 |
| Oct. 7 | " | 221 6 | 436 1 | 1 72 | 3 07 | 753 1 |
| Nov. 16 | " | 65 0 | 122 3 | 2 62 | 6 30 | 320 6 |
| Dec. 12 | D. D. McLeod | 102 0 | 103 3 | 1 28 | 1 51 | 131 9 |

## Daily Gauge-height and Discharge of St. Mary River at Kimball, for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 6.43 | 220 | 5.85 | 206 | 5.45 | 194 | 4.15 | 319 | 3.29 | 1074 | 4.27 | 2388 |
| 2 | 6.43 | 219 | 5.84 | 206 | 5.40 | 188 | 4.20 | 322 | 3.29 | 1074 | 4.87 | 3480 |
| 3 | 6.40 | 218 | 5.53 | 202 | 5.40 | 188 | 4.53 | 287 | 3.32 | 1108 | 5.01 | 3793 |
| 4 | 6.35 | 216 | 5.55 | 204 | 5.35 | 183 | 4.57 | 289 | 3.39 | 1188 | 5.10 | 4000 |
| 5 | 6.15 | 213 | 5.54 | 203 | 5.33 | 181 | 4.58 | 289 | 3.57 | 1407 | 4.98 | 3725 |
| 6 | 6.35 | 215 | 5.65 | 214 | 5.30 | 178 | 5.05 | 265 | 3.87 | 1794 | 4.88 | 3502 |
| 7 | 6.36 | 214 | 5.65 | 211 | 5.21 | 169 | 5.04 | 265 | 3.97 | 1933 | 4.77 | 3270 |
| 8 | 6.10 | 210 | 5.47 | 196 | 5.12 | 159 | 5.20 | 272 | 3.97 | 1933 | 4.79 | 3310 |
| 9 | 5.60 | 203 | 5.35 | 183 | 5.14 | 161 | 5.00 | 263 | 3.92 | 1863 | 4.77 | 3270 |
| 10 | 4.95 | 194 | 5.35 | 183 | 4.90 | 136 | 2.55 | 296 | 3.90 | 1835 | 4.77 | 3270 |
| 11 | * 4.95 | 194 | 5.45 | 194 | 4.85 | 131 | 2.45 | 330 | 3.87 | 1794 | 4.88 | 3502 |
| 12 | * 5.62 | 203 | 5.40 | 188 | 4.85 | 131 | 2.30 | 250 | 3.80 | 1700 | 5.09 | 3977 |
| 13 | 6.30 | 213 | 5.35 | 183 | 4.90 | 136 | 2.30 | 250 | 3.87 | 1794 | 5.19 | 4207 |
| 14 | 6.30 | 213 | 5.27 | 175 | 4.90 | 136 | 2.32 | 260 | 3.99 | 1961 | 5.27 | 4391 |
| 15 | 6.31 | 213 | 5.25 | 173 | 4.87 | 133 | 2.35 | 275 | 4.42 | 2629 | 5.27 | 4391 |
| 16 | 6.26 | 212 | 5.23 | 171 | 4.95 | 142 | 2.40 | 300 | 5.03 | 3839 | 5.24 | 4322 |
| 17 | 6.25 | 212 | 5.20 | 167 | 4.85 | 131 | 2.50 | 360 | 4.96 | 3680 | 5.19 | 4207 |
| 18 | 6.30 | 213 | 5.23 | 171 | 4.95 | 145 | 2.53 | 382 | 4.80 | 3330 | 5.17 | 4161 |
| 19 | 6.35 | 213 | 5.30 | 178 | 5.06 | 158 | 2.55 | 398 | 4.57 | 2891 | 5.10 | 4000 |
| 20 | 6.35 | 213 | 5.35 | 183 | 5.25 | 181 | 2.65 | 472 | 4.39 | 2579 | 5.04 | 3862 |
| 21 | 6.30 | 213 | 5.35 | 183 | 5.20 | 181 | 2.82 | 607 | 4.30 | 2435 | 4.97 | 3702 |
| 22 | 6.25 | 212 | 5.38 | 185 | 5.25 | 189 | 2.95 | 722 | 4.28 | 2404 | 4.90 | 3545 |
| 23 | 6.12 | 210 | 5.38 | 185 | 5.20 | 186 | 3.10 | 870 | 4.27 | 2388 | 4.92 | 3590 |
| 24 | 6.15 | 210 | 5.40 | 188 | 5.20 | 186 | 3.14 | 912 | 4.25 | 2358 | 4.97 | 3702 |
| 25 | 6.10 | 210 | 5.41 | 189 | 5.00 | 165 | 3.18 | 954 | 4.14 | 2187 | 5.17 | 4161 |
| 26 | 6.00 | 208 | 5.42* | 190 | 4.60 | 285 | 3.28 | 1063 | 4.07 | 2080 | 4.97 | 3702 |
| 27 | 5.95 | 208 | 5.44 | 192 | 4.45 | 331 | 3.34 | 1131 | 3.97 | 1933 | 4.78 | 3290 |
| 28 | 5.95 | 208 | 5.44 | 192 | 4.43 | 337 | 3.37 | 1165 | 3.89 | 1822 | 4.65 | 3038 |
| 29 | 5.95 | 208 | ... | | 4.65 | 360 | 3.39 | 1188 | 3.80 | 1700 | 4.57 | 2891 |
| 30 | 5.95 | 208 | | | 4.55 | 351 | 3.28 | 1063 | 3.76 | 1648 | 4.57 | 2891 |
| 31 | 6.00 | 208 | .. | | 4.40 | 335 | . | ... | 3.87 | 1794 | ....... | ...... |

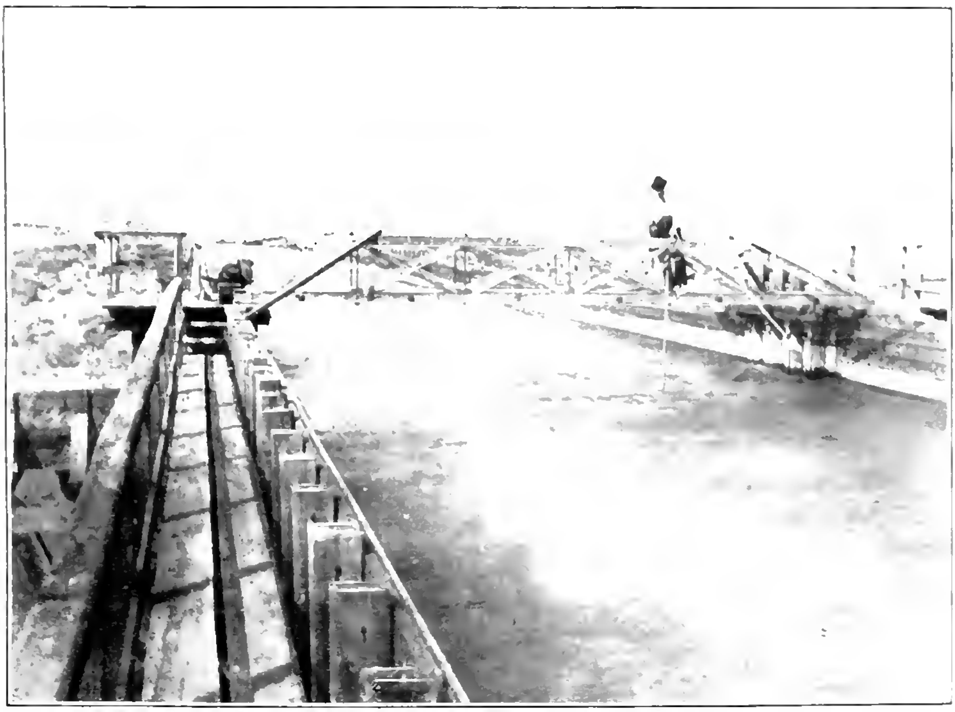
Notes:—* Interpolated from Jan. 1st to April 17th ice conditions.

Plate No. 18.



Headgates of Alberta Railway and Irrigation Company Canal at Kimball. Taken by F. H. Peters.

Plate No. 19.



Gauging Station on A. R. & I. Co. Canal at Rolph Creek Flume. Taken by F. H. Peters.

## Daily Gauge-height and Discharge of St. Mary River at Kimball, for 1911.

| Day. | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 4.47 | 2714 | 3.46 | 1272 | 2.91 | 684 | 3.25 | 1030 | 2.52 | 375 | 6.01 | 308 |
| 2 | 4.37 | 2547 | 3.42 | 1224 | 2.95 | 722 | 3.21 | 986 | 2.56 | 405 | 5.89 | 303 |
| 3 | 4.28 | 2404 | 3.41 | 1212 | 2.99 | 760 | 3.21 | 986 | 2.56 | 405 | 5.79 | 299 |
| 4 | 4.24 | 2342 | 3.36 | 1154 | 3.39 | 1188 | 3.18 | 954 | 2.56 | 405 | 5.85 | 301 |
| 5 | 4.22 | 2311 | 3.36 | 1154 | 4.07 | 2080 | 3.15 | 922 | 2.53 | 382 | 5.61 | 291 |
| 6 | 4.18 | 2249 | 3.36 | 1154 | 3.88 | 1808 | 3.11 | 880 | 2.51 | 368 | 5.42 | 282 |
| 7 | 4.17 | 2234 | 3.44 | 1248 | 3.77 | 1661 | 3.07 | 840 | 2.51 | 368 | 5.57 | 289 |
| 8 | 4.12 | 2156 | 3.38 | 1177 | 3.75 | 1635 | 2.99 | 760 | 4.48 | 351 | 5.59 | 290 |
| 9 | 4.07 | 2080 | 3.58 | 1420 | 3.65 | 1508 | 2.96 | 734 | 4.51 | 335 | 5.56 | 288 |
| 10 | 3.97 | 1933 | 3.56 | 1395 | 3.61 | 1458 | 2.96 | 734 | 4.48 | 319 | ...... | * 236 |
| 11 | 3.87 | 1794 | 3.41 | 1212 | 3.64 | 1495 | 2.93 | 704 | 4.59 | 303 | ...... | * 184 |
| 12 | 3.81 | 1714 | 3.41 | 1212 | 3.68 | 1545 | 2.96 | 734 | 5.52 | 286 | 1.50 | 132 |
| 13 | 3.76 | 1648 | 3.41 | 1212 | 3.71 | 1583 | 2.94 | 713 | 6.21 | 317 | 1.55 | 140 |
| 14 | 3.71 | 1583 | 3.34 | 1131 | 3.74 | 1622 | 3.00 | 770 | 6.35 | 324 | 1.55 | 140 |
| 15 | 3.74 | 1622 | 3.27 | 1052 | 3.65 | 1508 | 2.96 | 734 | 6.32 | 323 | 1.55 | 140 |
| 16 | 3.76 | 1648 | 3.28 | 1063 | 3.65 | 1508 | 2.91 | 684 | 6.30 | 322 | 1.60 | 149 |
| 17 | 3.84 | 1754 | 3.26 | 1041 | 3.58 | 1420 | 2.86 | 641 | 6.13 | 311 | 1.60 | 149 |
| 18 | 3.80 | 1700 | 3.20 | 975 | 3.56 | 1395 | 2.83 | 616 | 5.56 | 288 | 1.60 | 149 |
| 19 | 3.74 | 1622 | 3.21 | 986 | 3.51 | 1332 | 2.81 | 598 | 6.11 | 313 | 1.60 | 149 |
| 20 | 3.68 | 1545 | 3.21 | 986 | 3.15 | 1260 | 2.79 | 582 | 6.06 | 311 | 1.70 | 167 |
| 21 | 3.66 | 1520 | 3.26 | 1041 | 3.46 | 1272 | 2.77 | 566 | 6.01 | 309 | 1.80 | 185 |
| 22 | 3.64 | 1495 | 3.16 | 933 | 3.56 | 1395 | 2.78 | 574 | 5.90 | 303 | 1.55 | 140 |
| 23 | 3.66 | 1520 | 3.11 | 880 | 3.64 | 1495 | 2.77 | 566 | 5.82 | 300 | 1.55 | 140 |
| 24 | 3.66 | 1520 | 3.07 | 840 | 3.61 | 1458 | 2.77 | 566 | 5.76 | 297 | 2.38* | 134 |
| 25 | 3.56 | 1395 | 3.04 | 810 | 3.58 | 1420 | 2.71 | 518 | 5.77 | 298 | 3.20 | 129 |
| 26 | 3.56 | 1395 | 3.05 | 820 | 3.48 | 1296 | 2.61 | 442 | 5.72 | 295 | 3.30 | 128 |
| 27 | 3.56 | 1395 | 3.06 | 830 | 3.46 | 1272 | 2.64 | 465 | 6.23 | 318 | 3.30 | 128 |
| 28 | 3.53 | 1358 | 3.01 | 780 | 3.49 | 1308 | 2.61 | 442 | 7.26 | 365 | 3.45 | 128 |
| 29 | 3.47 | 1284 | 2.97 | 744 | 3.36 | 1154 | 2.54 | 390 | 7.16 | 360 | 3.70 | 128 |
| 30 | 3.56 | 1395 | 2.96 | 734 | 3.29 | 1074 | 2.56 | 405 | 7.16 | 360 | 3.45 | 128 |
| 31 | 3.56 | 1395 | 2.91 | 684 | .... | .... | 2.57 | 412 | ...... | ...... | 3.58* | 128 |

NOTES:—* Interpolated from Nov. 8 to Dec. 31 ice conditions.

## Monthly Discharge of St. Mary River at Kimball, for 1911.

(Drainage area 472 square miles.)

| Month. | Discharge in Second-Feet | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| January | 220 | 194 | 207 | 44 | .507 | 12,937 |
| February | 214 | 167 | 190 | 40 | .417 | 10,508 |
| March | 360 | 131 | 246 | 41 | .473 | 12,034 |
| April | 1188 | 250 | 719 | 1.12 | 1.250 | 31,376 |
| May | 3839 | 1074 | 2456 | 4.38 | 5.050 | 127,249 |
| June | 4391 | 2388 | 3390 | 7.74 | 8.636 | 217,269 |
| July | 2714 | 1284 | 1999 | 3.77 | 4.346 | 109,630 |
| August | 1420 | 684 | 1052 | 2.21 | 2.548 | 64,217 |
| September | 2080 | 684 | 1382 | 2.92 | 3.258 | 81,949 |
| October | 1030 | 390 | 710 | 1.43 | 1.649 | 41,547 |
| November | 405 | 286 | 346 | 70 | .781 | 19,874 |
| December | 308 | 128 | 218 | 40 | .461 | 11,664 |
| The year | .... | | .. | | .... | 740,254 |

## Alberta Railway and Irrigation Company Canal near Kimball, Alta.

This station was established July 26, 1910, by F. H. Peters. It is located at the flume over Rolph creek on the S. E.¼ Sec. 21, Tp. 2, Rge. 24, W. 4th Mer., It is by trail fifteen miles southeast of Cardston, and six miles northeast of Kimball.

The flume carries all the water delivered to the company's irrigation system. It is 768 feet long, 27 feet wide, and 6 feet high (inside dimensions) and is perfectly straight. It is built of smooth plank and has a fall of one hundredth of a foot in sixteen feet.

Discharge measurements are made from a small foot bridge spanning the flume at a point about midway from the ends. The initial point for soundings is the inside face of the left side of the left side of the flume.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to the side of the flume five feet dowstream from the foot-bridge. The datum of the gauge is the bottom of bottom of the flute.

During 1911, the gauge was read by J. M. Dunn, ditch rider for the company. The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken and before it could be repaired the rating station was frozen up and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked.

## Rolph Creek near Kimball, Alta.

This station was established on May 17, 1911, by L. J. Gleeson. It is located at the Alberta Railway and Irrigation Company's flume, in Sec. 21, Tp. 2, Rge. 24, W. 4th Mer. It is six miles northeast of Kimball and fifteen miles southeast of Cardston.

The channel is straight for 200 feet above the station, and for 150 feet below. The bed is gravelly in character, and shifts during high water. Both banks are low and bare, and overflow at high stages. While passing under the flume the water is carried over an apron built to protect the piling from scour.

Discharge measurements are made by wading at or near the gauge.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the downstream side of the right-hand wing-wall. The zero (elev., 93.461) is referred to the sill of a trestle ten feet from the gauge (assumed elev., 100.00).

The gauge was read four times a week by J. M. Dunn. The records for this station, for 1911, will be completed during 1912 and published with the records for that year.

## Lee Creek at Cardston, Alta.

This station was established on June 28, 1909, by H. C. Ritchie. It is located at a foot-bridge in the eastern portion of the town of Cardston in the N.W. ¼ Sec. 10, Tp. 3, Rge. 25, W. 4th Mer.

The channel is straight for 100 feet above and 300 feet below the station. The bed of the stream is composed of gravel with a thin covering of soft mud. In high water the current is very swift, but in low water is comparatively slow. The right bank is of clay formation, high and not liable to overflow. The left is low, gravelly and overflows during high water.

On account of the constantly shifting character of the bed during periods of high water, measurements are made at the most suitable sections near the gauge. When the water is low, a section, 150 feet upstream from the footbridge, is used. The initial point of soundings is on the left bank and is marked with a stake driven into the left bank, close to the water's edge.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a pile near the east end of the foot-bridge. The zero (elev., 91.60) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated on the right bank 100 feet upstream from the gauge.

During 1911, the gauge was read by Mr. Stirling Williams. The commutator of the meter used in making most of the discharge measurements at this station in 1911 was accidentally broken, and before it could be repaired the rating station was frozen up and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked.

## St. Mary River at Whitney's Ranche, Alta.

This station was established on October 13, 1911, by H. R. Carscallen. It is located on the N.E. ¼ Sec. 26, Tp. 7, Rge. 22, W. 4th Mer., near W. D. Whitney's house, and is about ten miles from Lethbridge post office.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to a post sunk in the bed of the river at the right bank. The zero of the gauge (elev., 87.55) is referred to a permanent iron bench-mark (assumed elev., 100.00) near Mr. Whitney's house.

The channel is straight for 900 feet above and 1,000 feet below the station. The right bank is low and may overflow during flood stage of the stream. The left bank is high, and will not overflow. The bed of the stream is composed of gravel and is not liable to shift.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is a spike driven into the downstream sill of the tower on the left bank.

The gauge is read by W. D. Whitney. Tables of daily and monthly discharge for 1911 have not yet been computed. These will be finished during 1912 and published with the records for that year.

Cable Support and Fastenings at Station on North Branch of Milk River at Peters' Ranche.
Taken by F. H. Peters.

DISCHARGE MEASUREMENTS of St. Mary River, at Whitney's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Oct. 28 | N. M. Sutherland | 177.0 | 249.88 | 2.25 | 2.23 | 561.40x |
| Nov. 29 | D. D. Macleod | 190.0 | 214.49 | 1.40 | 2.43 | 297.84 |
| Dec. 15 | do | 180.0 | 151.55 | 1.32 | 2.20 | 199.34 |

x Slush Ice.

## MILK RIVER DRAINAGE BASIN.

### *General Description.*

Milk River rises on the eastern slope of the foothills in the Blackfoot Indian reserve in the United States. Its head-waters run down in two main streams which are known, after entering Canada, as the north and south branches. The north branch runs in a northeasterly direction through the Blackfoot reserve for a distance of about fifteen miles and then enters Canada near the "quarter mound" on the south side of Section 3, Township 1, Range 23, west of the 4th Meridian. From the International Boundary the stream continues in a northeasterly direction for about nine miles, when it bends to the east and runs in an easterly direction through the second tier of townships to its junction with the south branch at the centre of Section 20, Township 2, Range 18, west of the 4th Meridian.

The south branch runs to the south and east of, and parallels, the north branch for a distance of about 48 miles, as the crow flies, through the Blackfoot reserve and then enters Canada near the "quarter mound" on the south side of Section 1, Township 1, Range 20, west of the 4th Meridian. From the International Boundary it runs in a northeasterly direction to its junction with the north branch. From the junction of the two branches Milk River runs in an easterly direction through the second tier of townships in Canada to the east boundary of Range 7. From this point the river runs in a southeasterly direction to its first point of crossing the International Boundary into the United States. This first point of crossing is near the "quarter mound" on the south side of Section 5, Township 1, Range 5, west of the 4th Meridian. From this point the river meanders in an easterly direction through Canada and United States to a point on the International Boundary about 900 feet west of the east boundary of Section 1, Township 1, Range 5, west of the 4th Meridian, where it finally crosses into the United States. This point is known as the "Eastern Crossing". The length of the course of Milk River in Canada from the western crossing of the north branch to the eastern crossing is 179 miles. The length of the course of the south branch in Canada is twenty miles.

Throughout its course in Canada from the western crossing of the north branch to the eastern crossing, Milk River runs through a well defined valley bordered on each side by a range of hills. The whole of its water-shed in Canada is bald prairie land. The river receives a number of small tributary creeks along its course, all of which discharge a considerable volume of water during the spring freshets; usually they all dry up by about July 1, and have no considerable discharge again until late in the fall, when some of them have a small flow for perhaps a month before the freeze-up.

The general conditions of flow in the river are such as are typical of all rivers which have a watershed devoid of tree growth; that is, it is subject to extreme floods during the freshet period and to correspondingly low flow during the summer months. From its head-waters to the eastern crossing the total area of the watershed of Milk River is 2,448 square miles. Of this total amount 1,645 square miles are in Canada and 803 square miles in the United States.

### NORTH BRANCH OF MILK RIVER NEAR PETER'S RANCHE, ALTA.

This station was established by P. M. Sauder and F. H. Peters on July 21, 1909. It is located 150 feet upstream from the north boundary of the N.E. ¼ Sec. 13, Tp. 1, Rge. 23, W. 4th. Mer. It is seven miles by trail from Taylorville post office and fifteen miles from Kimball.

The stream flows in one channel, which is about forty feet wide at ordinary stages. It is straight for about 200 feet above the station and is almost straight for about 300 feet below. Both banks are composed of solid clay. The right is high and not liable to overflow, but the left may overflow at extreme flood stage of the stream. The bed of the stream is composed of a layer of soft mud and stones over a solid clay foundation.

Discharge measurements are made during high water by means of a cable, car, tagged wire, and stay wire. The initial point for soundings is the face of a post on the left bank. At low water the discharge is measured by wading at a point about one quarter of a mile downstream from the cable.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. The zero (elev., 86.87) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated on the left bank, directly beneath the turn-buckle on the cable.

During 1911, the gauge was read by Bert Mecham from April 19 to September 25, and by Wm. Wheeler from September 25 to November 2nd.

The commutator of the meter used in making most of the discharge measurements at this station during 1911 was accidentally broken, and before it could be repaired the rating station was frozen and the meter could not be rated. The records are, therefore, withheld until the meter is rated and the computations checked.

## North Branch Milk River at Knight's Ranche, Alta.

This station was established by F. H. Peters and P. M. Sauder on July 17, 1909. It is located in Sec. 18, Tp. 2, Rge. 20, W. 4th Mer., almost directly south of the Knight Sugar Company's Horse-shoe Ranche buildings. It is about 36 miles by trail from Milk River station.

The stream flows in one channel about 41 feet wide at ordinary stages. It is straight for about 150 feet above and 100 feet below the station. The right bank is composed of clay, is high and not liable to overflow. The left bank is composed of light sandy loam, is low and liable to overflow to quite a distance, during high stages of the stream. The bed of the stream is composed of mud, gravel and boulders.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the face of a cedar post on the right bank. Discharge measurements can be made by wading during low water.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 97.70) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated close to the intitial point for soundings. As an observer could not be secured the gauge was not read during 1911.

The commutator of the meter used in making the discharge measurements at this station in 1911 was accidentally broken, and before it could be repaired the rating station was frozen up and the meter could not be rated or the computations checked.

## North Branch of Milk River near Mackie's Ranche, Alta.

This station was established July 16, 1909, by P. M. Sauder and F. H. Peters. It is located on the S.W. 1/4 Sec. 19, Tp. 2, Rge. 18, W. 4th Mer. It is seventeen miles by trail from Milk River, three miles north of the Mackie ranche buildings, and one mile west of the junction of the north and south branches.

The stream flows in one channel which at ordinary stages is about 60 feet wide. It is straight for 200 feet above and about 150 feet below the station. Both banks are low and liable to overflow at high stages. The bed of the stream is composed of gravel and is constantly changing.

Discharge measurements are made by means of a cable, car, tagged wire, and stay wire. The initial point for soundings is the face of a cedar post planted in the north bank and marked "O†OO".

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 91.50) is referred to a permanent iron bench-mark (assumed elev., 100.00), located 25 feet from the edge of the right bank, and under the cable.

As it was impossible to secure an observer the gauge was not read during 1911.

Discharge Measurements of North Branch of Milk River near Mackie's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 19 | L. G. Gleeson | 60 0 | 85 55 | 0 86 | 2 16 | 73 57 |
| May 4 | do | 59 6 | 79 30 | 0 72 | 2 01 | 56 96 |
| May 12 | do | 60 4 | 75 00 | 0 63 | 1 95 | 47 60 |
| May 21 | J. E. Degnan | 59 0 | 55 21 | 0 88 | 2 11 | 48 63 |
| June 10 | do | 61.0 | 82 67 | 1 22 | 2 50 | 101 44 |
| July 1 | do | 57 0 | 47 40 | 0 74 | 1 96 | 35 34 |
| Aug. 3 | do | 60 0 | 49 83 | 0 71 | 1 94 | 35 56 |
| Aug. 29 | do | 61 0 | 50 25 | 0 64 | 1 92 | 32 14 |
| Oct 17 | do | 61 0 | 68 24 | 0 73 | 2 06 | 50 95 |

## South Branch of Milk River at Mackie's Ranche, Alta.

This station was established July 14, 1909, by P. M. Sauder and F. H. Peters. It is seventeen miles by trail from Milk River and is located on the N.W. 1/4 Sec. 31, Tp. 1, Rge. 18, W.

4th Mer., about one quarter of a mile upstream from Mackie Bros' ranche buildings, and is about five miles upstream from the junction of the north and south branches of Milk River.

The stream flows in one channel and is straight for about 150 feet above the station and for 100 feet below. The right bank is composed of sand and gravel and is liable to overflow. The left bank is composed of clay and is high. The bed of the stream consists of gravel and sandand is liable to shift.

Discharge measurements are made during high stages by means of a cable, car, tagged wire, and stay wire, and at low stages by wading. The initial point for soundings is the face of a cedar post planted in the left bank.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. The zero of the gauge (elev., 86.60) is referred to a permanent iron bench-mark (assumed elev., 100.00) located on the left bank, directly under the cable and five feet from the initial point of soundings.

During 1911, the gauge was read by Mrs. F. Cathro.

DISCHARGE MEASUREMENTS of South Branch of Milk River at Mackie's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 18 | L. J. Gleason | 87.8 | 119.12 | 1.760 | 3.16 | 210.65 |
| May 5 | do | 88.2 | 119.20 | 1.730 | 3.10 | 206.40 |
| May 12 | do | 80.8 | 110.00 | 1.620 | 2.96 | 178.70 |
| May 20 | J. E. Degnan | 89.0 | 148.55 | 2.031 | 3.40 | 301.75 |
| June 9 | do | 88.0 | 131.25 | 1.470 | 3.14 | 194.02 |
| July 1 | do | 88.0 | 137.80 | 1.629 | 3.26 | 224.39 |
| Aug. 1 | do | 85.0 | 83.50 | 0.998 | 2.60 | 83.41 |
| Aug. 4 | do | 85.0 | 79.06 | 0.948 | 2.55 | 75.00 |
| Aug. 28 | do | 63.5 | 48.92 | 0.698 | 2.21 | 34.12 |
| Oct. 16 | do | 84.0 | 71.42 | 0.876 | 2.46 | 62.67 |

DAILY GAUGE-HEIGHT AND DISCHARGE of South Branch of Milk River at Mackie's Ranche, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | | | 3.10 | 204 | 3.15 | 196 |
| 2 | .... | .... | | | 3.09 | 202 | 3.15 | 196 |
| 3 | .... | .... | | | 3.09 | 203 | 3.15 | 196 |
| 4 | .... | .... | | | 3.05 | 193 | 3.10 | 184 |
| 5 | .... | .... | | | 3.05 | 193 | 3.05 | 172 |
| 6 | .... | .... | | | 3.05 | 193 | 3.15 | 196 |
| 7 | .... | .... | | | 3.07 | 199 | 3.10 | 184 |
| 8 | .... | .... | | | 3.07 | 201 | 3.10 | 184 |
| 9 | .... | .... | | | 3.05 | 198 | 3.15 | 196 |
| 10 | .... | .... | | | 3.07 | 204 | 3.10 | 184 |
| 11 | .... | .... | | | 3.07 | 205 | 3.10 | 184 |
| 12 | .... | .... | | | 2.87 | 158 | 3.15 | 196 |
| 13 | .... | .... | | | 3.05 | 202 | 3.15 | 196 |
| 14 | .... | .... | | | 3.15 | 228 | 3.00 | 160 |
| 15 | .... | .... | | | 3.60 | 365 | 2.79 | 116 |
| 16 | .... | .... | | .... | 4.41 | 660 | 2.79 | 116 |
| 17 | .... | .... | 3.11 | 198 | 5.05 | 961 | 2.83 | 124 |
| 18 | .... | .... | 3.20 | 224 | 3.79 | 426 | 2.80 | 118 |
| 19 | .... | .... | 3.40 | 281 | 3.50 | 333 | 2.80 | 118 |
| 20 | .... | .... | 3.19 | 221 | 3.40 | 301 | 2.79 | 116 |
| 21 | 5.05 | .... | 3.39 | 279 | 3.25 | 255 | 2.79 | 116 |
| 22 | 6.20 | .... | 3.40 | 283 | 3.25 | 250 | 2.73 | 105 |
| 23 | .... | .... | 3.59 | 341 | 3.25 | 246 | 2.70 | 100 |
| 24 | .... | .... | 3.39 | 281 | 3.25 | 243 | 3.32 | 242 |
| 25 | .... | .... | 3.29 | 253 | 3.20 | 226 | 5.21 | 982 |
| 26 | .... | .... | 3.29 | 253 | 3.25 | 237 | 4.95 | 853 |
| 27 | .... | .... | 3.29 | 255 | 3.39 | 273 | 4.41 | 613 |
| 28 | .... | .... | 3.10 | 287 | 3.39 | 269 | 4.51 | 653 |
| 29 | .... | .... | 3.30 | 258 | 3.36 | 258 | 3.72 | 363 |
| 30 | .... | .... | 3.09 | 202 | 3.30 | 237 | 3.37 | 257 |
| 31 | .... | .... | .... | .... | 3.20 | 209 | .... | .... |

DAILY GAUGE-HEIGHT AND DISCHARGE of South Branch of Milk River at Mackie's Ranche, Alta., for 1911.—*Continued.*

| Day. | July | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.25‡ | 223 | 2.51 | 74 | 2.21 | 34 | 2.59 | 82 | 2.60 | 83 |
| 2 | 3.23 | 217 | 2.59 | 82 | 2.24 | 37 | 2.54 | 74 | 2.61 | 85 |
| 3 | 3.23 | 217 | 2.46 | 63 | 2.35 | 49 | 4.55 | 76 | 2.60 | 83 |
| 4 | 3.10 | 184 | 2.55 | 76 | 2.40 | 55 | 2.59 | 82 | 2.63* | 83 |
| 5 | 3.09 | 182 | 2.56 | 77 | 2.55 | 76 | 2.65 | 92 | 2.65 | .... |
| 6 | 2.90 | 138 | 2.58 | 80 | 3.86‡ | 408 | 2.68 | 97 | 2.69 | .... |
| 7 | 2.86 | 130 | 2.55 | 76 | 3.97 | 446 | 2.64 | 90 | 2.65 | .... |
| 8 | 2.70 | 100 | 2.49 | 67 | 3.67 | 348 | 2.63 | 88 | 2.63 | .... |
| 9 | 2.69 | 98 | 2.39 | 54 | 3.60 | 326 | 2.60 | 83 | 2.50 | .... |
| 10 | 2.66 | 93 | 2.38 | 53 | 3.40 | 265 | 2.58 | 80 | 2.40 | .... |
| 11 | 2.60 | 83 | 2.40 | 55 | 3.21 | 212 | 2.57 | 78 | 2.35 | .... |
| 12. | 2.50 | 68 | 2.40 | 55 | 3.02 | 165 | 2.59 | 82 | 2.37 | .... |
| 13. | 2.46 | 63 | 2.45 | 62 | 2.90 | 138 | 2.55 | 76 | 2.38 | .... |
| 14 | 2.41 | 56 | 2.46 | 63 | 2.81 | 120 | 2.55 | 76 | 2.37 | .... |
| 15. | 2.39 | 54 | 2.45 | 62 | 2.74 | 107 | 2.54 | 74 | 2.36 | .... |
| 16. | 2.41 | 56 | 2.44 | 60 | 2.70 | 100 | 1.46 | 63 | 2.37 | .... |
| 17 | 2.41 | 56 | 2.43 | 59 | 2.75 | 109 | 2.45 | 62 | .... | .... |
| 18. | 2.44 | 60 | 2.41 | 56 | 2.73 | 105 | 2.44 | 60 | .... | .... |
| 19. | 2.45 | 62 | 2.41 | 56 | 2.69 | 98 | 2.44 | 60 | .... | .... |
| 20. | 2.45 | 62 | 2.41 | 56 | 2.66 | 93 | 2.43 | 59 | .... | .... |
| 21. | 2.44 | 60 | 2.24 | 37 | 2.65 | 92 | 2.43 | 59 | .... | .... |
| 22. | 2.43 | 59 | 2.26 | 39 | 2.59 | 82 | 2.45 | 62 | .... | .... |
| 23. | 2.42 | 58 | 2.21 | 34 | 2.55 | 76 | 2.44 | 60 | .... | .... |
| 24 | 2.42 | 58 | 2.26 | 39 | 2.69 | 98 | 2.47 | 64 | .... | .... |
| 25. | 2.38 | 53 | 2.16 | 30 | 2.75 | 109 | 2.48 | 65 | .... | .... |
| 26. | 2.36 | 50 | 2.15 | 29 | 2.70 | 100 | 2.50 | 68 | .... | .... |
| 27 | 2.34 | 48 | 2.15 | 29 | 2.71 | 102 | 2.53 | 72 | .... | .... |
| 28 | 2.33 | 47 | 2.21 | 34 | 2.69 | 98 | 2.56 | 77 | .... | .... |
| 29. | 2.33 | 47 | 2.19 | 32 | 2.68 | 97 | 2.58 | 80 | .... | .... |
| 30 | 2.31 | 44 | 2.24 | 37 | 2.66 | 93 | 2.57 | 78 | .... | .... |
| 31 | 2.42 | 58 | 2.22 | 35 | | | 2.58 | 80 | .... | .... |

NOTE—The ice started to break up on March 21, and the following day the gauge was carried out. It was re-established on April 17.

‡ Lowered the gauge one foot.

* Ice covered after Nov. 4.

MONTHLY DISCHARGE of South Branch of Milk River at Mackie's Ranche, Alta., for 1911.

Drainage area, 441 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (17-30) | 341 | 198 | 258 | 0.585 | 0.30 | 7,172 |
| May | 961 | 158 | 275 | 0.624 | 0.72 | 16,909 |
| June | 982 | 100 | 254 | 0.576 | 0.64 | 15,114 |
| July | 223 | 44 | 90 | 0.204 | 0.24 | 5,534 |
| August | 82 | 29 | 54 | 0.122 | 0.14 | 3,320 |
| September | 446 | 34 | 141 | 0.320 | 0.36 | 8,390 |
| October | 97 | 59 | 74 | 0.168 | 0.19 | 4,550 |
| November (1-3) | 85 | 83 | 84 | 0.190 | 0.01 | 550 |
| The period | ......... | ......... | | | ......... | 61,539 |

### Milk River at Milk River, Alta.

This station was established by H. C. Ritchie on May 18, 1909, and re-established by F. H. Petres on July 3, 1909. It is located on the N.E. ¼ Sec. 21, Tp. 2, Rge. 16, W. 4th Mer., at the A. R. and I. railway bridge, one quarter of a mile south of the town of Milk River.

The stream flows in one channel at all stages and in ordinary stages is not more than 140 feet wide. The channel is almost straight for 300 feet above and below the station. The right bank is sandy, fairly high, and not liable to overflow. The left bank is lower and overflows during high water. The bed of the stream is composed of sand and fine gravel, which is constantly shifting.

Discharge measurements are made from the downstream side of the bridge at high water and in low water a wading section, about 50 feet upstream, is used.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to an old bridge-pile about twelve feet above the present bridge. As this gauge is liable to be carried out by ice or flood-water, a chain-gauge has been attached to the bridge and will be read if the staff goes out. The datum of the chain-gauge is the same as that of the staff. The zero of both gauges (elev., 90.97) is referred to a permanent iron bench-mark (assumed elev., 100.00), located on the left bank, twenty feet upstream from the bridge and thirty feet back from the bank.

During 1911, the gauge was read by Dan. O'Connell.

Discharge Measurements of Milk River at Milk River, Alta., in 1911.

| Date. | Hydrographer. | Width | Area of Section | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 14 | L. J. Gleeson | 130 4 | 160 51 | 1 610 | 2 04 | 258 60 |
| May 2 | N. McL. Sutherland | 128 5 | 141 08 | 1 590 | 1 85 | 223 81 |
| May 7 | L. J Gleeson | 142 3 | 186 30 | 1 920 | 2 26 | 358 65 |
| May 17 | N. McL. Sutherland | 76 0 | 484 14 | 3 500 | 4 72 | 1,692 23* |
| May 22 | J. E. Degnan | 129 0 | 157 40 | 1 676 | 2 10 | 263 82 |
| June 13 | do | 128 0 | 113 83 | 1 420 | 1 70 | 162 00 |
| June 28 | do | 152 5 | 245 10 | 2 090 | 2 70 | 512 00 |
| July 5 | do | 128 5 | 120 80 | 1 452 | 1 74 | 175 45 |
| July 29 | do | 112 0 | 69 82 | 1 076 | 1 20 | 75 12 |
| Aug. 10 | do | 129 5 | 128 58 | 1 342 | 1 73 | 172 60 |
| Aug. 30 | do | 113 0 | 67 47 | 0 989 | 1 22 | 66 78 |
| Sept. 7 | do | 130 0 | 294 50 | 2 660 | 3 24 | 783 48* |
| Sept. 8 | do | 127 0 | 269 11 | 2 480 | 2 88 | 667 15* |
| Sept. 9 | do | 125 0 | 259 15 | 2 481 | 2 83 | 643 38* |
| Sept. 15 | do | 129 0 | 102 04 | 1 447 | 1 63 | 147 70 |
| Oct. 14 | do | 127 0 | 83 75 | 1 356 | 1 53 | 113.58 |
| Oct. 20 | do | 128 0 | 85 82 | 1 317 | 1 53 | 112 48 |
| Nov. 10 | L. J. Gleeson and D. D. Macleod | *84 0 | 45 19 | 1 520 | 1 45 | 68 59 |
| Dec. 7 | D. D. MacLeod | *84 0 | 10 67 | 1 180 | 2 28 | 119 80‡ |
| Dec. 29 | do | *75 0 | 53 35 | 0 900 | 2 25 | 47 97‡ |

* Measurement not taken at regular stations, waded at a better cross-section. ‡Ice conditions.

Daily Gauge-height and Discharge of Milk River at Milk River, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.51 | 426 | 1.87 | 228 | 2.01 | 214 | 2.45 | 401 |
| 2 | 1.95 | 227 | 1.85 | 224 | 1.97 | 233 | 2.36 | 365 |
| 3 | 1.95 | 227 | 1.85 | 224 | 1.94 | 224 | 2.10 | 272 |
| 4 | 1.85* | 200 | 1.85 | 224 | 2.00 | 241 | 1.97 | 233 |
| 5 | 1.65* | 162 | 2.00 | 267 | 1.94 | 224 | 1.75 | 176 |
| 6 | 1.85* | 200 | 2.11 | 303 | 1.90 | 213 | 1.70 | 164 |
| 7 | 1.45 | 111 | 2.16 | 321 | 1.88 | 208 | 1.62 | 146 |
| 8 | 1.85 | 200 | 2.26 | 358 | 1.85 | 200 | 1.50 | 120 |
| 9 | 1.85 | 200 | 1.96 | 255 | 1.76 | 178 | 1.53 | 126 |
| 10 | 1.85 | 200 | 1.95 | 252 | 2.03 | 250 | 1.46 | 112 |
| 11 | 2.69 | 507 | 1.95 | 252 | 1.85 | 200 | 1.41 | 103 |
| 12 | 2.45 | 402 | 1.91 | 240 | 1.74 | 174 | 1.39 | 99 |
| 13 | 2.15 | 288 | 1.90 | 237 | 1.68 | 159 | 1.37 | 96 |
| 14 | 2.04 | 253 | 1.91 | 240 | 1.65 | 152 | 1.34 | 90 |
| 15 | 1.96 | 230 | 2.60 | 501 | 1.61 | 143 | 1.31 | 85 |
| 16 | 1.86 | 204 | 4.12 | 1,326 | 1.56 | 133 | 1.30 | 83 |
| 17 | 1.96 | 232 | 5.00 | 1,884 | 1.57 | 135 | 1.30 | 83 |
| 18 | 2.01 | 249 | 3.10 | 710 | 1.54 | 128 | 1.29 | 82 |
| 29 | 2.16 | 299 | 2.72 | 521 | 1.50 | 120 | 1.40 | 101 |
| 20 | 2.10 | 282 | 2.50 | 422 | 1.42 | 105 | 1.50 | 120 |
| 21 | 2.20 | 318 | 2.10 | 272 | 1.40 | 101 | 1.44 | 109 |
| 22 | 2.60 | 485 | 2.10 | 272 | 1.50 | 120 | 1.39 | 99 |
| 23 | 2.81 | 589 | 2.10 | 272 | 1.60 | 141 | 1.36 | 94 |
| 24 | 2.51 | 449 | 2.18 | 298 | 2.04 | 253 | 1.32 | 87 |
| 25 | 2.31 | 368 | 2.19 | 301 | 5.09 | 915 | 1.32 | 87 |
| 26 | 2.51 | 454 | 2.22 | 312 | 5.24 | 2,049 | 1.34 | 90 |
| 27 | 2.51 | 457 | 2.36 | 365 | 3.78 | 1,090 | 1.30 | 83 |
| 28 | 2.41 | 414 | 2.30 | 342 | 2.65 | 489 | 1.20 | 69 |
| 29 | 2.21 | 338 | 2.32 | 350 | 2.50 | 422 | 1.20 | 69 |
| 30 | 2.00 | 265 | 2.15 | 288 | 2.42 | 389 | 1.20 | 69 |
| 31 | .... | ... | 2.02 | 247 | .... | ... | 1.19 | 68 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Milk River at Milk River, Alta., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1 34 | 90 | 1 10 | 56 | 1 58 | 131 | 1 70 | 147 | 2 28 | 121 |
| 2 | 1 51 | 122 | 1 05 | 50 | 1 55 | 125 | 1 75 | 159 | 2 27 | 120 |
| 3 | 1 41 | 103 | 1 14 | 61 | 1 55 | 125 | 1 80 | 171 | 2 30 | 125 |
| 4 | 1 46 | 112 | 1 50 | 120 | 1 65 | 144 | 1 85 | 184 | 2 30 | 124 |
| 5 | 1 45 | 110 | 2 50 | 422 | 1.78 | 172 | 1 95 | 208 | 2 30 | 122 |
| 6 | 1 47 | 114 | 3 50 | 927 | 1 71 | 156 | 1 95 | 205 | 2 28 | 121 |
| 7 | 1 62 | 146 | 3 50 | 927 | 1 65 | 142 | 1 80 | 169 | 2 28 | 120 |
| 8 | 1 75 | 176 | 3 00 | 730 | 1 60 | 131 | 1 50 | 95 | 2 28 | 120 |
| 9 | 1 71 | 166 | 2 85 | 653 | 1 56 | 123 | 1 50 | 85 | 2 28 | 119 |
| 10 | 1 65 | 152 | 2 40 | 427 | 1 55 | 120 | 1 45 | 69 | 2 23 | 115 |
| 11 | 1 53 | 126 | 2 10 | 303 | 1 53 | 116 | 1 70† | 81 | 2 20 | 112 |
| 12 | 1 50 | 120 | 1 91 | 236 | 1 52 | 112 | 1 70 | 80 | 2 15 | 97 |
| 13 | 1 46 | 112 | 1 80 | 200 | 1 52 | 112 | 1 70 | 81 | 2 00 | 67 |
| 14 | 1 40 | 101 | 1 66 | 160 | 1 53 | 112 | 1 75 | 84 | 2 00 | 65 |
| 15 | 1 31 | 85 | 1 63 | 148 | 1 57 | 120 | 1 90 | 93 | 2 00 | 64 |
| 16 | 1 26 | 77 | 1 52 | 123 | 1 50 | 107 | 2 15‡ | 111 | 2 10 | 68 |
| 17 | 1 21 | 70 | 1 56 | 131 | 1 48 | 103 | 2 40 | 136 | 2 10 | 66 |
| 18 | 1 18 | 66 | 1 58 | 135 | 1 50 | 107 | 2 35 | 132 | 2 10 | 62 |
| 19 | 1 10 | 56 | 1 65 | 150 | 1 50 | 107 | 2 30 | 128 | 2 08 | 60 |
| 20 | 1 10 | 56 | 1 60 | 138 | 1 50 | 107 | 2 25 | 123 | 2 03 | 53 |
| 21 | 1 10 | 56 | 1 57 | 131 | 1 51 | 109 | 2 25 | 121 | 2 00 | 47 |
| 22 | 1 10 | 56 | 1 58 | 134 | 1.50 | 107 | 2 25 | 122 | 2 02 | 47 |
| 23 | 1 10 | 56 | 1 59 | 138 | 1 53 | 112 | 2 25‡ | 120 | 2 02 | 48 |
| 24 | 1 10 | 56 | 1 66 | 149 | 1 50 | 107 | 2 30 | 122 | 2 02 | 45 |
| 25 | 1 15 | 62 | 1 68 | 153 | 1 50 | 107 | 2 30 | 121 | 2 05 | 47 |
| 26 | 1 14 | 61 | 1 77 | 172 | 1 40 | 89 | 2 37 | 128 | 2 05 | 46 |
| 27 | 1 15 | 62 | 1 78 | 177 | 1 30 | 73 | 2 37 | 126 | 2 09 | 47 |
| 28 | 1 15 | 62 | 1 68 | 152 | 1 55 | 116 | 2 35 | 125 | 2 20 | 51 |
| 29 | 1 18 | 66 | 1 60 | 134 | 1 60 | 125 | 2 35 | 123 | 2 25 | 48 |
| 30 | 1 20 | 69 | 1 59 | 132 | 1 65 | 136 | 2 28 | 122 | 2 25 | 47 |
| 31 | 1.15 | 62 | .. | .. | 1 70 | 147 | .. | . | 2 28 | 49 |

* Ice on river. † Ice conditions after Nov. 10th.
‡ Water was running over the ice from Nov. 16th to 23 (inc.)
NOTE—Discharge for Gauge-heights over 5.00 only approximate. Daily discharges for Nov. and Dec. are only approximate.

MONTHLY DISCHARGE of Milk River at Milk River, Alta., for 1911

Drainage area. 1,077 square miles.

| MONTH. | DISCHARGE IN SECOND-FEET. | | | | RUN-OFF. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | Per Square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April | 589 | 111 | 308 | 0 286 | 0 32 | 18,327 |
| May | 1,884 | 224 | 399 | 0 370 | 0 43 | 24,534 |
| June | 2,049 | 101 | 355 | 0 329 | 0 37 | 21,124 |
| July | 401 | 68 | 128 | 0 119 | 0 14 | 7,870 |
| August | 176 | 56 | 91 2 | 0 085 | 0 10 | 5,607 |
| September | 927 | 50 | 252 | 0 234 | 0 26 | 14,995 |
| October | 172 | 73 | 119 | 0 110 | 0 13 | 7,317 |
| November | 208 | 69 | 126 | 0 118 | 0 13 | 7,498 |
| December | 125 | 45 | 79 | 0 073 | 0 08 | 4,858 |
| The period | | | | | | 112,130 |

## Milk-River at Writing-on-Stone Police Detachment, Alta.

This station was established on August 2, 1909, by F. H. Peters. It is located at Writing-on-stone R. N. W. M. P. detachment, in the S.W. ¼ Sec. 35, Tp. 1, Rge. 13, W. 4th Mer. It is 17 miles by trail from Coutts and 25 miles from Milk River station.

The river flows in one channel at all stages. It is straight for 300 feet above and 250 feet below the station. Both banks are slightly wooded, high and not liable to overflow except in extreme flood stages of the stream. The bed of the stream is composed of sand, which is constantly shifting.

Discharge measurements are made during high water by means of a cable, car, tagged wire and stay wire, and at low stages by wading. The initial point for soundings is 50 feet south of a post on the right bank, marked "†50".

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 86.13) is referred to a permanent iron bench-mark (assumed elev., 100.00), located on the right bank directly under the cable and one foot north of the tower.

During 1911, the gauge was read by constable A. P. White.

Discharge Measurements of Milk River, at Writing-on-Stone Police Detachment, in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 17 | N. McL. Sutherland | 66.0 | 114.53 | 2.04 | 2.52 | 233.84 |
| May 4 | do | 74.7 | 97.11 | 2.17 | 2.36 | 211.32* |
| May 14 | do | 81.7 | 111.46 | 2.11 | 2.47 | 234.40* |
| May 24 | J. E. Degnan | 86.0 | 150.64 | 2.10 | 2.85 | 316.86* |
| June 6 | do | 87.0 | 123.76 | 1.73 | 2.45 | 214.60* |
| June 16 | do | 88.7 | 93.80 | 1.55 | 2.21 | 145.17* |
| July 7 | do | 68.5 | 97.90 | 1.78 | 2.36 | 174.56* |
| July 25 | do | 46.0 | 63.27 | 1.49 | 1.94 | 94.50 |
| Aug. 11 | do | 61.0 | 97.73 | 1.83 | 2.34 | 178.82 |
| Aug. 21 | do | 49.0 | 54.17 | 1.07 | 1.67 | 58.19 |
| Sept. 2 | do | 48.0 | 44.25 | 1.20 | 1.66 | 53.05 |
| Sept. 12 | do | 88.0 | 148.58 | 1.87 | 2.70 | 277.38* |
| Sept. 18 | do | 63.0 | 80.79 | 1.62 | 2.13 | 130.98* |
| Oct. 4 | do | 80.0 | 102.18 | 1.41 | 2.21 | 143.98* |
| Oct. 23 | do | 77.0 | 83.93 | 1.47 | 2.09 | 122.94* |
| Nov. 7 | do | 75.0 | 98.85 | 1.27 | 2.25 | 125.75* |

* Measurement not taken at regular station.

DAILY GAUGE-HEIGHT AND DISCHARGE of Milk River at Writing-on-Stone Police Detachment, Alta., for 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.89 | .... | 2.31 | .... | x | .... | 3.17 | 458 | 2.39 | 210 | 2.69 | 278 |
| 2 | 1.78 | .... | 2.35 | .... | 2.82 | .... | 3.05 | 412 | 2.36 | 201 | 2.53 | 232 |
| 3 | x | .... | 2.38 | .... | 2.84 | .... | 2.73 | 300 | 2.39 | 218 | 2.49 | 223 |
| 4 | x | .... | 2.43 | .... | 2.81 | .... | 2.49 | 226 | *2.44 | 233 | 2.46 | 216 |
| 5 | 1.91 | .... | 2.45 | .... | 2.83 | .... | 1.96 | 108 | *2.49 | 247 | 2.44 | 271 |
| 6 | 1.95 | .... | 2.52 | .... | 2.87 | .... | 2.26 | 120 | 2.54 | 263 | 2.45 | 215 |
| 7 | 2.05 | .... | 2.51 | .... | 2.82 | .... | 2.33 | 186 | 2.63 | 289 | 2.44 | 211 |
| 8 | 2.00 | .... | 2.50 | .... | 2.79 | .... | 2.50 | 229 | 2.86 | 366 | 2.37 | 193 |
| 9 | 1.94 | .... | 2.55 | .... | 2.80 | .... | 2.38 | 197 | 2.88 | 372 | 2.30 | 175 |
| 10 | 1.88 | .... | 2.55 | .... | 2.82 | .... | 2.55 | 244 | 2.64 | 291 | 2.32 | 179 |
| 11 | 1.78 | .... | 2.57 | .... | 2.76 | .... | 2.76 | 309 | 2.45 | 233 | 2.60 | 252 |
| 12 | 1.70 | .... | 2.57 | .... | 2.73 | .... | 3.23 | 482 | 2.51 | 250 | 2.32 | 177 |
| 13 | 1.65 | .... | 2.60 | .... | 2.90 | .... | 2.94 | 372 | 2.46 | 234 | 2.25 | 159 |
| 14 | 1.60 | .... | 2.64 | .... | 2.88 | .... | 2.69 | 287 | 2.50 | 245 | 2.24 | 157 |
| 15 | 1.57 | .... | 2.77 | .... | 3.06 | .... | 2.59 | 256 | 2.57 | 262 | 2.22* | 150 |
| 16 | 1.61 | .... | 2.79 | .... | 2.85 | .... | 2.54 | 241 | 3.33 | 532 | 2.19* | 141 |
| 17 | 1.69 | .... | 2.77 | .... | 2.99 | .... | 2.49 | 226 | 4.60 | 1,128 | 2.16 | 136 |
| 18 | 1.78 | .... | 2.74 | .... | 3.05 | .... | 2.56 | 248 | 4.31 | 969 | 2.15 | 134 |
| 19 | 1.80 | .... | 2.78 | .... | 2.90 | .... | 2.61 | 264 | 3.61 | 636 | 2.11 | 126 |
| 20 | 1.79 | .... | 2.85 | .... | 2.83 | .... | 2.75 | 307 | 3.28 | 494 | 2.08 | 120 |
| 21 | x | .... | 2.89 | .... | 2.78 | .... | 2.64 | 274 | 3.02 | 391 | 2.02 | 109 |
| 22 | 1.82 | .... | 2.91 | .... | 4.52 | .... | 2.82 | 335 | 2.80 | 312 | 2.34 | 175 |
| 23 | 1.72 | .... | 2.93 | .... | 3.71 | 683 | 3.10 | 439 | 2.79 | 305 | 2.05 | 114 |
| 24 | 1.67 | .... | 2.75 | .... | 3.50 | 593 | 3.22 | 489 | 2.84 | 318 | 2.76 | 291 |
| 25 | 1.72 | .... | 2.75 | .... | 3.39 | 547 | 3.03 | 418 | 2.89 | 335 | 3.50 | 569 |
| 26 | 1.85 | .... | 2.78 | .... | 3.34 | 526 | 2.87 | 362 | 2.91 | 342 | 6.20 | 2,068 |
| 27 | 1.89 | .... | 2.81 | .... | 3.21 | 474 | 2.96 | 395 | 2.98 | 367 | 4.76 | 1,179 |
| 28 | 1.95 | .... | 2.80 | .... | 3.02 | 401 | 3.11 | 451 | 3.82 | 384 | 3.94 | 761 |
| 29 | 1.96 | .... | .... | .... | 2.93 | 369 | 2.93 | 385 | 2.93 | 352 | 3.52 | 577 |
| 30 | 2.04 | .... | .... | .... | 2.88 | 351 | 2.81 | 345 | 2.98 | 371 | 3.31 | 492 |
| 31 | 2.03 | .... | .... | .... | 2.92 | 365 | .... | .... | 2.89 | 342 | .... | .... |

## Daily Gauge-height and Discharge of Milk River at Writing-on-Stone Police Detachment, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.37 | 516 | 1.95 | 97 | 1.76 | 68 | 2.23 | 150 | 2.40 | 189 |
| 2 | 3.12 | 418 | 1.99 | 103 | 1.82 | 77 | 2.24 | 152 | 2.08 | 120 |
| 3 | 3.12 | 418 | 2.05 | 114 | 2.06 | 116 | 2.25 | 154 | 2.23* | 150 |
| 4 | 2.86 | 324 | 2.03 | 111 | 2.57 | 233 | 2.22 | 148 | 2.39 | 187 |
| 5 | 2.70* | 272 | 2.01 | 107 | 2.56 | 230 | 2.26 | 157 | 2.35 | 177 |
| 6 | 2.54 | 224 | 2.08 | 120 | 3.65 | 631 | 2.32 | 170 | 2.34 | 175 |
| 7 | 2.38 | 184 | 2.25 | 154 | 4.08 | 827 | 2.26 | 157 | .... | ... |
| 8 | 2.29 | 163 | 2.39 | 187 | 3.80 | 697 | 2.26 | 157 | .... | ... |
| 9 | 2.23 | 150 | 2.36 | 179 | 3.49 | 565 | 2.28 | 154 | .... | ... |
| 10 | 2.16 | 136 | 2.39 | 187 | 3.33 | 500 | 2.23 | 150 | .... | ... |
| 11 | 2.15 | 134 | 2.30 | 165 | 3.04 | 388 | 2.23 | 150 | .... | ... |
| 12 | 2.14 | 132 | 2.20 | 144 | 2.66 | 260 | 2.20 | 144 | .... | ... |
| 13 | 2.10 | 124 | 2.14 | 132 | 2.48 | 208 | 2.17 | 138 | .... | ... |
| 14 | 2.08 | 120 | 2.06 | 116 | 2.30 | 165 | 2.15 | 134 | .... | ... |
| 15 | 2.04 | 113 | 1.99 | 103 | 2.22 | 148 | 2.14 | 132 | .... | ... |
| 16 | 2.00 | 105 | 1.95 | 97 | 2.10 | 124 | 2.12 | 128 | .... | ... |
| 17 | 1.96 | 99 | 1.91 | 91 | 2.10 | 124 | 2.10 | 124 | .... | ... |
| 18 | 1.95 | 97 | 1.82 | 77 | 2.15 | 134 | 2.12 | 128 | .... | ... |
| 19 | 1.95 | 97 | 1.75 | 67 | 2.14 | 132 | 2.10 | 124 | .... | ... |
| 20 | 1.97 | 100 | 1.69 | 59 | 2.16 | 136 | 2.10 | 124 | .... | ... |
| 21 | 1.96 | 99 | 1.68 | 57 | 2.20 | 144 | 2.10 | 124 | .... | ... |
| 22 | 1.98 | 102 | 1.66 | 55 | 2.23 | 150 | 2.10 | 124 | .... | ... |
| 23 | 2.00 | 105 | 1.60 | 47 | 2.19 | 142 | 2.10 | 124 | .... | ... |
| 24 | 2.00 | 105 | 1.57 | 43 | 2.22 | 148 | 2.15 | 134 | .... | ... |
| 25 | 2.00 | 105 | 1.55 | 41 | 2.24 | 152 | 2.12 | 128 | .... | ... |
| 26 | 2.00 | 105 | 1.56 | 42 | 2.26 | 157 | 2.10 | 124 | .... | ... |
| 27 | 2.00 | 105 | 1.61 | 48 | 2.29 | 163 | 2.10 | 124 | .... | ... |
| 28 | 1.94 | 95 | 1.66 | 55 | 2.33 | 172 | 2.02 | 109 | .... | ... |
| 29 | 1.89 | 88 | 1.68 | 57 | 2.28 | 161 | 1.68 | 57 | .... | ... |
| 30 | 1.84 | 80 | 1.70 | 60 | 2.25 | 154 | 1.87 | 84 | .... | ... |
| 31 | 1.83 | 78 | 1.71 | 61 | .... | ... | 2.20 | 144 | .... | ... |

x Observer absent.
* No observation, gauge height interpolated.

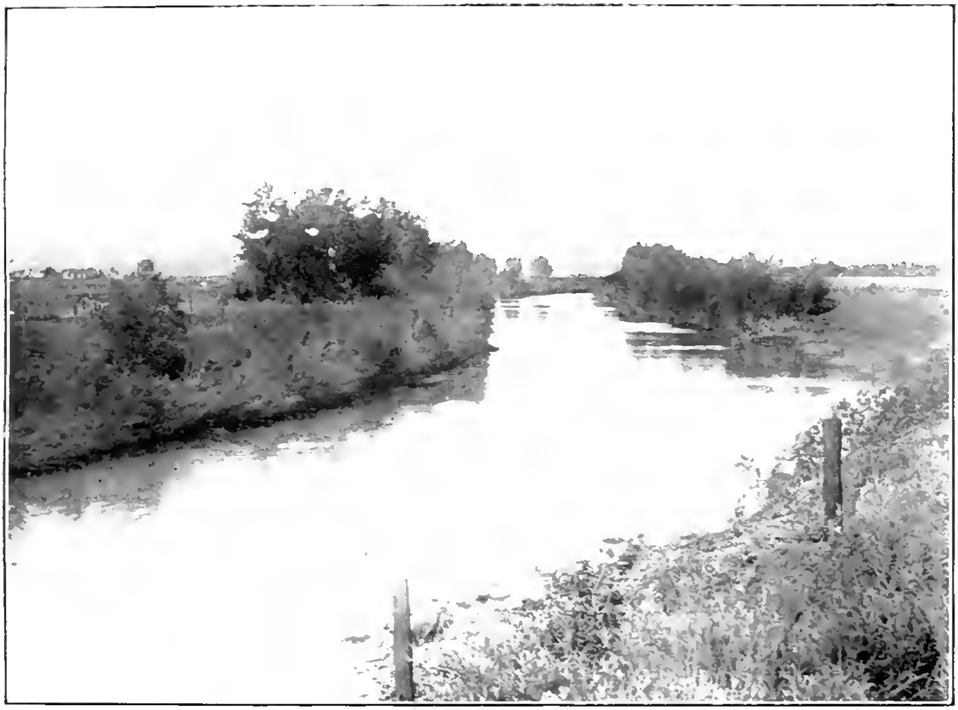
Note—Gauge was read during January, February and March, but the stream was frozen over, and as no discharge measurements were made during that period the daily discharges could not be computed. All gauge heights after March 23 have been reduced to 12 o'clock noon. Discharges for gauge heights over 3.00 are estimated.

## Monthly Discharge of Milk River, near Writing-on-Stone Police Detachment, for 1911.

Drainage area, 1,620 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage. Area. | Total in Acre-Feet. |
| March (23-31) | 683 | 351 | 479 | 0.308 | 0.10 | 8,551 |
| April | 489 | 108 | 317 | 0.196 | 0.22 | 18,863 |
| May | 1,128 | 209 | 371 | 0.229 | 0.26 | 22,812 |
| June | 2,068 | 109 | 334 | 0.206 | 0.23 | 19,874 |
| July | 516 | 78 | 161 | 0.099 | 0.11 | 9,900 |
| August | 187 | 41 | 96 | 0.059 | 0.07 | 5,903 |
| September | 827 | 68 | 244 | 0.150 | 0.17 | 14,519 |
| October | 170 | 57 | 134 | 0.083 | 0.10 | 8,239 |
| November (1-6) | 189 | 120 | 166 | 0.102 | 0.02 | 1,975 |
| The period | | ........ | ........ | ........ | ........ | 110,636 |

Plate No. 21.



View on Milk River near Pendant d'Oreille Police Detachment. Taken by F. H. Peters.

## Milk River at Pendant d'Oreille Police Detachment, Alta.

This station was established by F. H. Peters on August 5, 1909. It is located 300 feet upstream from the buildings of the police post, on the S.W. ¼ Sec. 21, Tp. 2, Rge. 8, W. 4th Mer., and is about 61 miles by trail from Milk River station.

The river flows in one channel which at ordinary stages is about 150 feet wide. It is straight for about 400 feet above and 300 feet below the station. The right bank is low, covered with small willows, and liable to overflow at high stages. The left bank is high, almost clear and not liable to overflow. The bed of the stream is composed of sand and is constantly changing.

Discharge measurements are made during high water by a means of a cable, car, tagged wire, and stay wire, and at low stages by wading. The initial point for soundings is the face of a cedar post on the left bank.

The gauge, which is a plain staff graduated to feet and hundredths, is at the left bank, about 80 feet downstream from the cable. The zero (elev., 82.45) is referred to a permanent iron bench-mark (assumed elev., 100.00), located directly under the cable, about five feet from the tower on the left bank.

During 1911, the gauge was read by Corporal T. B. Caulkin.

Discharge Measuremehts of Milk River at Pendant d'Oreille Police Detachment, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 19 | N. McL. Sutherland | 147.6 | 131.34 | 1.840 | 3.03 | **244.19** |
| April 25 | do | 173.7 | 245.97 | 2.040 | 3.63 | **501.51** |
| May 7 | do | 163.2 | 164.82 | 1.400 | 3.08 | **231.34** |
| May 12 | do | ..... | .... | .... | 3.15 | **231.21** |
| May 29 | J. E. Degnan | 140.0 | 199.94 | 1.990 | 3.55 | **397.87** |
| June 3 | do | 120.5 | 150.13 | 1.590 | 3.21 | **238.87** |
| June 18 | do | 113.5 | 93.87 | 1.540 | 2.78 | **133.51** |
| June 23 | do | 118.0 | 100.74 | 1.500 | 2.84 | **152.06** |
| July 12 | do | 87.0 | 91.21 | 1.690 | 2.93 | **153.99*** |
| July 21 | do | 62.0 | 64.87 | 1.570 | 2.75 | **102.17*** |
| Aug. 12 | do | 159.5 | 127.68 | 1.374 | 3.06 | **175.50** |
| Aug. 17 | do | 158.0 | 99.56 | 1.040 | 2.77 | **103.62** |
| Sept. 24 | do | 119.0 | 116.02 | 1.750 | 3.13 | **203.12** |
| Oct. 1 | do | 132.0 | 113.16 | 1.589 | 3.07 | **179.83** |
| Oct. 27 | do | 146.5 | 114.97 | 1.110 | 2.95 | **128.24** |
| Nov. 3 | do | 147.5 | 142.15 | 0.979 | 3.125 | **139.33** |

* Discharge measured by wading at a point down stream from the gauge

Daily Gauge-height and Discharge of Milk River at Pendant d'Oreille Police Detachment, Alta., in 1911.

| Day. | January. | | February. | | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.90 | .... | * | .... | 2.34 | .... | 3.57 | 516 | 3.46 | 412 | 3.48 | 362 |
| 2 | 2.90 | .... | * | .... | * | .... | 3.80 | 638 | 3.33 | 345 | 3.30 | 274 |
| 3 | 2.90 | .... | 2.50 | .... | 2.37 | .... | 3.46 | 458 | 3.26 | 311 | 3.26 | 286 |
| 4 | * | .... | 2.50 | .... | 2.40 | .... | 3.12 | 286 | 3.14 | 257 | 3.27 | 265 |
| 5 | * | .... | 2.53 | .... | 2.45 | .... | 2.78 | 155 | 3.05 | 219 | 3.25 | 259 |
| 6 | 2.85 | .... | 2.55 | .... | 2.50 | .... | 2.96 | 216 | 3.03 | 211 | 3.25 | 262 |
| 7 | 2.85 | .... | 2.55 | .... | * | .... | 3.11 | 282 | 3.07 | 227 | 3.19 | 240 |
| 8 | 2.83 | .... | 2.52 | .... | * | .... | 3.05 | 254 | 3.07 | 221 | 3.11 | 212 |
| 9 | 2.83 | .... | 2.55 | .... | 3.00 | .... | 3.05 | 254 | 3.36 | 345 | 3.08 | 201 |
| 10 | 2.83 | .... | 2.57 | .... | 3.10 | .... | 2.97 | 220 | 3.38 | 352 | 3.00 | 176 |
| 11 | * | .... | 2.63 | .... | 3.34 | .... | 3.03 | 246 | 3.20 | 258 | 3.04 | 194 |
| 12 | * | .... | 2.60 | .... | 3.04 | .... | 3.36 | 406 | 3.20 | 254 | 3.06 | 205 |
| 13 | 2.85 | .... | 2.57 | .... | 3.05 | .... | 3.76 | 617 | 3.19 | 246 | 3.02 | 195 |
| 14 | 2.85 | .... | * | .... | 2.95 | .... | 3.41 | 431 | 3.17 | 236 | 2.98 | 181 |
| 15 | 2.80 | .... | * | .... | 2.87 | .... | 3.21 | 329 | 3.21 | 252 | 2.94 | 169 |
| 16 | 2.77 | .... | 2.00 | .... | 2.90 | .... | 3.09 | 272 | 3.36 | 320 | 2.90 | 160 |
| 17 | 2.75 | .... | 1.97 | .... | 2.91 | .... | 3.05 | 254 | 4.22 | 774 | 2.86 | 151 |
| 18 | 2.73 | .... | 1.80 | .... | 2.86 | .... | 3.05 | 254 | 4.83 | 1,118 | 2.81 | 140 |
| 19 | 2.68 | .... | 1.78 | .... | 2.85 | .... | 3.03 | 246 | 4.38 | 859 | 2.77 | 130 |
| 20 | 2.68 | .... | 2.00 | .... | 3.01 | .... | 3.09 | 261 | 3.93 | 612 | 2.76 | 132 |
| 21 | 2.66 | .... | 2.00 | .... | 3.25 | .... | 3.23 | 317 | 3.74 | 506 | 2.79 | 139 |
| 22 | 2.65 | .... | 2.17 | .... | 3.31 | .... | 3.17 | 277 | 3.60 | 434 | 2.79 | 139 |
| 23 | 2.65 | .... | 2.24 | .... | 4.17 | .... | 3.45 | 412 | 3.44 | 350 | 2.80 | 142 |
| 24 | 2.55 | .... | 2.25 | .... | 4.00 | .... | 3.58 | 478 | 3.38 | 318 | 4.02 | 719 |
| 25 | 2.56 | .... | 2.37 | .... | 3.95 | .... | 3.63 | 501 | 3.41 | 331 | 3.97 | 688 |
| 26 | 2.48 | .... | 2.25 | .... | 4.04 | .... | 3.57 | 469 | 3.44 | 346 | 5.63 | 1,541 |
| 27 | 2.47 | .... | 2.27 | .... | 4.02 | .... | 3.48 | 422 | 3.45 | 347 | 5.10 | 1,331 |
| 28 | 2.40 | .... | 2.30 | .... | * | .... | 3.62 | 496 | 3.48 | 362 | 4.56 | 1,014 |
| 29 | 2.33 | .... | | .... | * | .... | 3.65 | 512 | 3.53 | 388 | 4.30 | 863 |
| 30 | 2.35 | .... | ... | .... | * | .... | 3.61 | 490 | 3.54 | 393 | 4.01 | 702 |
| 31 | * | .... | .... | .... | 4.00 | .... | ... | .... | 3.56 | 403 | .... | .... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Milk River at Pendant d'Oreille Police Detachment, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 4.67 | 1,069 | 2.58 | 76 | 2.51 | 67 | 3.08 | 184 | 2.97 | 114 |
| 2 | 4.23 | 817 | 2.66 | 88 | 2.50‡ | 66 | 3.10 | 191 | 3.00 | 116 |
| 3 | 3.83 | 600 | 2.65 | 86 | 2.51‡ | 67 | 3.42 | 327 | 3.15 | 147 |
| 4 | 3.73 | 543 | 2.69 | 92 | 4.07‡ | 673 | 3.39 | 309 | 3.17 | 153 |
| 5 | 3.49 | 414 | 2.74 | 101 | 4.74 | 1,047 | 3.30 | 268 | 3.15 | 147 |
| 6 | 3.39 | 356 | 2.81 | 113 | 5.02 | 1,210 | 3.30 | 266 | 3.13 | 142 |
| 7 | 3.26 | 289 | 3.05 | 174 | 4.83 | 1,098 | 3.28 | 257 | 3.10 | 134 |
| 8 | 3.19 | 255 | 3.06 | 178 | 4.55 | 938 | 3.23 | 236 | 3.08 | 129 |
| 9 | 3.09 | 213 | 3.08 | 184 | 4.41 | 860 | 3.19 | 219 | † | |
| 10 | 3.04 | 194 | 3.09 | 188 | 4.38 | 843 | 3.14 | 197 | | .. |
| 11 | 3.00 | 178 | 3.07 | 181 | 4.18 | 732 | 3.12 | 190 | | |
| 12 | 2.95 | 159 | 3.05 | 174 | 3.98 | 623 | 3.09 | 177 | | . |
| 13 | 2.85 | 132 | 3.01 | 161 | 3.76 | 507 | 3.08 | 174 | | .. |
| 14 | 2.83 | 129 | 2.97 | 150 | 3.49 | 367 | 3.05 | 163 | | . |
| 15 | 2.83 | 126 | 2.98 | 153 | 3.36 | 302 | 3.03 | 157 | | . |
| 16 | 2.76 | 111 | 2.96 | 148 | 3.26 | 256 | 3.03 | 166 | | |
| 17 | 2.69 | 98 | 2.82 | 115 | 3.22 | 239 | 3.01 | 151 | | |
| 18 | 2.70 | 97 | 2.70 | 94 | 3.16 | 214 | 3.00 | 147 | | |
| 19 | 2.71 | 99 | 2.67 | 89 | 3.13 | 203 | 2.99 | 144 | | |
| 20 | 2.73 | 101 | 2.63 | 84 | 3.12 | 199 | 2.98 | 139 | | . |
| 21 | 2.73 | 99 | 2.60 | 79 | 3.10 | 191 | 2.98 | 139 | | |
| 22 | 2.77 | 106 | 2.59 | 78 | 3.12 | 199 | 2.98 | 138 | | . |
| 23 | 2.80 | 111 | 2.57 | 75 | 3.16 | 214 | 2.99 | 140 | | .. |
| 24 | 2.79 | 109 | 2.57 | 75 | 3.05 | 174 | 2.98 | 136 | | . |
| 25 | 2.77 | 106 | 2.56 | 74 | 3.05 | 174 | 2.97 | 135 | | .. |
| 26 | 2.74 | 101 | 2.56 | 74 | 3.08 | 184 | 2.97 | 133 | | . |
| 27 | 2.72 | 97 | 2.58 | 76 | 3.16 | 214 | 2.95 | 128 | | . |
| 28 | 2.69 | 92 | 2.57 | 75 | 3.20 | 230 | 2.94 | 122 | | . |
| 29 | 2.66 | 88 | 2.56 | 74 | 3.18 | 222 | 2.92 | 115 | | |
| 30 | 2.63 | 84 | 2.54 | 71 | 3.14 | 207 | 2.94 | 115 | | |
| 31 | 2.61 | 80 | 2.53 | 70 | . | . | 2.96 | 115 | | |

NOTE—Gauge was read during January, February, and March, but the stream was frozen over and as no discharge measurements were made during that period the daily discharge could not be computed. All gauge heights have been reduced to 12 o'clock noon. Discharges for gauge heights over 3.80 are estimated.

* Observer away.
† River frozen over, observations discontinued.
‡ No observation, gauge height interpolated.

MONTHLY DISCHARGE of Milk River at Pendant d'Oreille Police Detachment, Alta., for 1911.

Drainage area, 2,175 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area | Total in Acre-Feet. |
| April | 638 | 155 | 366 | 0.169 | 0.19 | 21,779 |
| May | 1,118 | 211 | 419 | 0.192 | 0.22 | 25,763 |
| June | 1,541 | 130 | 382 | 0.176 | 0.20 | 22,731 |
| July | 1,069 | 80 | 228 | 0.105 | 0.12 | 14,019 |
| August | 188 | 70 | 111 | 0.051 | 0.06 | 6,825 |
| September | 1,210 | 66 | 417 | 0.192 | 0.21 | 24,813 |
| October | 327 | 115 | 176 | 0.081 | 0.09 | 10,822 |
| November (1-8) | 153 | 114 | 135 | 0.062 | 0.02 | 2,146 |
| The period | .... | | | | | 128,898 |

## MILK RIVER AT SPENCER'S LOWER RANCHE, ALTA.

This station was established on August 7, 1909, by F. H. Peters. It is located on the S.E. ¼ Sec. 1, Tp. 1, Rge. 5, W. 4th Mer., about 1000 feet upstream from the International boundary. It is 90 miles by trail from Milk River station, 26 miles from Pendant d'Oreille police detachment and 19 miles from Wild Horse police detachment.

The river flows in one channel at all stages. It is straight for about 300 feet above and 500 feet below the station. The right bank is low, wooded and liable to overflow during extreme flood stages. The bed is composed of sand, which is constantly shifting.

Discharge measurements are made during high water by means of a cable, car, tagged wire, and stay wire, and at low stages by wading. The initial point for soundings is the inner face of a round post on the left bank.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank, about 450 feet below the cable. The zero (elev., 85.32) is referred to a permanent iron bench-mark (assumed elev., 100.00) located on the left bank, 450 feet below the cable and directly opposite the gauge.

During 1911, the gauge was read by Charles Lattimer.

DISCHARGE MEASUREMENTS of Milk River at Spencer's Lower Ranche, Alta., in 1911.

| Date. | Hydrographer | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 21 | N. M. Sutherland | 96.0 | 136.63 | 1.980 | 2.85 | 270.35 |
| May 9 | do | 100.5 | 152.65 | 1.680 | 2.84 | 255.97 |
| May 31 | J. E. Degnan | 94.5 | 178.77 | 2.146 | 3.22 | 383.57 |
| June 20 | do | 95.0 | 86.63 | 1.527 | 2.42 | 132.30 |
| July 14 | do | 88.0 | 100.99 | 1.395 | 2.40 | 140.92* |
| Aug. 14 | do | 105.0 | 102.26 | 1.510 | 2.54 | 154.46 |
| Sept. 26 | do | 105.0 | 130.15 | 1.678 | 2.64 | 218.48 |
| Oct. 29 | do | 102.5 | 86.55 | 1.330 | 2.20 | 115.76 |

* Measurement not taken at regular station.

DAILY GAUGE-HEIGHT AND DISCHARGE of Milk-River at Spencer's Lower Ranche, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 3.13 | 357 | 3.18 | 367 | 3.20 | 379 |
| 2 | | | 3.18 | 373 | 3.04 | 323 | 3.05 | 334 |
| 3 | | | 3.40 | 444 | 2.84 | 263 | 2.98 | 309 |
| 4 | | | 3.18 | 373 | 2.76 | 235 | 2.91 | 289 |
| 5 | | | 2.20 | 114 | 2.68 | 214 | 2.90 | 287 |
| 6 | | | 2.44 | 161 | 2.51 | 170 | 2.88 | 279 |
| 7 | | | 2.16 | 108 | 2.65 | 204 | 2.86 | 274 |
| 8 | | | 2.89 | 280 | 2.69 | 214 | 2.87 | 275 |
| 9 | | | 2.70 | 227 | 2.84 | 256 | 2.84 | 269 |
| 10 | | | 2.79 | 252 | 2.91 | 286 | 2.75 | 240 |
| 11 | | | 2.70 | 227 | 3.00 | 306 | 2.65 | 212 |
| 12 | | | 2.65 | 214 | 2.78 | 241 | 2.58 | 193 |
| 13 | | | 2.10 | 99 | 2.87 | 269 | 2.76 | 239 |
| 14 | | | 2.36 | 144 | 2.77 | 242 | 2.74 | 232 |
| 15 | | | 3.08 | 341 | 2.84 | 262 | 2.62 | 198 |
| 16 | 2.80 | 255 | 3.00 | 315 | 3.00 | 310 | 2.56 | 190 |
| 17 | 2.78 | 249 | 2.85 | 269 | 2.94 | 291 | 2.53 | 171 |
| 18 | 2.76 | 244 | 2.76 | 244 | 4.68 | 1,013 | 2.51 | 162 |
| 19 | 2.74 | 238 | 2.84 | 266 | 4.28 | 804 | 2.45 | 144 |
| 20 | 2.86 | 272 | 2.78 | 249 | 3.90 | 630 | 2.43 | 135 |
| 21 | 3.05 | 331 | 2.84 | 266 | 3.90 | 630 | 2.39 | 129 |
| 22 | 2.98 | 309 | 3.00 | 317 | 3.34 | 420 | 2.97 | 275 |
| 23 | 3.63 | 528 | 2.76 | 243 | 3.23 | 387 | 2.64 | 183 |
| 24 | 4.60 | 981 | 2.88 | 275 | 3.10 | 347 | 2.59 | 171 |
| 25 | 3.86 | 619 | 3.30 | 407 | 3.05 | 330 | 3.64 | 490 |
| 26 | 3.84 | 611 | 3.30 | 407 | 3.17 | 369 | 3.72 | 519 |
| 27 | 3.68 | 547 | 3.25 | 391 | 3.14 | 361 | 5.86 | 1,655 |
| 28 | 3.60 | 516 | 3.14 | 355 | 3.13 | 358 | 4.62 | 948 |
| 29 | 3.54 | 494 | 3.32 | 411 | 3.19 | 375 | 4.13 | 701 |
| 30 | 3.24 | 392 | 3.33 | 414 | 3.25 | 395 | 3.78 | 549 |
| 31 | 3.10 | 347 | .... | ... | 3.24 | 392 | .... | ... |

Camp Equipment of the Hydrographer in the Western Cypress Hills district.

DAILY GAUGE-HEIGHT AND DISCHARGE of Milk River at Spencer's Lower Ranche, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 4.32 | 789 | 2.10 | 87 | 1.95 | 70 | 2.64 | 218 | 2.44 | 167 |
| 2 | 4.45 | 853 | 2.05 | 78 | 1.94 | 71 | 2.55 | 194 | 2.10 | 101 |
| 3 | 3.69 | 520 | 2.20 | 99 | 1.95 | 72 | 3.02 | 331 | 2.10 | 101 |
| 4 | 3.55 | 469 | 2.25 | 107 | 3.84 | 582 | 2.96 | 312 | 2.68 | 229 |
| 5 | 3.53 | 461 | 2.38 | 129 | 4.08 | 689 | 3.08 | 350 | 2.36 | 149 |
| 6 | 3.34 | 399 | 2.45 | 142 | 5.45 | 1,409 | 2.85 | 278 | 2.60 | 207 |
| 7 | 3.20 | 355 | 2.34 | 120 | 4.87 | 1,088 | 2.84 | 275 | 2.65 | 221 |
| 8 | 2.96 | 291 | 2.56 | 164 | 4.82 | 1,068 | 2.84 | 275 | 2.83 | * |
| 9 | 2.75 | 229 | 2.54 | 159 | 4.32 | 809 | 2.85 | 278 | 2.63 | ... |
| 10 | 2.74 | 218 | 2.63 | 180 | 4.00 | 660 | 2.86 | 281 | 2.64 | ... |
| 11 | 2.68 | 213 | 2.70 | 195 | 3.96 | 646 | 2.78 | 259 | 2.74 | ... |
| 12 | 2.53 | 188 | 2.65 | 182 | 3.74 | 559 | 2.70 | 235 | 2.66 | ... |
| 13 | 2.51 | 166 | 2.61 | 172 | 3.56 | 510 | 2.64 | 218 | 2.56 | ... |
| 14 | 2.44 | 149 | 2.60 | 169 | 3.35 | 419 | 2.58 | 202 | 2.52 | ... |
| 15 | 2.35 | 129 | 2.51 | 150 | 3.29 | 400 | 2.52 | 186 | 2.58 | ... |
| 16 | 2.33 | 126 | 2.46 | 140 | 3.05 | 325 | 2.47 | 174 | 2.58 | ... |
| 17 | 2.25 | 116 | 2.48 | 145 | 2.89 | 279 | 2.45 | 169 | 2.59 | ... |
| 18 | 2.25 | 115 | 2.38 | 128 | 2.80 | 253 | 2.44 | 166 | 2.60 | ... |
| 19 | 2.23 | 108 | 2.30 | 114 | 2.74 | 235 | 2.42 | 162 | ... | ... |
| 20 | 2.24 | 110 | 2.27 | 109 | 2.72 | 233 | 2.41 | 159 | ... | ... |
| 21 | 2.14 | 95 | 2.10 | 86 | 2.64 | 211 | 2.39 | 155 | ... | ... |
| 22 | 2.24 | 110 | 2.05 | 79 | 2.68 | 222 | 2.36 | 149 | ... | ... |
| 23 | 2.24 | 110 | 2.05 | 79 | 2.76 | 246 | 2.36 | 149 | ... | ... |
| 24 | 2.26 | 112 | 2.04 | 79 | 2.75 | 245 | 2.37 | 151 | ... | ... |
| 25 | 2.28 | 115 | 1.99 | 72 | 2.69 | 231 | 2.38 | 153 | ... | ... |
| 26 | 2.25 | 111 | 2.03 | 76 | 2.64 | 216 | 2.35 | 146 | ... | ... |
| 27 | 2.22 | 105 | 2.00 | 75 | 2.75 | 249 | 2.31 | 138 | ... | ... |
| 28 | 2.18 | 98 | 2.00 | 75 | 2.64 | 218 | 2.29 | 134 | ... | ... |
| 29 | 2.15 | 93 | 1.99 | 74 | 2.69 | 232 | 2.24 | 124 | ... | ... |
| 30 | 2.13 | 90 | 1.98 | 75 | 2.64 | 218 | 2.30 | 136 | ... | ... |
| 31 | 2.10 | 87 | 1.96 | 71 | .... | ... | 2.28 | 132 | | |

NOTE—Discharges for gauge heights over 3.40 are estimated.
* Ice conditions, not sufficient data to compute the discharge after Nov. 7.

MONTHLY DISCHARGE of Milk River at Spencer's Lower Ranche, Alta., for 1911.

Drainage area, 2,448 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| March (16-31) | 981 | 238 | 433 | 0.177 | .10 | 13,751 |
| April | 444 | 99 | 285 | 0.116 | .13 | 16,959 |
| May | 1,013 | 170 | 363 | 0.148 | .17 | 22,320 |
| June | 1,655 | 129 | 348 | 0.142 | .16 | 20,707 |
| July | 853 | 87 | 230 | 0.094 | .11 | 14,142 |
| August | 195 | 71 | 116 | 0.048 | .06 | 7,133 |
| September | 1,409 | 70 | 422 | 0.172 | .19 | 25,111 |
| October | 350 | 124 | 200 | 0.082 | .09 | 12,298 |
| November (1-7) | 229 | 101 | 168 | 0.069 | .02 | 2,332 |
| The period | | | | | 1.03 | 134,753 |

STUDY OF CONDITIONS OF RUN-OFF WATERSHED OF MILK RIVER from its head waters to its eastern crossing from Canada in Sec. 3, Tp. 1, Rge. 5, W. 4th Mer. for the period from August 1st to October 31st, 1911.

| Station. | Area of Watershed in Square Miles. | | | | | | Run-off in Ac. ft. | | Run-off per sq. mile in Ac. ft. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Additional to last Station. | | | Total for Station. | | | | | | |
| | Canada. | U. S. A. | Total. | Canada. | U. S. A. | Total. | Additional to last Station. | Total for Station. | For additional Area. | For total Area. |
| Milk River, 21-2-16-4 | ...... | ...... | ...... | 588 | 489 | 1,077 | ...... | 27,919 | | 25.92 |
| Writing-on-Stone, 35-1-13-4 | 411 | 129 | 543 | 1,002 | 618 | 1,620 | 742 | 28,661 | 1.37 | 17.69 |
| Pendant d'Oreille, 16-2-8-4 | 397 | 158 | 555 | 1,399 | 776 | 2,175 | 13,799 | 12,460 | 24.86 | 19.52 |
| Spencer's Lower Ranche, 3-1-5-4 | 246 | 27 | 273 | 1,645 | 803 | 2,448 | 2,082 | 14,512 | 7.63 | 18.20 |

NOTE.—As a result of exceptionally large precipitation in September the conditions during 1911 were quite different from previous years.

## Deer Creek at Dickinson's Ranche, Alta.

This station was established May 26, 1911, by J. E. Degnan. It is 22 miles by trail from Coutts and is located on the S.W. 1/4 Sec. 15, Tp. 1, Rge. 12, W. 4th Mer., about 300 feet above the dam and intake of Dickinson Bros' irrigation ditch and about one quarter of a mile above their ranche buildings.

The stream flows in one channel and is straight for about 30 feet above and 100 feet below the station. The right bank is composed of a sandy loam, covered with rose bushes, and is liable to overflow. The left bank is high and liable to overflow. The bed of the stream is composed of gravel and sand, and is about 40 feet wide. In ordinary stages the stream averages from six feet to ten feet wide, and runs along the right side of the bed. It is liable to great change in high water, but apparently remains constant in low water.

Discharge measurements are made by wading. The initial point for sounding is the face of a stake driven in the left bank and marked 'I.P.'

The gauge, which is a plain staff graduated to feet and hundredths, is located at the right bank. The zero (elev., 90.72) is referred to the top of a post at the final point for soundings on the right bank (assumed elev., 100.00).

During 1911, the gauge was read by N. Dickinson.

Discharge Measurements of Deer Creek at Dickinson's Ranche, Alta., in 1911.

| Date. | Hydrographer | Width. | Area of Section | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 26 | J. E. Degnan | 7 5 | 3 29 | 0 81 | 1 75 | 2 67 |
| June 6 | do | 7 0 | 3 22 | 0 79 | 1 75 | 2 56 |
| June 26 | do | 25 0 | 9 77 | 2 13 | 2 34 | 20 82 |
| July 8 | do | 7 0 | 3 25 | 1 38 | 2 16 | 4 48* |
| July 24 | do | 7 0 | 2 54 | 0 54 | 2 05 | 1.36 |
| Aug. 11 | do | 19 0 | 5 44 | 1 16 | 2 19 | 6 30 |
| Aug. 21 | do | 6 0 | 2 68 | 0 94 | 2 10 | 2.51 |
| Sept. 2 | do | 6 0 | 2 00 | 0 27 | 1 97 | 0 54 |
| Sept. 20 | do | 8 3 | 5 80 | 1 19 | 1 46 | 6 89 |
| Oct. 24 | do | 7 5 | 4 74 | 0 70 | 1 29 | 3 30 |
| Nov. 6 | do | 8 0 | 4 30 | 0 60 | 1 22 | 2 56 |

* Gauged upstream from the regular section.

DAILY GAUGE-HEIGHT AND DISCHARGE of Deer Creek at Dickinson's Ranche, Alta., for 1911.

| | May. | | June. | | July. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1 80 | 4 20 | 2 60 | 50 5 |
| 2 | | | 1 78 | 3 60 | 2 50 | 39 0 |
| 3 | | | 1.76 | 3 00 | 2 40 | 27 5 |
| 4 | | | 1 76 | 3 00 | 2 30 | 16 0 |
| 5 | | | 1 75 | 2 70 | 2 20 | 7.0 |
| 6 | | | 1 73 | 2 10 | 2.15 | 4 75 |
| 7 | | | 1 72 | 1 80 | 2 14 | 4 30 |
| 8 | | | 1 70 | 1 20 | 2 13 | 3.85 |
| 9 | | | 1 68 | 1 06 | 2 12 | 3 40 |
| 10 | | | 1 67 | 0 99 | 2 11 | 2 95 |
| 11 | | | 1 65 | 0 85 | 2 10 | 2 50 |
| 12 | | | 1 64 | 0 78 | 2 09 | 2 35 |
| 13 | | | 1 64 | 0 78 | 2 08 | 2.20 |
| 14 | | | 1 63 | 0 71 | 2 06 | 1 90 |
| 15 | | | 1 63 | 0.71 | 2 05 | 1.75 |
| 16 | | | 1 61 | 0 57 | 2 05 | 1.75 |
| 17 | | | 1 59 | 0 45 | 2 04 | 1.60 |
| 18 | | | 1 58 | 0 40 | 2 06 | 1.90 |
| 19 | | | 1 61 | 0 57 | 2 06 | 1 90 |
| 20 | | | 1 61 | 0.57 | 2 05 | 1.75 |
| 21 | | | 1 65 | 0 85 | 2 04 | 1 60 |
| 22 | | | 1 67 | 0 99 | 2 05 | 1.75 |
| 23 | | | 1 68 | 1 06 | 2 05 | 1 75 |
| 24 | | | 3 00 | 127 00 | 2 05 | 1.75 |
| 25 | | | 2.90 | 99 00 | 2 04 | 1.60 |
| 26 | 1 75 | 2 70 | 2 35 | 21.30 | 2 04 | 1.60 |
| 27 | 1 75 | 2 70 | 2 32 | 18 10 | 2 04 | 1 60 |
| 28 | 1 77 | 3.30 | 2 30 | 16 00 | 2 05 | 1.75 |
| 29 | 1 78 | 3 60 | 2 25 | 11 50 | 2.00 | 1 00 |
| 30 | 1.82 | 5 60 | 2 15 | 4 75 | 2 05 | 1 75 |
| 31 | 1.82 | 5 60 | | | 2 04 | 1.60 |

Daily Gauge-height and Dircharge of Deer Creek at Dickinson's Ranche, Alta., for 1911.—*Continued.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.04 | 1.60 | 1.97 | 0.70 | 1.39 | 5.00 | | |
| 2 | 2.25 | 11.50 | 1.97 | 0.70 | 1.43 | 5.70 | | |
| 3 | 2.25 | 11.50 | | | 1.49 | 6.80 | | |
| 4 | 2.25 | 11.50 | | | 1.53 | 8.84 | | |
| 5 | 2.24 | 10.60 | | | 1.59 | 10.50 | | |
| 6 | 2.25 | 11.50 | | | 1.67 | 12.60 | 1.22 | 2.60 |
| 7 | 2.26 | 12.40 | | | 1.67 | 12.60 | 1.22 | 2.60 |
| 8 | 2.27 | 13.30 | | | 1.63 | 11.40 | | |
| 9 | 2.28 | 14.20 | | | 1.60 | 10.50 | | |
| 10 | 2.24 | 10.60 | | | 1.56 | 9.68 | | |
| 11 | 2.19 | 6.50 | | | | | | |
| 12 | 2.18 | 6.10 | | | | | | |
| 13 | 2.17 | 5.60 | | | | | | |
| 14 | 2.16 | 5.20 | | | | | | |
| 15 | 2.14 | 4.30 | | | | | | |
| 16 | 2.11 | 2.95 | | | | | | |
| 17 | 2.08 | 2.20 | | | | | | |
| 18 | 2.06 | 1.90 | | | | | | |
| 19 | 2.06 | 1.90 | | | | | | |
| 20 | 2.08 | 2.20 | 1.46 | 6.30 | 1.44 | 5.92 | | |
| 21 | 2.10 | 2.50 | | | | | | |
| 22 | 2.02 | 1.30 | | | 1.29 | 3.30 | | |
| 23 | 2.01 | 1.15 | | | 1.29 | 3.30 | | |
| 24 | 2.01 | 1.15 | | | 1.29 | 3.30 | | |
| 25 | 2.02 | 1.30 | | | | | | |
| 26 | 2.01 | 1.15 | | | | | | |
| 27 | 2.01 | 1.15 | | | | | | |
| 28 | 1.99 | 0.90 | | | | | | |
| 29 | 1.98 | 0.80 | | | | | | |
| 30 | 1.98 | 0.80 | | | | | | |
| 31 | 1.97 | 0.70 | | | | | | |

Note—Heavy rains in early part of September caused a larger run-off during that month than usual, but on Sept. 4 the gauge was washed out and no observations were made during the high water period. The gauge was re-established on Sept. 19, but the observer was away from home from Sept. 20 to Oct. 1, and from Oct. 10 to Oct. 20, and no observations were made during his absence. Creek froze over Oct. 25. Opened Nov. 6 and 7 and froze up again on Nov. 8.

Monthly Discharge of Deer Creek near Dickinson's Ranche, for 1911.

Drainage area, 6 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| May (26-31) | 5.6 | 2.7 | 3.92 | 0.653 | 0.15 | 47 |
| June | 127.0 | 0.40 | 11.0 | 1.830 | 2.04 | 655 |
| July | 50.5 | 1.00 | 6.34 | 1.060 | 1.22 | 390 |
| August | 14.2 | 0.70 | 5.17 | 0.862 | 0.99 | 318 |
| September (1, 2 and 20) | 6.30 | 0.70 | 2.57 | .428 | 0.05 | 15 |
| October (1-10, 20, 22-24) | 12.6 | 3.30 | 7.80 | 1.300 | 0.68 | 217 |
| The period | | | | | | 1,642 |

Deer Creek at Deer Creek Cattle Company's Ranche.

This station was established May 27, 1911, by J. E. Degnan. It is 24 miles by trail from Coutts, and is located on the N.E. 1/4 Sec. 26, Tp. 1, Rge. 12, W. 4th Mer. It is about one mile upstream from the Deer Creek Cattle Co's ranche buildings, three quarters of a mile above their dam and intake, and three miles below Dickinson Bros' dam and intake.

The stream flows in one channel and is straight for sixty feet above and fifty feet below the station. The right bank is composed of a sandy loam, and is liable to overflow during high water for about forty feet from the bank. The left bank is composed of a sandy loam, is high with a gradual slope and not liable to overflow. The bed of the stream consists of gravel and sand, and is liable to great change in high water, apparently remaining constant during low water.

Discharge measurements are made by wading. The initial point for sounding is the face of a cedar post in the left bank, marked 'B.M.'

The gauge is a plain staff graduated to feet and hundredths, located at the right bank. The zero (elev., 89.47) is referred to the top of the post at the initial point for soundings on the left bank (assumed elev., 100.00).

During 1911, the gauge was read by H. Webster.

Discharge Measurements of Deer Creek at Deer Creek Cattle Company's Ranche, in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 27 | J. E. Degnan | 6 5 | 2 33 | 0 906 | 1 710 | 2.11 |
| June 25 | do | 14 0 | 12 68 | 3 540 | 2 560 | 44 87* |
| July 8 | do | 8 5 | 4 04 | 1 130 | 2 140 | 4 54 |
| July 24 | do | 7 0 | 1 69 | 0 437 | 1 940 | 0 74 |
| Aug. 21 | do | 6 0 | 2 56 | 0 679 | 2 030 | 1 74 |
| Sept. 20 | do | 8 5 | 4 30 | 1 374 | 2 560 | 5 91 |
| Oct. 25 | do | 8 0 | 3 68 | 0 959 | 2 495 | 3 53 |
| Nov. 6 | do | 8 0 | 2 88 | 0 559 | 2 420 | 1.61 |

* Measurement not taken at regular station.

Daily Gauge-height and Discharge of Deer Creek at Deer Creek Cattle Co's Ranche, Alta., for 1911.

| Day. | May. | | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge |
| | Feet. | Sec.-ft | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | ... | ... | 1.83 | 5.50 | ... | ... | 1.93 | ... | * | ... | 2.57 | 6.40 |
| 2 | ... | ... | 1.81 | 4.80 | | | 1.93 | ... | * | ... | 2.59 | 7.10 |
| 3 | ... | ... | 1.74 | 3.00 | | ... | 1.98 | ... | * | | 2.59 | 7.10 |
| 4 | ... | ... | 1.74 | 3.00 | | ... | 2.00 | ... | * | | * | ... |
| 5 | ... | ... | 1.73 | 2.80 | ... | ... | 2.03 | ... | * | ... | * | ... |
| 6 | ... | ... | 1.71 | 2.30 | | ... | 2.03 | ... | | | * | ... |
| 7 | ... | ... | 1.65 | 1.30 | ‡ | ... | 2.00 | ... | * | ... | * | ... |
| 8 | ... | ... | 1.65 | 1.30 | 2.14 | 4.20 | 2.00 | ... | * | | * | ... |
| 9 | ... | ... | 1.60 | 0.50 | 1.99 | 1.60 | 2.00 | | * | | * | ... |
| 10 | ... | ... | 1.60 | 0.50 | 1.99 | 1.60 | 2.00 | ... | * | | * | ... |
| 11 | ... | ... | 1.60 | 0.50 | 1.98 | 1.40 | 2.01 | | * | | * | ... |
| 12 | ... | ... | 1.60 | 0.50 | 1.98 | 1.40 | 2.02 | | * | | * | ... |
| 13 | ... | ... | 1.58 | 0.40 | 1.98 | 1.40 | 2.03 | | * | | * | ... |
| 14 | | | 1.52 | 0.20 | 1.99 | 1.60 | 2.00 | | * | | * | ... |
| 15 | ... | ... | 1.48 | 0.10 | 2.00 | 1.70 | 2.00 | ... | * | | * | ... |
| 16 | ... | ... | 1.48 | 0.10 | 1.99 | 1.60 | 2.00 | | * | | * | ... |
| 17 | | | 1.48 | 0.10 | 1.98 | 1.40 | 2.00 | | * | | * | ... |
| 18 | ... | ... | 1.48 | 0.10 | 1.97 | 1.30 | 2.00 | ... | * | | * | ... |
| 19 | ... | ... | 1.48 | 0.10 | 1.96 | 1.10 | 2.00 | | * | | * | ... |
| 20 | ... | ... | 1.48 | 0.10 | 1.95 | 1.00 | 1.99 | | 2.56 | 6.00 | * | ... |
| 21 | ... | ... | 1.54 | 0.30 | 1.93 | 0.70 | 1.98 | ... | 2.55 | 5.60 | * | ... |
| 22 | ... | ... | 1.71 | 2.30 | 1.93 | 0.70 | 1.98 | ... | 2.58 | 6.80 | * | |
| 23 | ... | ... | 1.71 | 2.30 | 2.01 | 1.90 | 1.97 | | 2.59 | 7.10 | * | |
| 24 | ... | ... | * | | 1.94 | 0.90 | 1.97 | | 2.59 | 7.10 | * | |
| 25 | ... | ... | 2.56 | 44.90 | 1.95 | 1.00 | 1.98 | ... | 2.58 | 6.80 | 2.50 | 3.80 |
| 26 | ... | | ‡ | | 1.96 | 1.10 | 2.00 | ... | 2.58 | 6.80 | 2.47 | 3.00 |
| 27 | 1.74 | 3.00 | | | 1.97 | 1.30 | 2.00 | | 2.56 | 6.00 | 2.50 | 3.80 |
| 28 | 1.77 | 3.80 | | | 1.95 | 1.00 | 2.00 | ... | 2.55 | 5.60 | 2.52 | 4.50 |
| 29 | 1.77 | 3.80 | | | 1.94 | 0.90 | 2.00 | ... | 2.56 | 6.00 | ... | ... |
| 30 | 1.85 | 6.10 | | | 1.94 | 0.90 | 2.00 | ... | 2.56 | 6.00 | ... | ... |
| 31 | 1.87 | 6.80 | | ... | 1.93 | 0.70 | 2.00 | ... | ... | ... | | ... |

Gauge heights for August are not reliable on account of changing conditions.
Discharge for gauge heights above 2.56 estimated.
*No observations. ‡Gauge washed out. ‡Gauge replaced.

Monthly Discharge of Deer Creek at Deer Creek Cattle Company's Ranche, for 1911.

Drainage area, 13 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| May (27-31) | 6.8 | 3.0 | 4.70 | 0.362 | 0.07 | 47 |
| June (1-23 and 25) | 44.9 | 0.10 | 3.21 | 0.247 | 0.22 | 153 |
| July (8-31) | 4.2 | 0.70 | 1.35 | 0.104 | 0.09 | 64 |
| September (20-30) | 7.1 | 5.6 | 6.3 | 0.488 | 0.20 | 138 |
| October (1-3, 25-28) | 7.1 | 3.0 | 5.1 | 0.395 | 0.10 | 71 |
| The period | ... | ... | ... | ... | ... | 473 |

MISCELLANEOUS DISCHARGE MEASUREMENTS made in Milk River Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. ft.* | *Feet per Sec.* | *Sec.-ft.* |
| April 26 | N. M. Sutherland. | Beargulch Creek | Sec. 19-2-9-4 | 2.60 | 0.64 | 0.830 | 0.53 |
| May 5 | " | " | " | | | | 0.37 |
| May 13 | " | " | " | | | | Nil. |
| June 5 | J. E. Degnan | " | " | 4.50 | 2.09 | 0.483 | 1.01 |
| July 22 | " | " | Sec. 20-2-9-4 | | | | Nil. |
| Aug. 12 | " | " | " 19-2-9-4 | | | | Nil. |
| Oct. 26 | " | " | " " | 8.00 | 2.61 | 0.911 | 2.38 |
| May 3 | L. J. Gleeson | Creek | " 24-1-23-4 | 4.00 | 0.75 | 0.660 | *0.50 |
| May 4 | " | " | " 19-2-18-4 | 3.00 | 3.00 | 0.400 | *1.20 |
| April 18 | " | Dead Horse Creek | " 4-2-11-4 | 0.90 | 0.22 | 0.760 | 0.17 |
| April 26 | " | " | " " | | | | Nil. |
| May 28 | " | " | " 10-2-11-4 | | | | 0.02 |
| July 22 | " | " | " 4-2-11-4 | | | | Nil. |
| Aug. 18 | " | " | " " | 1.85 | 0.48 | 0.416 | 0.20 |
| Sept. 23 | " | " | " " | 3.00 | 2.82 | 1.880 | 5.31 |
| Oct. 26 | " | " | " " | 4.50 | 2.03 | 0.931 | 1.89 |
| Nov. 24 | " | " | " " | 6.50 | 2.88 | 1.360 | 3.92 |
| April 18 | N. M. Sutherland | Halfbreed Creek | " 28-2-10-4 | 3.80 | 1.36 | 1.630 | 2.22 |
| April 26 | " | " | " " | 3.50 | 0.97 | 1.400 | 1.39 |
| May 5 | " | " | " " | 3.70 | 1.03 | 1.330 | 1.37 |
| May 13 | " | " | " " | 3.00 | | | 1.01 |
| May 28 | J. E. Degnan | " | " " | 10.5 | 6.48 | 0.856 | 5.55 |
| June 5 | " | " | " 22-2-10-4 | 9.0 | 7.6 | 0.706 | 5.37 |
| July 22 | " | " | " 28-2-10-4 | 5.0 | 1.05 | 0.78 | 0.82 |
| Aug. 18 | " | " | " " | 9.5 | 4.75 | 0.357 | 1.70 |
| Sept. 23 | " | " | " 21-2-10-4 | 10.0 | 10.44 | 1.38 | 14.4 |
| Oct. 26 | " | " | " 28-2-10-4 | 9.0 | 6.76 | 0.736 | 4.98 |
| Nov. 4 | " | " | " " | 9.8 | 6.49 | 1.36 | 8.71 |
| May 31 | " | Kennedy Creek | " 3-1-5-4 | x | | | 0.07 |
| June 20 | " | " | " " | 5.5 | 2.02 | 0.787 | 1.59 |
| July 14 | " | " | " " | | | | Nil. |
| Sept. 26 | " | " | " " | 6.5 | 3.66 | 0.685 | 2.56 |
| July 15 | " | Lost River | " 2-1-4-4 | | | | Nil. |
| July 22 | " | Miners Coulee | " 10-2-11-4 | | | | Nil. |
| Aug. 18 | " | " | " " | 5.5 | 2.82 | 0.673 | 1.90 |
| Sept. 23 | " | " | " " | 11.0 | 5.75 | 1.69 | 9.74 |
| Oct. 3 | " | " | " " | 18.0 | 16.92 | 2.151 | 36.40 |
| Oct. 26 | " | " | " " | 10.0 | 4.91 | 0.496 | 2.44 |
| Nov. 4 | " | " | " " | 10.0 | 4.80 | 1.24 | 5.98 |
| July 18 | " | Pritchard Coulee | " 4-1-11-4 | | | | Nil. |
| April 17 | N. M. Sutherland | Police Creek | " 35-1-13-4 | 1.7 | 0.68 | 1.39 | 0.94 |
| May 24 | J. E. Degnan | " | " " | x | | | 0.24 |
| May 25 | " | " | " " | x | | | 0.480 |
| July 7 | " | " | " " | 5.0 | 1.65 | 1.096 | 1.810 |
| Aug. 21 | " | " | " " | x | | | 0.331 |
| Sept. 2 | " | " | " " | | | | Nil. |
| Sept. 11 | " | " | " " | 9.0 | 7.54 | 1.274 | 9.610 |
| Sept. 18 | " | " | " " | 8.0 | 4.57 | 1.074 | 4.910 |
| Oct. 4 | " | " | " " | 9.5 | 8.16 | 1.102 | 9.000 |
| Oct. 23 | " | " | " " | 5.5 | 2.77 | 0.783 | 2.070 |
| July 29 | " | Red Creek | " 13-1-15-4 | | | | Nil. |
| Aug. 8 | " | " | " 20-1-15-4 | | | | Nil. |
| Nov. 5 | " | Spring Creek | " 31-2-11-4 | 2.7 | 2.01 | 0.587 | 1.180 |
| July 25 | " | Verdigris Creek | " 11-2-14-4 | | | | Nil. |
| Aug 10 | " | " | " 28-2-14-4 | | | | Nil. |

x Weir measurement.

## PAKOWKI LAKE DRAINAGE BASIN.

*General Description.*

The drainage into Pakowki Lake comes from three different directions; from the west by way of Etzikom Coulee, from the southeast in Canal and Ketchum creeks and from the northeast in Manyberries Creek. The lake has no outlet. The streams making up the drainage basin are very similar in their general characteristics, all having narrow, deep, and well defined valleys, with sparse growths of brush along the bottoms, and all draining a sandy and very unproductive-appearing soil. The drainage consists almost entirely of the spring run-off, the soil being so devoid of moisture as to take care of any ordinary rainfall without allowing any drainage into the streams.

Very little information has as yet been collected regarding the flow in any of the above mentioned streams, the one only touched upon as yet being Manyberries Creek. During the months of April, May, June and part of July, in 1911, Manyberries Creek showed an average run-off of 716 acre-feet per month. There was also a large run-off in September, but no records were obtained. Hooper and Huckvale have constructed very efficient irrigation works and divert water from Manyberries Creek to irrigate 2,120 acres of hay meadow. The yield of hay has been very much increased by the use of the water.

### Manyberries Creek at Hooper and Huckvale's Ranche.

This station was established June 17, 1910, by H. R. Carscallen. It is located on the S.E. ¼ Sec. 3, Tp. 5, Rge. 6, W. 4th Mer., at Hooper and Huckvale's ranche, seven miles east of Pakowki Lake, one and one quarter miles above Hooper and Huckvale's dam and intake, and below the mouth of the south branch.

The stream flows in one channel, and is straight for 400 feet above and 500 feet below the station. Both banks are high and do not overflow. They are composed of a sandy loam, sparsely covered with brush. The bed of the stream is composed of sand and gravel, which apparently remains constant.

Discharge measurements are made by wading. The initial point for soundings is the face of a stake driven close to the ground on the left bank and marked 'I.P.' At extreme low-water stage a weir is used.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 79.48) is referred to the top of the post at the initial point for soundings (assumed elev., 100.00).

During 1911, the gauge was read by Sydney Hooper.

Discharge Measurements of Manyberries Creek at Hooper and Huckvale's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 24 | N. M. Sutherland | 9.0 | 3.92 | 2.140 | 1.38 | 8.38* |
| April 26 | M. H. French | 22.4 | 21.38 | 0.266 | 1.31 | 5.69 |
| April 27 | do | 22.4 | 19.52 | 0.206 | 1.26 | 4.03 |
| May 11 | N. M. Sutherland | 4.0 | 1.22 | 0.870 | 1.09 | 1.06* |
| June 2 | J. E. Degnan | 15" weir. | .. | .. | 0.85 | 0.14* |
| July 17 | do | . | .... | .. | 0.69 | Nil. |
| Aug. 16 | do | 15" weir. | . | | 0.70 | 0.039* |
| Sept. 28 | do | 4.0 | 1.63 | 0.450 | 0.82 | 0.730 |

* Measurement taken below regular station.

DAILY GAUGE-HEIGHT AND DISCHARGE of Manyberries Creek near Hooper and Huckvale's Ranche, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.01 | 0.65 | 1.52 | 16.10 | 1.02 | 0.70 | 3.57 | 220.2† |
| 2 | 1.01 | 0.65 | 1.51 | 17.20 | 0.93 | 0.39 | 3.57 | 220.2† |
| 3 | 1.10 | 1.10 | 1.76 | 30.00 | 0.83 | 0.16 | 2.44 | 80.4† |
| 4 | 1.10 | 1.10 | 1.44 | 11.70 | 0.81 | 0.12 | 1.58 | 19.4 |
| 5 | 1.06 | 0.90 | 1.54 | 17.20 | * | Nil. | 1.16 | 2.1 |
| 6 | 1.05 | 0.85 | 1.38 | 8.70 | .... | .... | 1.09 | 1.0 |
| 7 | 1.01 | 0.65 | 1.30 | 5.30 | .... | .... | 0.99 | 0.57 |
| 8 | 1.03 | 0.75 | 1.24 | 3.70 | .... | .... | 0.92 | 0.36 |
| 9 | 1.26 | 4.30 | 1.18 | 2.40 | .... | .... | 0.88 | 0.26 |
| 10 | 2.69 | 103.00† | 1.15 | 1.90 | .... | .... | 0.86 | 0.22 |
| 11 | 2.39 | 76.20† | 1.10 | 1.10 | .... | .... | 0.84 | 0.18 |
| 12 | 1.56 | 18.30 | 1.08 | 1.00 | .... | .... | 0.80 | 0.10 |
| 13 | 1.42 | 10.60 | 1.06 | 0.90 | .... | .... | 0.77 | 0.07 |
| 14 | 1.34 | 7.00 | 1.07 | 0.95 | .... | .... | 0.75 | 0.05 |
| 15 | 1.25 | 4.00 | 1.08 | 1.00 | .... | .... | 0.74 | 0.04 |
| 16 | 1.33 | 6.60 | 1.12 | 1.40 | .... | .... | ‡ | .... |
| 17 | 1.71 | 27.20 | 1.26 | 4.30 | .... | .... | .... | .... |
| 18 | 1.44 | 11.70 | 1.20 | 2.70 | .... | .... | .... | .... |
| 19 | 1.35 | 7.40 | 1.18 | 2.40 | .... | .... | .... | .... |
| 20 | 1.54 | 17.20 | 1.15 | 1.90 | .... | .... | .... | .... |
| 21 | 1.48 | 13.90 | 1.16 | 2.10 | .... | .... | .... | .... |
| 22 | 1.44 | 11.70 | 1.15 | 1.90 | 1.07 | 0.95 | .... | .... |
| 23 | 1.39 | 9.10 | 1.18 | 2.40 | 1.62 | 21.70 | .... | .... |
| 24 | 1.38 | 8.70 | 1.20 | 2.70 | 1.38 | 8.70 | .... | .... |
| 25 | 1.32 | 6.10 | 1.21 | 3.00 | 1.90 | 39.50† | .... | .... |
| 26 | 1.28 | 4.80 | 1.42 | 10.60 | 2.55 | 90.00† | .... | .... |
| 27 | 1.26 | 4.30 | 1.18 | 2.40 | 1.57 | 18.80 | .... | .... |
| 28 | 1.26 | 4.30 | 1.14 | 1.70 | 1.16 | 2.10 | .... | .... |
| 29 | 1.26 | 4.30 | 1.10 | 1.10 | 1.09 | 1.00 | .... | .... |
| 30 | 1.30 | 5.30 | 1.13 | 1.60 | 1.11 | 1.30 | .... | .... |
| 31 | .... | .... | 1.03 | 0.75 | .... | .... | .... | .... |

* No Gauge Heights given from June 5 to June 21.
Noted dry on June 5.
Rain-storm noted June 22.
†Approximate.
‡Observer absent and no one else available after July 15th. Creek was almost dry after that date except for a week in September when, as the result of heavy rains, there was a good flow.

MONTHLY DISCHARGE of Manyberries Creek near Hooper and Huckvale's Ranche, Alta., for 1911.

Drainage area, 134 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| April | 103 | 0.65 | 12.4 | 0.092 | 0.10 | 738 |
| May | 30 | 0.75 | 5.2 | 0.039 | 0.04 | 320 |
| June | 90 | Nil. | 6.2 | 0.046 | 0.05 | 369 |
| July (1-15) | 220 | 0.04 | 36.3 | 0.270 | 0.15 | 1,080 |
| The period | | | | | | 2,507 |

MISCELLANEOUS DISCHARGE MEASUREMENTS in Pakowki Lake Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. ft.* | *Feet per Sec.* | *Sec.-ft.* |
| April 24 | N. M. Sutherland.. | Canal Creek | Sec. 6-4-6-4 | | | | 0.436 |
| May 11 | " | " | " " | | | | Nil. |
| July 21 | J. E. Degnan | " | " " | | | | Nil. |
| Aug. 16 | " | " | " " | | | | Nil. |
| July 17 | " | S.B. Manyberries Crk. | " 11-5-6-4 | | | | Nil. |
| Aug. 16 | " | " | " " | | | | Nil. |
| July 21 | " | Ketchum Creek | " 15-4-6-4 | | | | Nil. |
| Aug. 16 | " | " | " " | | | | Nil. |

## SAGE CREEK DRAINAGE BASIN.

### *General Description.*

Sage creek is a small and unimportant stream which rises in the hills, or 'bad-lands,' a few miles north of the International boundary on the divide between Milk River and Lodge creek

The stream has no definite or permanent source of supply, and derives its discharge solely from the melting of snow, which accumulates in innumerable coulees during the winter months. When the first warm days of spring arrive the snow is melted and each coulee, acting as a water-course, throws its volume of water into the main stream. For a very short period the stream has a good flow, but soon dwindles and dries up.

After leaving Canadian territory, Sage creek spreads out over a large dry lake which has no outlet. This dry lake is about ten miles long, and averages about one and a half miles wide, and lies southeast and northwest and close to the boundary. It is bounded on the south by a low range of hills and at some time has held probably two or three feet of water at its deepest parts, but since 1908, neither it nor Grassy Lake nor Wild Horse Lake have held any water.

### SAGE CREEK AT WILD HORSE POLICE DETACHMENT.

This station was established on August 10, 1909, by F. H. Peters. It is located in Sec. 9, Tp. 1, Rge. 2, W. 4th Mer., about one and a quarter miles from Wild Horse police post. It is about 115 miles by trail from Milk River post office.

The channel is straight for forty feet above and below the station. The banks are composed of hard clay and are high but liable to overflow. The bed is composed of hard gumbo clay.

Discharge measurements are made by wading. The initial point for soundings is the face of a post on the right bank marked "0+00" in red paint.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post in the centre of the channel. It is referred to the top of the post at the initial point for soundings.

During 1911, the gauge was read by Corp. Tom Brewer, but, as the district hydrographer did not visit the station during 1911, estimates of the discharge have not been made.

There are two small irrigation ditches under construction which will divert water from Sage Creek. It is not likely that any water was diverted during 1911.

MEAN DAILY GAUGE-HEIGHT, in feet, of Sage Creek at Wild Horse Police Detachment, Alta., for 1911.

| Day. | April. | May. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.07 | 1.90 | Dry. | 1.20 | 1.10 | Dry. | 2.50 | 1.00 |
| 2 | 2.03 | 1.60 | " | 1.27 | 1.02 | " | 3.64 | 1.00 |
| 3 | 2.02 | 1.20 | " | 3.86 | 1.00 | " | 3.57 | 1.00 |
| 4 | 1.98 | 1.20 | " | 3.76 | 1.00 | 1.02 | 3.21 | .... |
| 5 | 1.98 | 1.00 | " | 3.50 | 0.95 | 1.55 | 3.02 | .... |
| 6 | 1.79 | Dry. | " | 3.00 | 0.90 | 4.52 | 2.85 | .... |
| 7 | 1.70 | " | " | 2.87 | Dry. | 6.01 | 2.78 | .... |
| 8 | 1.65 | " | " | 2.50 | " | 5.52 | 2.78 | .... |
| 9 | | " | " | 2.42 | " | 4.12 | 2.77 | .... |
| 10 | 1.62 | " | " | 2.21 | " | 4.38 | 2.74 | .... |
| 11 | 1.70 | | " | 2.00 | " | 4.34 | 2.72 | .... |
| 12 | 1.73 | " | " | 1.93 | " | 4.10 | 2.66 | .... |
| 13 | 1.72 | " | " | 1.90 | " | 3.85 | 2.61 | .... |
| 14 | 1.72 | " | " | 1.88 | " | 3.10 | 2.50 | .... |
| 15 | 2.25 | " | " | 1.80 | " | 2.35 | 2.42 | .... |
| 16 | 2.07 | " | " | 1.76 | " | 2.10 | 2.35 | .... |
| 17 | 2.04 | " | " | 1.68 | " | 1.81 | 2.29 | .... |
| 18 | 1.90 | " | " | 1.60 | " | 1.81 | 2.20 | .... |
| 19 | 1.60 | " | " | 1.55 | " | 1.80 | 1.98 | .... |
| 20 | 1.70 | " | " | 1.53 | " | 1.80 | 1.98 | .... |
| 21 | 1.65 | " | " | 1.51 | " | 1.77 | 1.86 | .... |
| 22 | 1.41 | " | " | 1.52 | " | 1.84 | 1.72 | .... |
| 23 | 1.40 | " | " | 1.51 | " | 1.83 | 1.61 | .... |
| 24 | 1.32 | " | " | 1.48 | " | 1.87 | 1.34 | .... |
| 25 | 1.25 | " | " | 1.47 | " | 1.87 | 1.19 | .... |
| 26 | 1.20 | " | " | 1.44 | " | 1.82 | 1.01 | .... |
| 27 | 1.17 | " | " | 1.40 | " | 1.77 | 1.01 | .... |
| 28 | 1.10 | " | " | 1.35 | " | 1.71 | 1.00 | .... |
| 29 | 1.12 | " | " | 1.33 | " | 1.74 | 1.00 | .... |
| 30 | 1.11 | " | " | 1.30 | " | 1.73 | 1.00 | .... |
| 31 | . | " | " | 1.24 | " | .... | 1.00 | .... |

## LODGE CREEK DRAINAGE BASIN.

*General Description.*

Lodge Creek, which rises in township 7, range 3, west of the fourth meridian, flows in a southerly direction for about 12 miles, then turns south-eastward, crosses the International Boundary in section 4, township 1, range 28, west of the third meridian, and eventually empties into Milk river near Chinook, Montana. Its principal tributary is Middle Creek wheih joins it in section 4, township 2, range 29, west of the third meridian.

Near its head the valley is very deep and narrow but it broadens out considerably lower down, giving rise to large flats and meadows. The upper part of the drainage basin is cut up to a great extent by deep coulees which drain into the creek. This part of the creek is thickly covered with brush along the banks, but lower down it is totally devoid of tree growth. The valley is rather unproductive owing to the absence of moisture but a few good hay meadows have developed along its course through the storage of the flood waters and their application to the soil by irrigation. As is the case with many of the streams in this locality the flow in Lodge Creek is not continuous throughout the year, the creek being dry, with the exception of pools of standing water, during the greater part of the summer months. At flood stages the creek carries a considerable amount of water and as a result its channel is wide and well defined throughout the whole length of its course.

Two stations have been established on the main stream, one at Willow Creek police detachment near the International Boundary, and the other near the head of the creek at Hart's ranche. Descriptions of these stations are given below.

### EAST BRANCH OF LODGE CREEK AT ENGLISH'S RANCHE.

This station was established on October 7, 1911, by M. H. French. It is located at James English's ranche in the S.E. ¼ Sec. 1, Tp. 7, Rge. 3, W. 4th Mer., about 150 feet north of his house. It is about 45 miles by trail from Medicine Hat.

The channel is straight for about 50 feet above and 25 feet below the station. Both banks are wooded and high enough to contain the stream during all stages. The bed is composed of very coarse gravel and will not shift.

Discharge measurements are made with a meter by wading a short distance above the gauge. The initial point for soundings is a four-inch stake, one foot above ground on the left bank.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post sunk in the bed of the stream near the left bank. The zero of the gauge (elev., 94.92) is referred to the top of the initial point stake (assumed elev., 100.00). As a further reference the top of the final point stake is 0.83 feet below the top of the initial point stake. The gauge was read by Mrs. Annie English.

DISCHARGE MEASUREMENTS of East Branch of Lodge Creek at English's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Oct. 7 | M. H. French | 8 6 | 2 68 | 0 388 | 0 96 | 1.04 |

MEAN DAILY GAUGE-HEIGHT, in feet, of East Branch Lodge Creek, at English's Ranche, Alta., for 1911.

| Day. | October. | November. |
|---|---|---|
| 1 | | 1 17 |
| 2 | | 1.17 |
| 3 | | 1 18 |
| 4 | | 1 20 |
| 5 | | .... |
| 6 | | .... |
| 7 | 0 95 | |
| 8 | 0 95 | |
| 9 | 0 94 | |
| 10 | 0 92 | |
| 11 | 0 90 | |
| 12 | 0 90 | |
| 13 | 0 90 | |
| 14 | 0 90 | |
| 15 | 0 90 | |
| 16 | 0 88 | |
| 17 | 0 92 | |
| 18 | 0 98 | |
| 19 | 0 99 | |
| 20 | 0 99 | |
| 21 | 1 00 | |
| 22 | 1 04 | |
| 23 | 1 05 | |
| 24 | 1 07 | |
| 25 | 1 07 | |
| 26 | 1 08 | |
| 27 | 1 09 | |
| 28 | 1 10 | |
| 29 | 1 12 | |
| 30 | 1 15 | |
| 31 | 1 16 | |

## ANDERSON DITCH NEAR THELMA.

This station was established on September 23, 1911, by W. A. Fletcher. It is located on the S.W. ¼ Sec. 23, Tp. 6, Rge. 3, W. 4th Mer., about fifteen feet below the intake of the ditch, and about one quarter of a mile from Robert Henderson's house.

The gauge, which is a plain staff graduated to feet and inches, is fixed to a post at the left bank of the ditch. The zero of the gauge (elev., 98.63) is referred to the top of a stake (assumed elev., 100.00), about five feet southeast of the gauge.

The channel is straight for twenty feet above and thirty feet below the gauge. Both banks are low, but are not liable to overflow. The bed is composed of clay and gravel and is not liable to shift.

Discharge measurements are made by wading near the gauge. The initial point for soundings is the inner face of the post used as a bench-mark.

No water was diverted after the gauge had been installed.

## Lodge Creek at Hart's Ranche.

This station was established July 22, 1909, by F. T. Fletcher. It is located just north of the road allowance between Secs. 15 and 10, Tp. 6, Rge. 3, W. 4th Mer., about one half mile below the junction of the east and west branches of Lodge Creek and is about 45 miles by trail south of Medicine Hat.

The channel is straight for about 60 feet above and 250 feet below the station. The banks are high, steep and not liable to overflow. Both are covered with a dense growth of willow brush. The bed of the stream is composed of soft clay and there is one channel at all stages. On account of the narrow channel, the steep banks and soft condition of the creek bed, the stream cannot be waded at any stage. Discharge measurements are made at a bridge a few hundred feet downstream.

The gauge is a plain staff graduated to feet and hundredths, spiked to a post sunk in the bed of the stream near the left bank. The zero of the gauge (elev., 86.36, is referred to a permanent iron bench-mark (assumed elev., 100.00), which is located upon the left bank 4.91 feet south of the square stake used as the initial point for soundings and in line with the square stake upon the right bank used as the final point.

During 1911, the gauge was read by Mrs. Clara B. Hart.

The intake of Mr. Hart's irrigation ditch is about a mile above this station, but very little water passed through it during 1911.

### Discharge Measurements of Lodge Creek at Hart's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 25 | M. H. French | 13 7 | 31 19 | 0 722 | 3 06 | 22 51 |
| May 22 | do | 9 3 | 10 40 | 0 337 | 1 35 | 3.51 |
| Oct 5 | do | 9 0 | 10 95 | 0 294 | 2 02* | 3 22 |

* Beaver dams raising water.

### Daily Gauge-height and Discharge of Lodge Creek at Hart's Ranche, Alta., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | 2 47 | 14 0 | 1 08 | 2 2 | 4 80 | 55 0 |
| 2 | .... | .... | 2 55 | 16 0 | 1 08 | 2 2 | 4 75 | 54 0 |
| 3 | .... | .... | 2 92 | 20 0 | 1 10 | 2 3 | 2 95 | 21 0 |
| 4 | .... | .... | 3 10 | 23 0 | 1 00 | 1 7 | 2 15 | 10 0 |
| 5 | .... | .... | 2 82 | 19 0 | 0 75 | 0 7 | 2 00 | 9 0 |
| 6 | .... | .... | 1 92 | 8 2 | 0 66 | 0 3 | 1 85 | 7.0 |
| 7 | .... | .... | 1 88 | 7 8 | Dry. | Nil. | 1 40 | 4 1 |
| 8 | .... | .... | 1 68 | 6 0 | " | " | 1 30 | 3 5 |
| 9 | .... | .... | 1 60 | 5 4 | " | " | 1 40 | 4 1 |
| 10 | .... | .... | 1 60 | 5 4 | " | " | 1 45 | 4 4 |
| 11 | .... | .... | 1 81 | 7 1 | " | " | 1 35 | 3.8 |
| 12 | .... | .... | 1 80 | 7 0 | " | " | 1 15 | 2 6 |
| 13 | .... | .... | 1 65 | 5 8 | " | " | 1 10 | 2 3 |
| 14 | .... | .... | 1 65 | 5 8 | " | " | 1 05 | 2 0 |
| 15 | .... | .... | 1 76 | 6 7 | " | " | 0 98 | 1 6 |
| 16 | .... | .... | 2 47 | 11 0 | " | " | 0 95 | 1 5 |
| 17 | .... | .... | 2 58 | 16 0 | " | " | 0 70 | 0 5 |
| 18 | .... | .... | 1 94 | 8 4 | " | " | 0 55 | 0 1 |
| 19 | .... | .... | 1 72 | 6 4 | " | " | Dry. | Nil. |
| 20 | .... | .... | 1 90 | 8 0 | " | " | " | " |
| 21 | .... | .... | 1 65 | 5.8 | 0 95 | 1 5 | " | " |
| 22 | .... | .... | 1 35 | 3 8 | 7 50 | 144 0 | " | " |
| 23 | .... | .... | 1 85 | 7 5 | 2 65 | 17 0 | " | " |
| 24 | .... | .... | 2 70 | 18 0 | 2 75 | 18 0 | " | " |
| 25 | 4 08 | 41 0 | 1 65 | 5 8 | 6 25 | 98 0 | " | " |
| 26 | 3 00 | 22 0 | 1.94 | 8 4 | 4 44 | 48 0 | " | " |
| 27 | 2 45 | 14 0 | 1 74 | 6 5 | 3 00 | 22 0 | " | " |
| 28 | 1 95 | 8 5 | 1 66 | 5 9 | 2 10 | 10 0 | " | " |
| 29 | 1 93 | 8 3 | 1 35 | 3 8 | 2 00 | 9 0 | " | " |
| 30 | 2 24 | 11 0 | 1.15 | 2 6 | 1 80 | 7 0 | " | " |
| 31 | | | 1 15 | 2 6 | .... | .... | " | " |

DAILY GAUGE-HEIGHT AND DISCHARGE of Lodge Creek at Hart's Ranche, Alta., for 1911—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | Dry. | Nil. | Dry. | Nil. | 1.62 | 2.0 | 1.05 | 2.0 |
| 2 | " | " | " | " | 1.55 | 1.2 | 1.05 | 2.0 |
| 3 | " | " | " | " | 1.65 | 1.3 | 1.05 | 2.0 |
| 4 | " | " | 4.00 | 39.0 | 2.15 | 4.0 | ... | ... |
| 5 | " | " | 6.00 | 91.0 | 2.01 | 3.4 | ... | ... |
| 6 | " | " | 4.60 | 51.0 | 1.00 | 1.7 | ... | ... |
| 7 | " | " | 2.10 | 10.0 | 0.97 | 1.6 | ... | ... |
| 8 | " | " | 1.95 | 8.5 | 0.90 | 1.3 | ... | ... |
| 9 | " | " | 1.46 | 4.5 | 0.85 | 1.1 | ... | ... |
| 10 | " | " | 1.10 | 2.3 | 0.90 | 1.3 | ... | ... |
| 11 | " | " | 1.00 | 1.7 | 0.95 | 1.5 | ... | ... |
| 12 | " | " | 0.95 | 1.0 | 0.96 | 1.5 | ... | ... |
| 13 | " | " | 0.95 | 1.0 | 0.95 | 1.5 | ... | ... |
| 14 | " | " | 0.78 | 0.5 | 0.95 | 1.5 | ... | ... |
| 15 | " | " | 0.70 | 0.2 | 0.96 | 1.5 | ... | ... |
| 16 | " | " | 0.65 | 0.1 | 0.97 | 1.6 | ... | ... |
| 17 | " | " | 0.80 | 0.4 | 0.97 | 1.6 | ... | ... |
| 18 | " | " | 0.92 | 0.6 | 1.01 | 1.8 | ... | ... |
| 19 | " | " | 1.00 | 0.7 | 1.00 | 1.7 | ... | ... |
| 20 | " | " | 1.30 | 1.8 | 1.15 | 2.6 | ... | ... |
| 21 | " | " | 1.28 | 1.6 | 1.15 | 2.6 | ... | ... |
| 22 | " | " | 1.25 | 1.2 | 1.25 | 3.2 | ... | ... |
| 23 | " | " | 1.20 | 1.0 | 1.50 | 4.7 | ... | ... |
| 24 | " | " | 1.30 | 1.2 | 1.25 | 3.2 | ... | ... |
| 25 | " | " | 1.50 | 1.8 | 1.15 | 2.6 | ... | ... |
| 26 | " | " | 1.60 | 2.0 | 1.10 | 2.3 | ... | ... |
| 27 | " | " | 1.67 | 2.2 | 1.10 | 2.3 | ... | ... |
| 28 | " | " | 1.70 | 2.4 | 1.08 | 2.2 | ... | ... |
| 29 | " | " | 1.68 | 2.0 | 1.08 | 2.2 | ... | ... |
| 30 | " | " | 1.65 | 1.8 | 1.07 | 2.1 | ... | ... |
| 31 | " | " | | ... | 1.05 | 2.0 | ... | ... |

NOTE—Changing conditions from Sept. 12 to Oct. 5, because of beaver dams. On Oct. 5, part of the dam was removed which lowered the gauge heights 0.8 feet.

MONTHLY DISCHARGE of Lodge Creek at Hart's Ranche, Alta., for 1911.

Drainage area, 78 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per Square Mile | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| April (25-30) | 41.0 | 8.3 | 17.47 | 0.224 | 0.050 | 208 |
| May | 23.0 | 2.6 | 9.06 | 0.116 | 0.134 | 557 |
| June | 144.0 | 0.0 | 12.80 | 0.164 | 0.183 | 762 |
| July | 55.0 | 0.0 | 6.05 | 0.078 | 0.090 | 372 |
| August | 00.0 | 0.0 | 0.00 | 0.000 | 0.000 | 00 |
| September | 91.0 | 0.1 | 7.71 | 0.099 | 0.110 | 459 |
| October | 4.7 | 1.1 | 2.10 | 0.027 | 0.031 | 129 |
| November (1-3) | 2.0 | 2.0 | 2.00 | 0.026 | 0.003 | 12 |
| The period | ... | | ... | ... | 0.601 | 2,499 |

NOTE—There was considerable run-off before April 25 not included in this data.

The water diverted from Lodge Creek above this station by Hart's irrigation ditch, and several small ditches in Medicine Lodge Coulee is inappreciable for 1911.

## MIDDLE CREEK AT MCKINNON'S RANCHE.

This station was established June 21, 1910, by H. R. Carscallen. It is located on the S.W. ¼ Sec. 35, Tp. 5, Rge. 1, W. 4th Mer., about eleven miles southwest of Battle Creek post office.

The channel is almost straight for about 150 feet above and 100 feet below the station. The right bank is high with a gradual slope; the left bank is high and steep. Neither bank is liable to overflow except in extreme flood. The bed of the stream is composed of sand and coarse gravel.

During ordinary stages, discharge measurements are made with a current-meter by wading, and at extreme low stages a weir is used.

The gauge is a plain staff graduated to feet and hundredths, spiked to a post sunk in the bed of the stream near the left bank. The zero of the gauge (elev., 91.49) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the left bank about 25 feet from the edge of the bank. It is also 661 feet northeast of the N.E. corner of Sec. 27, Tp. 5, Rge. 1, W. 4th. Mer.

During 1911, the gauge was read by Angus McKinnon.

Springs just above this station keep the creek flowing at this point all summer, although at other places it is often dry. A small amount of water is stored in Mr. McKinnon's dam about two miles above this station.

DISCHARGE MEASUREMENTS of Middle Creek at McKinnon's Ranche, in 1911.

| Date. | Hydrographer | Width. | Area of Section | Mean Velocity | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 24 | M. H. French | 15.0 | 22.60 | 0.754 | 2.10 | 17.05 |
| May 20 | do | 10.0 | 4.24 | 0.239 | 0.62 | 1.01 |
| June 12 | do | 9.6 | 3.41 | 1.630 | 0.55 | 0.56* |
| July 20 | do | | 4.64 | 0.114 | 0.71 | 0.53* |
| Aug. 11 | do | 11.0 | 4.85 | 0.137 | 0.68 | 0.67* |
| Oct. 4 | do | 11.5 | 4.37 | 0.215 | 0.63 | 0.94 |

* Weir measurements.

DAILY GAUGE-HEIGHT AND DISCHARGE of Middle Creek at McKinnon's Ranche, Alta., for 1911.

| Day. | January. | | February. | | March | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.62 | | 3.15 | | 3.42 | | 1.70 | 10.5 | 0.84 | 2.0 | 0.58 | 0.7 |
| 2 | 0.62 | | 3.14 | | 3.45 | | 1.70 | 10.5 | 0.70 | 1.2 | 0.58 | 0.7 |
| 3 | 0.62 | | 3.20 | | 3.47 | | 1.68 | 10.2 | 0.95 | 2.8 | 0.58 | 0.7 |
| 4 | 0.62 | | 3.22 | | 3.48 | | 1.67 | 10.1 | 1.08 | 3.8 | 0.57 | 0.7 |
| 5 | 0.62 | | 3.22 | | 3.48 | | 1.66 | 10.0 | 0.79 | 1.7 | 0.57 | 0.7 |
| 6 | 0.62 | | 3.25 | | 3.50 | | 1.64 | 9.7 | 0.75 | 1.5 | 0.56 | 0.6 |
| 7 | 0.62 | | 3.27 | | 3.51 | | 1.64 | 9.7 | 0.64 | 1.0 | 0.58 | 0.7 |
| 8 | 0.62 | | 3.27 | | 3.52 | | 1.66 | 10.0 | 0.64 | 1.0 | 0.60 | 0.8 |
| 9 | 0.62 | | 3.29 | | 3.57 | | 1.69 | 10.4 | 0.61 | 0.8 | 0.57 | 0.7 |
| 10 | 0.62 | | 3.30 | | 3.61 | | 3.10 | 41.0 | 0.59 | 0.8 | 0.56 | 0.6 |
| 11 | 0.62 | | 3.30 | | 3.65 | | 4.85 | 156.0 | 0.59 | 0.8 | 0.56 | 0.6 |
| 12 | 0.62 | | 3.32 | | 3.68 | | 3.00 | 38.0 | 0.60 | 0.8 | 0.55 | 0.6 |
| 13 | 0.62 | | 3.33 | | 3.77 | | 2.40 | 23.0 | 0.58 | 0.7 | 0.55 | 0.6 |
| 14 | 0.62 | | 3.35 | | 3.79 | | 1.35 | 6.4 | 0.62 | 0.9 | 0.57 | 0.7 |
| 15 | 0.62 | | 3.35 | | 3.81 | | 0.99 | 3.1 | 0.64 | 1.0 | 0.56 | 0.6 |
| 16 | 0.62 | | 3.35 | | 3.85 | | 0.88 | 2.2 | 0.75 | 1.5 | 0.56 | 0.6 |
| 17 | 0.62 | | 3.38 | | 3.90 | | 1.80 | 12.0 | 0.67 | 1.1 | 0.56 | 0.6 |
| 18 | 0.62 | | 3.38 | | 3.97 | | 2.78 | 31.0 | 0.65 | 1.0 | 0.57 | 0.7 |
| 19 | 0.62 | | 3.38 | | 4.00 | | 2.38 | 22.6 | 0.60 | 0.8 | 0.59 | 0.8 |
| 20 | 0.62 | | 3.38 | | | | 2.47 | 26.4 | 0.62 | 0.9 | 0.59 | 0.5 |
| 21 | 0.62 | | 3.38 | | | | 2.37 | 22.4 | 0.60 | 0.8 | 0.63 | 0.7 |
| 22 | 0.62 | | 3.38 | | | | 2.22 | 19.4 | 0.59 | 0.8 | 0.70 | 1.0 |
| 23 | 0.64 | | 3.38 | | | | 2.07 | 16.5 | 0.64 | 1.0 | *2.20 | 18.0 |
| 24 | 0.68 | | 3.40 | | 1.70 | | 2.16 | 18.2 | 0.63 | 0.9 | *3.05 | 39.0 |
| 25 | 0.91 | | 3.41 | | 1.72 | | 1.55 | 8.6 | 0.63 | 0.9 | *2.58 | 24.0 |
| 26 | 1.10 | | 3.41 | | 1.68 | | 1.33 | 6.1 | 0.62 | 0.9 | 1.17 | 4.4 |
| 27 | 1.71 | | 3.41 | | 1.70 | | 0.94 | 2.7 | 0.61 | 0.8 | 2.50 | 24.0 |
| 28 | 2.10 | | 3.41 | | 1.72 | | 1.02 | 3.4 | 0.60 | 0.8 | 1.92 | 13.5 |
| 29 | 2.60 | | | | 1.72 | | 1.17 | 4.6 | 0.61 | 0.8 | 1.16 | 4.0 |
| 30 | 3.70 | | | | 1.72 | | 1.15 | 4.4 | 0.60 | 0.8 | 1.08 | 3.3 |
| 31 | 3.10 | | | | 1.72 | | | | 0.60 | 0.8 | | |

## Daily Gauge-height and Discharge of Middle Creek at McKinnon's Ranche, Alta., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.16 | 4.0 | 0.67 | 0.5 | 0.55 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 |
| 2 | 3.57* | 60.0 | 0.70 | 0.8 | 0.54 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 |
| 3 | 2.95* | 36.0 | 0.95 | 2.0 | 0.54 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 |
| 4 | 2.28 | 21.0 | 0.68 | 0.6 | 0.75 | 1.5 | 0.63 | 0.9 | 0.62 | 0.9 |
| 5 | 1.73 | 10.5 | 0.68 | 0.6 | 1.18 | 4.6 | 0.63 | 0.9 | 0.62 | 0.9 |
| 6 | 1.21 | 4.5 | 2.49* | 25.0 | 4.50 | 128.0 | 0.62 | 0.9 | 0.62 | 0.9 |
| 7 | 0.98 | 2.5 | 1.35 | 5.5 | 3.50 | 56.0 | 0.61 | 0.8 | 0.62 | 0.9 |
| 8 | 0.92 | 2.0 | 0.66 | 0.6 | 2.27 | 20.0 | 0.61 | 0.8 | 0.61 | 0.8 |
| 9 | 0.85 | 1.5 | 0.65 | 0.6 | 1.71 | 10.6 | 0.61 | 0.8 | 0.61 | 0.8 |
| 10 | 0.92 | 2.0 | 0.65 | 0.6 | 1.55 | 8.6 | 0.61 | 0.8 | 0.61 | 0.8 |
| 11 | 0.85 | 1.5 | 0.66 | 0.7 | 0.93 | 2.6 | 0.61 | 0.8 | 0.60 | 0.8 |
| 12 | 0.81 | 1.3 | 0.63 | 0.5 | 0.82 | 1.9 | 0.60 | 0.8 | 0.60 | 0.8 |
| 13 | 0.78 | 1.0 | 0.60 | 0.5 | 0.74 | 1.4 | 0.60 | 0.8 | 0.60 | 0.8 |
| 14 | 0.74 | 0.9 | 0.60 | 0.5 | 0.65 | 1.0 | 0.60 | 0.8 | 0.60 | 0.8 |
| 15 | 0.70 | 0.7 | 0.59 | 0.5 | 0.64 | 1.0 | 0.60 | 0.8 | 0.60 | 0.8 |
| 16 | 0.70 | 0.6 | 0.58 | 0.5 | 0.63 | 0.9 | 0.60 | 0.8 | | |
| 17 | 0.70 | 0.6 | 0.57 | 0.4 | 0.63 | 0.9 | 0.61 | 0.8 | | |
| 18 | 0.70 | 0.6 | 0.57 | 0.4 | 0.62 | 0.9 | 0.61 | 0.8 | | |
| 19 | 0.70 | 0.6 | 0.57 | 0.4 | 0.62 | 0.9 | 0.61 | 0.8 | | |
| 20 | 0.70 | 0.5 | 0.57 | 0.4 | 0.62 | 0.9 | 0.62 | 0.9 | | |
| 21 | 0.70 | 0.5 | 0.56 | 0.4 | 0.62 | 0.9 | 0.62 | 0.9 | | |
| 22 | 0.70 | 0.5 | 0.56 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 | | |
| 23 | 0.70 | 0.5 | 0.56 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 | | |
| 24 | 0.69 | 0.5 | 0.56 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 | | |
| 25 | 0.69 | 0.5 | 0.56 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 | | |
| 26 | 0.68 | 0.5 | 0.56 | 0.4 | 0.64 | 1.0 | 0.62 | 0.9 | | |
| 27 | 0.68 | 0.5 | 0.56 | 0.4 | 0.63 | 0.9 | 0.62 | 0.9 | | |
| 28 | 0.68 | 0.5 | 0.56 | 0.4 | 0.63 | 0.9 | 0.62 | 0.9 | | |
| 29 | 0.67 | 0.5 | 0.55 | 0.4 | 0.63 | 0.9 | 0.62 | 0.9 | | |
| 30 | 0.67 | 0.5 | 0.55 | 0.4 | 0.63 | 0.9 | 0.62 | 0.9 | | |
| 31 | 0.67 | 0.5 | 0.55 | 0.4 | | | 0.62 | 0.9 | | |

* Heavy rain in hills.

NOTE—Could not use gauge heights previous to April 1st because of considerable ice in channel. Shifting conditions occured between June 12 and Aug 11.

A part of above run-off was impounded by Wright's and McKinnon's dams below.

## Monthly Discharge of Middle Creek at McKinnon's Ranche, Alta., for 1911.

Drainage area, 123 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area | Total in Acre-Feet. |
| April | 156.0 | 2.2 | 18.6 | 0.151 | 0.168 | 1,107 |
| May | 3.8 | 0.7 | 1.1 | 0.009 | 0.010 | 68 |
| June | 39.0 | 0.5 | 4.8 | 0.038 | 0.042 | 286 |
| July | 60.0 | 0.5 | 5.1 | 0.041 | 0.047 | 314 |
| August | 25.0 | 0.4 | 1.4 | 0.011 | 0.013 | 80 |
| September | 128.0 | 0.4 | 8.4 | 0.068 | 0.076 | 500 |
| October | 1.0 | 0.8 | 0.9 | 0.007 | 0.008 | 55 |
| November (1-15) | 0.9 | 0.8 | 0.8 | 0.007 | 0.004 | 24 |
| The period | | | | | 0.368 | 2,434 |

NOTE—Springs just above kept the creek running continuously at the station though it went dry both above and below.

## MIDDLE CREEK AT ROSS'S RANCHE.

This station was established July 20, 1908, by H. R. Carscallen. It is located on the S.W. ¼ Sec. 30, Tp. 5, Rge. 29, W. 3rd Mer., about four miles southwest of Battle Creek post office.

The channel is straight for 50 feet above and below the station. The right bank is high, but the left is low and liable to overflow in flood stages of the stream. The bed of the stream is composed of sand and coarse gravel with a little vegetation at the station, and may shift slightly during high water. There is only one channel at low stages, but in extreme flood stages, water breaks out over the left bank and forms two channels. The current is sluggish at low stages and moderate at higher stages.

Discharge measurements are made by wading at ordinary stages, and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank, marked "I.P.," and surrounded with a few stones.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a pine post sunk in the bed of the stream at the left bank and securely stayed. The zero of the gauge (elev., 93.62) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated on the right bank 123 feet from the initial point and in line with the regular section. The bench-mark is about one foot above ground and is protected by a mound of stones. During 1911, the gauge was read by Maurice Ross.

The stream would be dry most of the summer at this station if it were not for the discharge of a few springs a short distance above. A part of the run-off of the drainage basin above this station is held by dams at Wright's and McKinnon's ranches and used for irrigation purposes.

DISCHARGE MEASUREMENTS of Middle Creek at Ross's Ranche, Sask., in 1911.

| Date. | Hydrographer | Width. | Area of Section. | Mean Velocity. | Gauge Height | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet* | *Sec.-ft* |
| April 21 | M. H. French | 9.2 | 5.97 | 0.336 | 0.72 | 2.01 |
| May 20 | do | 9.0 | 3.89 | 0.095 | 0.51 | 0.37 |
| June 12 | do | 8.5 | 3.89 | 0.073 | 0.54 | 0.28 |
| July 20 | do | 8.8 | 5.21 | 0.062 | 0.56 | 0.33 |
| Sept. 1 | do | | 5.06 | 0.063 | 0.57 | 0.32 |
| Sept. 7 | do | 12.0 | 24.26 | 2.499 | 2.36 | 60.64 |
| Sept. 8 | do | 13.4 | 28.48 | 2.852 | 2.68 | 81.25 |
| Sept. 30 | do | 9.0 | 5.57 | 0.088 | 0.60 | 0.49 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Middle Creek, at Ross's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | 1.05 | 6.1 | 0.54 | 0.3 | 1.30 | 12.0 |
| 2 | .... | .... | 1.03 | 5.7 | 0.54 | 0.3 | 1.10 | 7.2 |
| 3 | .... | .... | 0.70 | 1.3 | 0.54 | 0.3 | 0.90 | 3.5 |
| 4 | .... | .... | 0.60 | 0.5 | 0.54 | 0.3 | 1.80 | 30.0 |
| 5 | .... | .... | 0.60 | 0.5 | 0.54 | 0.3 | 1.70 | 26.0 |
| 6 | .... | .... | 0.56 | 0.4 | 0.54 | 0.3 | 1.48 | 17.0 |
| 7 | .... | .... | 1.53 | 19.0 | 0.54 | 0.3 | 1.20 | 9.6 |
| 8 | .... | .... | 1.30 | 12.0 | 0.54 | 0.3 | 0.99 | 4.9 |
| 9 | .... | .... | 1.30 | 12.0 | 0.54 | 0.3 | 0.70 | 1.3 |
| 10 | .... | .... | 1.30 | 12.0 | 0.54 | 0.3 | 0.59 | 0.5 |
| 11 | 0.74 | 1.7 | 1.30 | 12.0 | 0.54 | 0.3 | 0.59 | 0.5 |
| 12 | 1.10 | 7.2 | 1.00 | 5.0 | 0.54 | 0.3 | 0.55 | 0.4 |
| 13 | 3.10 | *114.0 | 0.80 | 2.3 | 0.54 | 0.3 | 0.55 | 0.4 |
| 14 | 2.00 | 40.0 | 0.60 | 0.5 | 0.54 | 0.3 | 0.55 | 0.4 |
| 15 | 1.30 | 12.0 | 0.55 | 0.4 | 0.54 | 0.3 | 0.55 | 0.4 |
| 15 | 0.79 | 2.2 | 0.55 | 0.4 | 0.54 | 0.3 | 0.55 | 0.4 |
| 17 | 0.79 | 2.2 | 0.55 | 0.4 | 0.54 | 0.3 | 0.56 | 0.4 |
| 18 | 0.79 | 2.2 | 0.55 | 0.4 | 0.54 | 0.3 | 0.56 | 0.4 |
| 19 | 0.80 | 2.3 | 0.54 | 0.3 | 0.54 | 0.3 | 0.56 | 0.4 |
| 20 | 0.90 | 3.5 | 0.53 | 0.3 | 0.54 | 0.3 | 0.57 | 0.4 |
| 21 | 1.30 | 12.0 | 0.54 | 0.3 | 0.55 | 0.4 | 0.57 | 0.4 |
| 22 | 3.12 | 116.0 | 0.54 | 0.3 | 0.60 | 0.5 | 0.57 | 0.4 |
| 23 | 1.70 | 25.0 | 0.55 | 0.4 | 0.60 | 0.5 | 0.57 | 0.4 |
| 24 | 0.90 | 3.5 | 0.54 | 0.3 | 0.60 | 0.5 | 0.57 | 0.4 |
| 25 | 1.02 | 5.4 | 0.53 | 0.3 | 0.60 | 0.5 | 0.57 | 0.4 |
| 26 | 1.05 | 6.1 | 0.53 | 0.3 | 0.61 | 0.6 | 0.57 | 0.4 |
| 27 | 1.05 | 6.1 | 0.53 | 0.3 | 0.61 | 0.6 | 0.57 | 0.4 |
| 28 | 1.07 | 6.5 | 0.54 | 0.3 | 0.62 | 0.7 | 0.57 | 0.4 |
| 29 | 1.09 | 7.0 | 0.54 | 0.3 | 0.95 | 4.2 | 0.57 | 0.4 |
| 30 | 1.20 | 9.6 | 0.55 | 0.4 | 1.11 | 7.4 | 0.57 | 0.4 |
| 31 | .... | .... | 0.54 | 0.3 | .... | .... | 0.57 | 0.4 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Middle Creek at Ross's Ranche, Sask., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | 0 57 | 0 4 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0.5 |
| 2 | 0 57 | 0 4 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 |
| 3 | 0 57 | 0 4 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 |
| 4 | 0 57 | 0 4 | 0 80 | 2 3 | 0 60 | 0 5 | 0 60 | 0 5 |
| 5 | 0 57 | 0 4 | 1 20 | 9 6 | 0 60 | 0 5 | 0 60 | 0 5 |
| 6 | 0 60 | 0 5 | 3 02 | 107 0 | 0 60 | 0 5 | 0 60 | 0 5 |
| 7 | 0 60 | 0 5 | 2 36 | 61 0 | 0 60 | 0 5 | 0 60 | 0 5 |
| 8 | 0 60 | 0 5 | 2 69 | 82 0 | 0 60 | 0 5 | 0 60 | 0 5 |
| 9 | 0 60 | 0 5 | 2 30 | 57 0 | 0 60 | 0 5 | | .... |
| 10 | 0 60 | 0 5 | 2 00 | 40 0 | 0 60 | 0 5 | | |
| 11 | 1 00 | 5 0 | 1 45 | 16 0 | 0 60 | 0 5 | | |
| 12 | 0 80 | 2 3 | 1 00 | 5 0 | 0 60 | 0 5 | | |
| 13 | 0 70 | 1 3 | 0 90 | 3 5 | 0 60 | 0 5 | | .... |
| 14 | 0 61 | 0 6 | 0 85 | 2 9 | 0 60 | 0 5 | | |
| 15 | 0 60 | 0 5 | 0 81 | 2 4 | 0 60 | 0 5 | | |
| 16 | 0 59 | 0 5 | 0 74 | 1 7 | 0 60 | 0 5 | | |
| 17 | 0 58 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 18 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 19 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 20 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 21 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 22 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 23 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 24 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 25 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 26 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 27 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 28 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 29 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 30 | 0 57 | 0 4 | 0 60 | 0 5 | 0 60 | 0 5 | | .... |
| 31 | 0 57 | 0 4 | | | 0 60 | 0 5 | | .... |

* Sudden rise due to failure of dykes at Wright's ranche.

NOTE—There was considerable rain during the latter part of June but most of the water appears to have been held up by Wright's and McKinnon's dams.

MONTHLY DISCHARGE of Middle Creek at Ross's Ranche, Sask., for 1911.

Drainage area, 173 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet |
| April (11-30) | 116 0 | 1 7 | 19 3 | 0 112 | 0 083 | 766 |
| May | 19 0 | 0 3 | 3 1 | 0 018 | 0 021 | 191 |
| June | 7 4 | 0 3 | 0 7 | 0 004 | 0 004 | 42 |
| July | 30 0 | 0 4 | 3 9 | 0 023 | 0 025 | 240 |
| August | 5 0 | 0 4 | 0 7 | 0 004 | 0 005 | 43 |
| September | 107 0 | 0 4 | 13 3 | 0 077 | 0 086 | 791 |
| October | 0 5 | 0 5 | 0 5 | 0 003 | 0 004 | 31 |
| November (1-8) | 0 5 | 0 5 | 0 5 | 0 003 | 0 001 | 8 |
| The period | | | | | 229 | 2,112 |

NOTE—Springs just above this station keep water flowing at this point throughout dry periods though the creek was dry above the springs, and a distance below the station due to loss by evaporation and see page.

## MIDDLE CREEK AT HAMMOND'S RANCHE.

This station was established June 13, 1910, by H. R. Carscallen. It is located at Hammond's ranche, on the N.W. ¼ Sec. 4, Tp. 2, Rge. 29, W. 3rd Mer., about seven miles above the Willow Creek police detachment and about one quarter of a mile above the junction of Middle and Lodge Creeks.

The channel is straight for 200 feet above and 125 feet below the station. Both banks are high and fairly steep, free from brush and not liable to overflow. The bed of the stream is sandy and may shift at high stages. The station, being located only a short distance above the junction with Lodge Creek, may be affected by backwater from that creek during high-water stages.

Discharge measurements are made at the station by wading, and at extreme low stages a weir may be used. High-water measurements are not attainable, as there is so structure at or near the station to support the engineer in taking the gaugings when the water becomes too deep for wading. The initial point for soundings is a stake driven close to the ground on the left bank and marked "I.P."

The gauge is a plain staff graduated to feet and hundredths, spiked to a post sunk in the bed of the creek near the left bank. The zero of the gauge (elev., 87.60) is referred to a permanent iron bench-mark (assumed elev., 100.00) upon the left bank. The bench-mark is about six inches above ground and is protected by a mound of stones. It is also used as the initial point for soundings.

During 1911, the gauge was read by Mrs. D. A. Hammond.

Discharge Measurements of Middle Creek at Hammond's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section | Mean Velocity | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 20 | M. H. French | 9.5 | 25.38 | 0.312 | 1.94 | 7.94 |
| May 17 | do | 17.8 | 17.68 | 0.096 | 1.50 | 1.70 |
| Aug. 8 | do | 15.2 | 9.87 | | 1.04 | Nil. |
| July 7 | do | 19.2 | 36.00 | 0.669 | 2.71 | 24.30 |
| Sept. 16 | do | 19.0 | 21.10 | 0.381 | 1.975 | 8.04 |
| Oct. 23 | do | 18.8 | 11.18 | 0.062 | 1.40 | 0.70 |

Daily Gauge-height and Discharge of Middle Creek at Hammond's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.52 | 2.2 | 1.66 | 3.6 | 1.47 | 1.7 |
| 2 | | | 1.52 | 2.2 | 1.74 | 4.6 | 1.47 | 1.7 |
| 3 | | | 1.52 | 2.2 | 2.55 | 29.0 | 1.47 | 1.7 |
| 4 | | | 1.52 | 2.2 | 2.29 | 13.0 | 1.46 | 1.6 |
| 5 | | | 1.52 | 2.2 | 2.05 | 10.0 | 1.50 | 2.0 |
| 6 | | | 1.71 | 4.2 | 2.12 | 11.0 | 1.48 | 1.8 |
| 7 | | | 1.70 | 4.0 | 1.94 | 7.8 | 1.46 | 1.6 |
| 8 | | | 1.40 | 1.0 | 1.80 | 5.5 | 1.40 | 1.0 |
| 9 | | | 1.38 | 0.8 | 1.80 | 5.5 | 1.34 | 0.4 |
| 10 | | | 1.38 | 0.8 | 1.67 | 3.7 | 1.30 | Nil. |
| 11 | | | 1.42 | 1.2 | 1.42 | 1.2 | 1.25 | " |
| 12 | | | 1.45 | 1.5 | 1.43 | 1.3 | 1.25 | " |
| 13 | | | 1.67 | 3.7 | 1.29 | 0.0 | 1.25 | " |
| 14 | 1.06 | Nil. | 1.68 | 3.8 | 1.42 | 1.2 | 1.25 | " |
| 15 | 1.09 | " | 1.72 | 4.3 | 1.46 | 1.6 | 1.25 | " |
| 16 | 1.04 | " | 2.70 | *24.0 | 1.48 | 1.8 | 1.25 | " |
| 17 | 1.05 | " | 2.70 | 24.0 | 1.52 | 2.2 | 1.25 | " |
| 18 | 1.02 | " | 2.36 | 16.0 | 1.51 | 2.1 | 1.25 | " |
| 19 | 1.01 | " | 1.96 | 8.2 | 1.51 | 2.1 | 1.25 | " |
| 20 | 1.03 | " | 1.94 | 7.8 | 1.51 | 2.1 | 2.10 | 11.0 |
| 21 | 1.01 | " | 1.80 | 5.5 | 1.50 | 2.0 | 2.10 | 11.0 |
| 22 | 1.01 | " | 1.36 | 0.6 | 1.50 | 2.0 | 1.90 | 7.0 |
| 23 | 1.05 | " | 3.94 | *34.0 | 1.52 | 2.2 | 1.72 | 4.3 |
| 24 | 1.05 | " | 2.70 | 24.0 | 1.52 | 2.2 | 1.70 | 4.0 |
| 25 | 2.27 | 14.0 | 2.06 | 10.0 | 1.52 | 2.1 | 1.57 | 2.7 |
| 26 | 2.35 | 16.0 | 1.95 | 8.0 | 1.51 | 2.1 | 1.50 | 2.0 |
| 27 | 2.05 | 10.0 | 1.90 | 7.0 | 1.51 | 2.1 | 1.50 | 2.0 |
| 28 | 2.07 | 10.0 | 1.90 | 7.0 | 1.50 | 2.0 | 1.48 | 1.8 |
| 29 | 2.04 | 10.0 | 1.98 | 8.6 | 1.45 | 1.5 | 1.48 | 1.8 |
| 30 | 1.94 | 7.8 | 1.70 | 4.0 | 1.47 | 1.7 | 1.48 | 1.8 |
| 31 | 1.96 | 8.2 | | | 1.50 | 2.0 | | |

DAILY GAUGE-HEIGHT AND DISCHARGE of Middle Creek at Hammond's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.48 | 1.8 | Dry. | Nil. | Dry. | Nil. | 1.52 | 2.2 | 1.40 | 1.0 |
| 2 | 1.48 | 1.8 | | | . | . | 1.52 | 2.2 | 1.40 | 1.0 |
| 3 | 1.52 | 2.2 | | | | | 1.51 | 2.1 | 1.40 | 1.0 |
| 4 | 3.00 | a33.0 | | | 1.70 | 4.0 | 1.51 | 2.1 | 1.40 | 1.0 |
| 5 | 2.46 | 18.0 | | | 1.95 | 8.0 | 1.51 | 2.1 | 1.40 | 1.0 |
| 6 | 2.20 | 13.0 | | | 9.20 | a452.0 | 1.50 | 2.0 | 1.40 | 1.0 |
| 7 | 2.74 | 25.0 | | | 7.45 | 284.0 | 1.50 | 2.0 | 1.40 | 1.0 |
| 8 | 2.30 | 15.0 | | | 6.30 | 195.0 | 1.49 | 1.9 | 1.40 | 1.0 |
| 9 | 2.28 | 15.0 | | | 4.45 | 88.0 | 1.49 | 1.9 | 1.40 | 1.0 |
| 10 | 2.19 | 13.0 | | | 4.14 | 74.0 | 1.49 | 1.9 | 1.40 | 1.0 |
| 11 | 2.15 | 12.0 | | | 3.95 | 66.0 | 1.48 | 1.8 | 1.40 | 1.0 |
| 12 | 1.97 | 8.4 | | | 3.20 | 39.0 | 1.47 | 1.7 | 1.40 | 1.0 |
| 13 | 1.81 | 5.6 | | | 2.45 | 18.0 | 1.46 | 1.6 | 1.40 | 1.0 |
| 14 | 1.72 | 4.3 | | | 2.42 | 17.0 | 1.45 | 1.5 | 1.40 | 1.0 |
| 15 | 1.60 | 3.0 | | | 2.37 | 16.0 | 1.44 | 1.4 | 1.40 | 1.0 |
| 16 | 1.56 | 2.6 | | | 1.99 | 9.0 | 1.44 | 1.4 | 1.40 | 1.0 |
| 17 | 1.56 | 2.6 | | | 1.87 | 6.6 | 1.43 | 1.3 | 1.40 | 1.0 |
| 18 | 1.53 | 2.3 | | | 1.79 | 5.1 | 1.43 | 1.3 | 1.40 | 1.0 |
| 19 | 1.52 | 2.2 | | | 1.70 | 4.0 | 1.42 | 1.2 | 1.40 | 1.0 |
| 20 | 1.51 | 2.1 | | | 1.68 | 3.8 | 1.42 | 1.2 | 1.40 | 1.0 |
| 21 | 1.47 | 1.7 | | | 1.67 | 3.7 | 1.41 | 1.1 | | ... |
| 22 | 1.44 | 1.4 | | | 1.65 | 3.5 | 1.41 | 1.1 | | ... |
| 23 | 1.40 | 1.0 | | | 1.67 | 3.7 | 1.40 | 1.0 | ... | ... |
| 24 | 1.37 | 0.7 | | | 1.66 | 3.6 | 1.40 | 1.0 | | ... |
| 25 | Dry. | Nil. | | | 1.65 | 3.5 | 1.40 | 1.0 | | ... |
| 26 | | | | | 1.59 | 2.9 | 1.40 | 1.0 | | ... |
| 27 | | | | | 1.58 | 2.8 | 1.40 | 1.0 | | ... |
| 28 | | | | | 1.56 | 2.6 | 1.40 | 1.0 | | ... |
| 29 | | | | | 1.55 | 2.5 | 1.40 | 1.0 | | ... |
| 30 | | | | | 1.53 | 2.3 | 1.40 | 1.0 | | ... |
| 31 | | | | | . | | 1.40 | 1.0 | | ... |

* Wright's dykes gave way.
a Heavy rains.

NOTE—Although the gauge heights for September 6, 7 and 8, are correct, backwater from Lodge Creek might be partly responsible for the high readings.

MONTHLY DISCHARGE of Middle Creek at Hammond's Ranche, Sask., for 1911.

Drainage area, 301 square miles.

| Month. | Discharge in Second-Feet. | | | Run-Off. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| March (14-31) | 16.0 | 0.0 | 4.2 | 0.014 | 0.009 | 150 |
| April | 34.0 | 0.8 | 7.5 | 0.025 | 0.028 | 446 |
| May | 20.0 | 0.0 | 3.9 | 0.013 | 0.015 | 240 |
| June | 11.0 | 0.0 | 2.1 | 0.007 | 0.008 | 125 |
| July | 33.0 | 0.0 | 6.1 | 0.020 | 0.023 | 375 |
| August | ... | ... | ... | ... | ... | ... |
| September | 452.0 | 0.0 | 44.0 | 0.146 | 0.163 | 2,618 |
| October | 2.2 | 1.0 | 1.5 | 0.005 | 0.006 | 92 |
| November (1-20) | 1.0 | 1.0 | 1.0 | 0.003 | 0.002 | 40 |
| The period | ... | ... | ... | ... | 0.254 | 4,086 |

LODGE CREEK AT WILLOW CREEK POLICE DETACHMENT.

This station was established on August 13, 1909, by F. H. Peters. It is located on the S.E. ¼ Sec. 12, Tp. 1, Rge. 29, W. 3rd Mer., and about 500 feet east of the house at Willow Creek police detachment. It is about 75 miles by trail from Maple Creek, and about 35 miles by trail south of Battle Creek post office.

The stream flows in one channel, which is straight for about 200 feet above and 150 feet below the station. The right bank is steep, composed of solid clay and not liable to overflow. The left bank gradually rises, is composed of solid clay and stones, and not liable to overflow.

During ordinary stages of flow, discharge measurements are made by wading, and at very low stages a weir is used. It is impossible at present to obtain high-water measurements as there is no bridge or other structure from which the hydrographer may work.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. The zero of the gauge (elev., 2721.18) is referred to a concrete bench-mark (elev., 2768.00 above mean sea-level) which was set by the International Boundary survey, upon a hill about 500 feet west of the gauge.

During 1911, the gauge was read until July 1, by Constable C. H. Cuthbertson, and after that by William Tudgay.

Discharge Measurements of Lodge Creek at Willow Creek Police Detachment, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 19 | M. H. French | 65.0 | 72.50 | 2.050 | 2.93 | 107.70 |
| May 12 | do | 20.2 | 13.08 | 0.608 | 1.65 | 7.96 |
| June 6 | do | 18.2 | 7.40 | 0.234 | 1.41 | 1.73* |
| July 8 | do | 22.0 | 23.40 | 1.139 | 2.04 | 26.66 |
| Aug. 7 | do | | .. | .. | 1.05 | Nil. |
| Sept. 18 | do | 21.0 | 14.86 | 0.836 | 1.75 | 12.42 |

* Weir measurement.

Daily Gauge-height and Discharge of Lodge Creek at Willow Creek Police Detachment, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | 4.35 | 377 | 2.20 | 37.0 | 1.44 | 2.8 |
| 2 | .... | .... | 4.22 | 345 | 2.22 | 38.0 | 1.48 | 3.6 |
| 3 | .... | .... | 4.12 | 321 | 2.48 | 59.0 | 1.44 | 2.8 |
| 4 | .... | .... | 3.58 | 297 | 2.35 | 48.0 | 1.41 | 2.2 |
| 5 | .... | .... | 3.20 | 144 | 2.22 | 38.0 | 1.37 | 1.7 |
| 6 | .... | .... | 2.90 | 103 | 2.18 | 36.0 | 1.38 | 1.8 |
| 7 | .... | .... | 2.88 | 101 | 2.10 | 30.0 | 1.42 | 2.4 |
| 8 | .... | .... | 2.88 | 101 | 2.08 | 29.0 | 1.42 | 2.4 |
| 9 | .... | .... | 2.82 | 93 | 2.05 | 26.0 | 1.40 | 2.0 |
| 10 | .... | .... | 2.65 | 75 | 2.08 | 29.0 | 1.40 | 2.0 |
| 11 | .... | .... | 2.58 | 68 | 1.70 | 11.0 | 1.38 | 1.8 |
| 12 | .... | .... | 2.52 | 63 | 1.70 | 11.0 | 1.34 | 1.4 |
| 13 | .... | .... | 2.50 | 61 | 1.61 | 7.4 | 1.33 | 1.3 |
| 14 | .... | .... | 2.70 | 80 | 1.61 | 7.4 | 1.30 | 1.0 |
| 15 | .... | .... | 3.23† | 149 | 1.57 | 6.1 | 1.30 | 1.0 |
| 16 | .... | .... | 2.95 | 110 | 1.61 | 7.4 | 1.32 | 1.2 |
| 17 | 1.15 | 0.0 | 2.88 | 101 | 1.61 | 7.4 | 1.30 | 1.0 |
| 18 | 1.50 | 4.0 | 2.98 | 113 | 1.55 | 5.5 | 1.30 | 1.0 |
| 19 | 1.25 | 0.5 | 3.08 | 127 | 1.52 | 4.6 | 1.30 | 1.0 |
| 20 | 1.15 | 0.0 | 2.22 | 38 | 1.46 | 3.2 | 1.30 | 1.0 |
| 21 | 1.20 | 0.0 | 2.20 | 37 | 1.50 | 4.0 | 1.30 | 1.0 |
| 22 | 1.42 | 2.4 | 2.32 | 46 | 1.50 | 4.0 | 1.30 | 1.0 |
| 23 | 1.52 | 4.6 | 2.35 | 48 | 1.49 | 3.8 | 1.29 | 0.9 |
| 24 | 1.75 | 13.0 | 2.32 | 46 | 1.49 | 3.8 | 2.61§ | 70.0 |
| 25 | 1.53 | 4.9 | 2.55 | 66 | 1.52 | 4.6 | 2.70 | 80.0 |
| 26 | 2.02 | 24.4 | 2.25 | 40 | 1.50 | 4.0 | 2.42 | 54.0 |
| 27 | 2.20 | 37.0 | 2.15 | 34 | 1.48 | 3.6 | 2.30 | 44.0 |
| 28 | 2.20 | 37.0 | 2.15 | 34 | 1.50 | 4.0 | 2.48 | 59.0 |
| 29 | 5.35‡ | 684.0 | 2.15 | 34 | 1.52 | 4.6 | 2.81 | 92.0 |
| 30 | 5.28‡ | 660.0 | 2.15 | 34 | 1.50 | 4.0 | 2.46 | 57.0 |
| 31 | 5.23‡ | 644.0 | .... | .... | 1.52 | 4.6 | | |

DAILY GAUGE-HEIGHT AND DISCHARGE of Lodge Creek at Willow Creek Police Detachment, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.33 | 46.0 | 0.99 | Nil. | 0.35 | Nil. | 1.50 | 4.0 | 1.30 | 1.0 |
| 2 | 2.25 | 40.0 | 0.99 | | 0.30 | | 1.48 | 3.6 | 1.30 | 1.0 |
| 3 | 2.32 | 46.0 | 0.99 | | 0.30 | | 1.46 | 3.2 | 1.30 | 1.0 |
| 4 | 4.12 | *321.0 | 0.99 | | 1.18 | | 1.45 | 3.0 | 1.32 | 1.2 |
| 5 | 3.12 | 133.0 | 0.98 | | 1.85 | 17.0 | 1.45 | 3.0 | 1.32 | 1.2 |
| 6 | 2.74 | 84.0 | 0.98 | | 7.44 | 1,550.0 | 1.44 | 2.8 | 1.32 | 1.2 |
| 7 | 2.10 | 30.0 | 1.00 | | 8.00 | 1,830.0 | 1.44 | 2.8 | 1.33 | 1.3 |
| 8 | 2.20 | 37.0 | 1.01 | | 5.98 | 918.0 | 1.43 | 2.6 | 1.33 | 1.3 |
| 9 | 1.92 | 20.0 | 1.01 | | 3.80 | 249.0 | 1.43 | 2.6 | 1.34 | 1.4 |
| 10 | 1.96 | 21.0 | 1.00 | | 3.13 | 131.0 | 1.42 | 2.4 | 1.35 | 1.5 |
| 11 | 1.70 | 11.0 | 1.00 | | 2.66 | 76.0 | 1.40 | 2.0 | 1.35 | 1.5 |
| 12 | 1.76 | 13.0 | 1.02 | | 2.34 | 47.0 | 1.39 | 1.9 | 1.34 | 1.4 |
| 13 | 1.70 | 11.0 | 1.02 | | 2.26 | 41.0 | 1.37 | 1.7 | 1.34 | 1.4 |
| 14 | 1.59 | 6.7 | 1.01 | | 2.05 | 26.0 | 1.35 | 1.5 | 1.34 | 1.4 |
| 15 | 1.58 | 6.4 | 1.00 | | 1.98 | 22.0 | 1.35 | 1.5 | 1.34 | 1.4 |
| 16 | 1.57 | 6.1 | 0.99 | | 1.86 | 17.0 | 1.34 | 1.4 | ... | ... |
| 17 | 1.55 | 5.5 | 0.95 | | 1.86 | 17.0 | 1.34 | 1.4 | ... | ... |
| 18 | 1.51 | 4.3 | 0.91 | | 1.75 | 13.0 | 1.33 | 1.3 | ... | ... |
| 19 | 1.50 | 4.0 | 0.87 | | 1.70 | 11.0 | 1.33 | 1.3 | ... | ... |
| 20 | 1.46 | 3.2 | 0.80 | | 1.64 | 8.6 | 1.32 | 1.2 | ... | ... |
| 21 | 1.39 | 1.9 | 0.78 | | 1.57 | 6.1 | 1.32 | 1.2 | ... | ... |
| 22 | 1.28 | 0.8 | 0.74 | | 1.60 | 7.0 | 1.31 | 1.1 | ... | ... |
| 23 | 1.25 | 0.5 | 0.72 | | 1.62 | 7.8 | 1.30 | 1.0 | ... | ... |
| 24 | 1.19 | Nil. | 0.70 | | 1.56 | 5.8 | 1.30 | 1.0 | ... | ... |
| 25 | 1.15 | | 0.65 | | 1.55 | 5.5 | 1.30 | 1.0 | ... | ... |
| 26 | 1.10 | | 0.62 | | 1.54 | 5.2 | 1.30 | 1.0 | ... | ... |
| 27 | 1.07 | | 0.59 | | 1.54 | 5.2 | 1.30 | 1.0 | ... | ... |
| 28 | 1.06 | | 0.55 | | 1.54 | 5.2 | 1.30 | 1.0 | ... | ... |
| 29 | 1.05 | | 0.50 | | 1.53 | 4.9 | 1.30 | 1.0 | ... | ... |
| 30 | 1.02 | | 0.44 | | 1.51 | 4.3 | 1.30 | 1.0 | ... | ... |
| 31 | 0.98 | | 0.40 | | | | 1.30 | 1.0 | ... | ... |

* Heavy rain.
† Spring thaw.
‡ Doubt accuracy of these gauge heights.

MONTHLY DISCHARGE of Lodge Creek at Willow Creek Police Detachment, Sask., for 1911.

Drainage area, 803 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| March (17-31) | 684.0 | 0.0 | 141.1 | 0.176 | 0.098 | 4,198 |
| April | 377.0 | 34.0 | 106.5 | 0.133 | 0.148 | 6,337 |
| May | 59.0 | 3.2 | 15.7 | 0.020 | 0.023 | 965 |
| June | 92.0 | 0.9 | 16.5 | 0.020 | 0.022 | 982 |
| July | 321.0 | 0.0 | 27.5 | 0.034 | 0.039 | 1,691 |
| August | | | | | | |
| September | 1,830.0 | 0.0 | 167.8 | 0.209 | 0.223 | 9,985 |
| October | 4.0 | 1.0 | 1.8 | 0.002 | 0.002 | 111 |
| November (1-15) | 1.5 | 1.0 | 1.3 | 0.002 | 0.001 | 39 |
| The period | | | | | 0.556 | 24,308 |

PLATE No. 23.

Forest along Headwaters of Battle Creek, which helps to hold back the snow water until late in Summer. Taken by M. H. French.

Miscellaneous Discharge Measurements in Lodge Creek Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. ft.* | *Feet per Sec.* | *Sec.-ft.* |
| May 17 | M. H. French | Lodge Creek | Sec. 4-2-29-3 | | 4.89 | 0.680 | 3.330 |
| June 8 | " | " | " " | | | | 1.935 |
| Sept. 8 | W. A. Fletcher | " | N.E. 24-2-30-3 | 44.0 | 78.40 | 2.840 | 222.400 |
| April 25 | M. H. French | Lodge Creek (East Br) | Sec. 25-6-3-4 | 10.0 | 3.11 | 1.570 | 4.900 |
| May 22 | " | " | " 22-6-3-4 | 5.7 | 2.55 | 1.120 | 2.870 |
| June 13 | " | " | " " | | | | 0.055 |
| April 21 | " | Middle Creek | " 3-4-29-3 | x | | | 1.520 |
| April 29 | " | " | " 14-6-2-4 | x | | | 1.230 |
| May 23 | " | " (East Br.) | " 14-6-2-4 | | | | 1.080 |
| April 29 | " | Mitchell Creek | " 13-6-2-4 | x | | | 0.490 |
| May 22 | " | " | " " | 9.0 | 6.25 | 0.619 | 3.870 |
| April 28 | " | Read Creek | " 34-6-3-4 | 5.3 | 2.45 | 0.320 | 0.290 |
| May 22 | " | " | " " | | | | 0.362 |
| June 13 | " | " | " " | | | | 0.080 |
| May 22 | " | Sexton Creek | " 21-7-3-4 | | | | 0.551 |
| June 13 | " | " | " " | | | | 0.167 |
| June 13 | " | Spring Creek | " 22-5-2-4 | | | | 0.118 |
| July 21 | " | " | " " | x | | | 0.190 |

x Weir measurements.

## BATTLE CREEK DRAINAGE BASIN.

*General Description.*

Battle Creek rises in Tp. 8, Rge. 2, W. 4th Mer., and flows in an easterly direction for about eight miles, where it crosses the fourth meridian, then turns in a southeasterly direction and crosses the International Boundary in Sec. 3, Tp. 1, Rge. 26. W. 3rd Mer., eventually emptying into Milk River near Chinook, Montana. As is characteristic of the streams in this locality, the valley is narrow and deep near the source and gradually broadens out into large flats and meadows. These large flats are first noticed in the vicinity of Battle Creek post office. Near the head of the stream the valley is well wooded with fair-sized timber, but this diminishes to a growth of willow brush along the banks and finally disappears altogether.

The chief tributaries of Battle Creek are Tenmile Creek, joining it in Sec. 4, Tp. 6, Rge. 26 W. 3rd Mer., and Sixmile Coulee, joining it in Sec. 21, Tp. 6, Rge. 29, W. 3rd Mer. Stations have been established on both of these streams.

There are three stations on Battle Creek at the following places:—Nashe's ranche, Wilson's ranche and Tenmile police detachment.

Although it will be several years before it reaches its fullest development, the irrigation of the flats along the creek is increasing every season. This, it is expected, will result in a more uniform flow in the creek, as a certain amount of the water diverted by the irrigation ditches will be returned to the creek through seepage.

The principal irrigation schemes under developemnt at the present time are Marshall and Gaff's near Battle Creek post office, Richardson's, McKinnon's, Stirling's, and Nashe's near Kelvinhurst post office.

### Cheeseman Ditch near Coulee.

This station was established on June 24, 1911, by W. A. Fletcher. It is located in the S.W. ¼ Sec. 12, Tp. 8, Rge. 29, W. 3rd Mer., about fifty yards from Ben Cheeseman's house.

The channel is straight for 40 feet above and 30 feet below the station. The bottom of the ditch is composed of clay.

The gauge, which is a plain board divided into feet and inches, is nailed to a post at the left bank. The zero (elevation, 96.005) is referred to a bench-mark (assumed elevation, 100.00) six feet southwest of the gauge. Discharge measurements are made with a weir.

No records were obtained at this station during 1911.

### Sixmile Coulee at Soderstrom's Ranche.

This station was established July 2, 1909, by H. R. Carscallen. It is located on Sec. 29, Tp. 7, Rge. 28, W. 3rd Mer., 200 yards west of the surveyed trail from Maple Creek to Tenmile and about thirty miles south of Maple Creek.

The channel is straight for 50 feet above and 20 feet below the station. Both banks are high and not liable to overflow. The right bank is sparsely covered with brush; the left bank is free of brush. The bed of the stream is composed of sand and very coarse gravel with clay at the banks. The current is moderate. A small amount of vegetation is present at the station.

Discharge measurements are made at or near the station by wading, and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P." in red paint.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to an upright post sunk in the bed of the creek at the right bank, and securely stayed to the bank. The gauge is referred to bench-marks as follows:—(1) A nail-head driven into the top of a pointed willow stump on the right bank, about 150 feet upstream from the gauge, the stump blazed and marked "B.M." in red paint; (elevation, 7.77 feet above gauge zero.) (2) Nail-heads in the top of a log near the ground at the southeast corner of Mr. Soderstrom's north stable (elevation, 18.08 feet above gauge zero.)

During 1911, the gauge was read by J. M. Soderstrom until June 10, when he moved away, and another observer could not be secured.

DISCHARGE MEASUREMENTS of Sixmile Coulee at Soderstrom's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 1 | M. H. French | 20.0 | 24.20 | 0.733 | 2.43 | 17.75 |
| May 27 | do | 17.0 | 19.24 | 0.582 | 2.25 | 11.21 |
| June 19 | do | 4.0 | 2.84 | 0.612 | 0.98 | 1.74 |
| June 30 | do | 6.0 | 13.80 | 0.490 | 1.95 | 6.77 |
| Sept. 13 | do | 26.0 | 28.00 | 0.659 | 2.76 | 18.45 |

DAILY GAUGE-HEIGHT AND DISCHARGE of Sixmile Coulee at Soderstrom's Ranche, for 1911.

| | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.39 | 13.1 | 2.40 | 13.2 | 1.86 | 6.7 |
| 2 | 2.39 | 13.1 | 2.28 | 11.5 | 1.82 | 6.4 |
| 3 | 2.39 | 13.1 | 2.23 | 10.9 | 1.78 | 6.0 |
| 4 | 2.39 | 13.1 | 2.10 | 9.3 | 1.76 | 5.8 |
| 5 | 2.39 | 13.1 | 1.98 | 7.9 | 1.74 | 5.7 |
| 6 | 2.39 | 13.1 | 1.78 | 6.0 | 1.72 | 5.5 |
| 7 | 2.39 | 13.1 | 1.76 | 5.8 | 1.70 | 5.3 |
| 8 | 2.49 | 14.6 | 1.74 | 5.7 | 2.00 | 8.1 |
| 9 | 2.59 | 16.3 | 1.70 | 5.3 | 1.90 | 7.1 |
| 10 | 2.33 | 12.2 | 1.68 | 5.2 | 1.88 | 6.9 |
| 11 | 2.33 | 12.2 | 1.78 | 6.0 | ... | ... |
| 12 | 2.33 | 12.2 | 1.76 | 5.8 | ... | ... |
| 13 | 2.32 | 12.1 | 1.74 | 5.7 | ... | ... |
| 14 | 2.34 | 12.4 | 1.72 | 5.5 | ... | ... |
| 15 | 2.36 | 12.6 | 1.90 | 7.1 | ... | ... |
| 16 | 2.50 | 14.8 | 2.00 | 8.1 | ... | ... |
| 17 | 2.45 | 14.0 | 1.90 | 7.1 | ... | ... |
| 18 | 2.59 | 16.3 | 1.80 | 6.2 | ... | ... |
| 19 | 2.49 | 14.6 | 1.76 | 5.8 | ... | ... |
| 20 | 2.45 | 14.0 | 1.80 | 6.2 | ... | ... |
| 21 | 2.35 | 12.5 | 1.80 | 6.2 | ... | ... |
| 22 | 2.35 | 12.5 | 1.78 | 6.0 | ... | ... |
| 23 | 2.35 | 12.5 | 1.76 | 5.8 | ... | ... |
| 24 | 2.30 | 11.8 | 1.80 | 6.2 | ... | ... |
| 25 | 2.10 | 9.3 | 2.27 | 11.4 | ... | ... |
| 26 | 2.03 | 8.5 | 2.20 | 10.5 | ... | ... |
| 27 | 2.00 | 8.1 | 2.18 | 10.3 | ... | ... |
| 28 | 2.00 | 8.1 | 2.14 | 9.8 | ... | ... |
| 29 | 2.45 | 14.0 | 2.04 | 8.6 | ... | ... |
| 30 | 3.20 | 29.1 | 2.00 | 8.1 | ... | ... |
| 31 | ... | ... | 1.90 | 7.1 | ... | ... |

MONTHLY DISCHARGE of Sixmile Coulee at Soderstrom's Ranche, Sask., for 1911.

Drainage area, 27 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area | Total in Acre-Feet |
| April | 29.1 | 8.1 | 13.2 | 0.489 | 0.546 | 786 |
| May | 13.2 | 5.2 | 7.6 | 0.281 | 0.324 | 467 |
| June (1-10) | 8.1 | 5.3 | 6.4 | 0.237 | 0.088 | 127 |
| The period | | | | | 0.958 | 1,380 |

## SPANGLER'S DITCH NEAR BATTLE CREEK.

This station was established on July 10, 1911, by W. A. Fletcher. It is located in Sec. 6, Tp. 7, Rge. 28, W. 3rd Mer., about one half mile north of J. M. Spangler's house. This ditch is above the regular station on Sixmile coulee at Spangler's ranche.

The channel is straight for 40 feet above and 30 feet below the station. The bottom of the ditch is composed of clay.

The zero of the gauge (elevation, 96.30) is referred to a bench-mark (assumed elevation, 100.00), which is located just back of the gauge.

Discharge measurements are made with a current-meter or weir.

DISCHARGE MEASUREMENTS of Spangler's Ditch near Battle Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Inches* | *Sec.-ft.* |
| July 4 | M. H. French | 0.0 | 2.84 | 1.130 | ... | 3.21 |
| July 31 | do | 4.5 | 1.34 | 0.111 | 8 | 1.50x |

x Weir measurement.

## SIXMILE COULEE AT SPANGLER'S RANCHE.

This station was established July 4, 1911, by M. H. French. It is located about 1000 feet east of J. M. Spangler's house on the N.W. 1/4 Sec. 36, Tp. 6, Rge. 29, W. 3rd Mer., and is about 34 miles by trail southwest of Maple Creek and six miles north of Battle Creek post office.

The channel is straight for about fifty feet above and below the station. The banks are covered with brush, which cause back-water in a portion of the cross-section during flood stage. The bed of the stream is composed of sand and gravel, and is not liable to shift. The current is swift at all stages.

Discharge measurements are made near the gauge, in low water by wading, and at a bridge 2000 feet upstream during high water. The initial point for soundings is a four-nich post on the right bank 562 feet from the bench mark on the left bank.

The gauge is a plain staff graduated to feet and hundredths, nailed vertically to a post sunk in the bed of the stream near the left bank. The zero of the gauge (elev., 90.68) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated on the left bank and used as the final point for soundings. The gauge was read, during 1911, by Carl Spangler.

This station is about three quarters of a mile below the Spangler irrigation ditch, which diverted a small amount of water from the creek during July and August, in 1911.

DISCHARGE MEASUREMENTS of Sixmile Coulee at Spangler's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 3 | M. H. French | 5.5 | 3.77 | 0.947 | 1.26 | 3.59 |
| July 4 | do | 5.3 | 3.44 | 0.849 | 1.20 | 2.92 |
| July 31 | do | 4.6 | 1.37 | 0.330 | 0.73 | 0.46* |
| Aug. 22 | do | 5.0 | 1.15 | 0.19 | 0.75 | 0.22* |
| Sept. 8 | do | 15.0 | 84.64 | 0.824 | 5.69 | 69.77 |
| Sept. 14 | do | 11.5 | 18.50 | 1.000 | 3.00 | 18.46 |
| Oct. 30 | do | 5.7 | 4.68 | 0.961 | 1.35 | 4.50 |

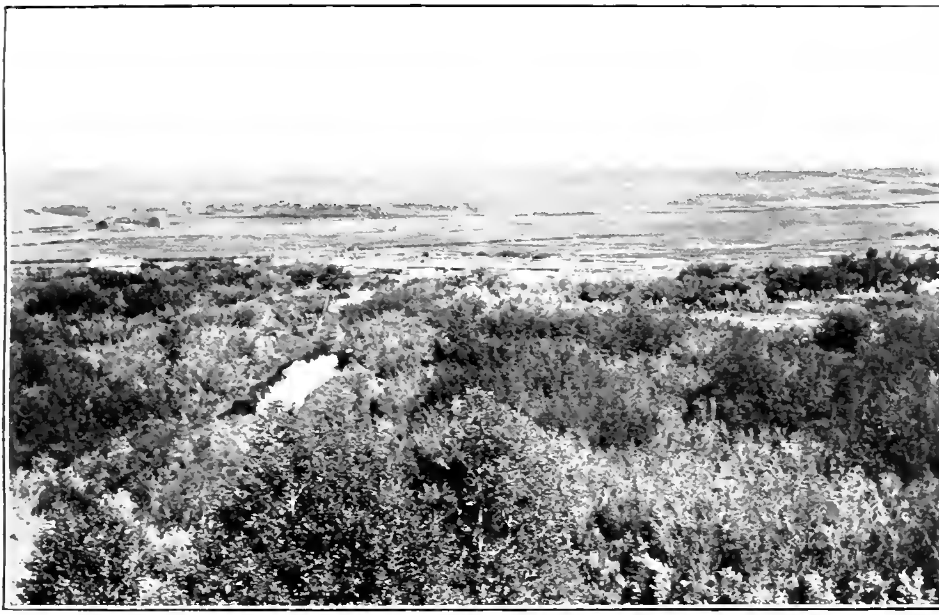
* Discharge determined by means of a weir and referred to the regular cross-section.

DAILY GAUGE-HEIGHT AND DISCHARGE of Sixmile Coulee at Spangler's Ranche, Sask., for 1911.

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ... | ... | 0.68 | 0.2 | 0.76 | 0.4 | 2.12 | 9.3 | 1.45 | 4.1 |
| 2 | | | 0.70 | 0.2 | 0.70 | 0.2 | 2.10 | 9.1 | * ... | ... |
| 3 | 1.26 | 3.0 | 0.68 | 0.2 | 0.69 | 0.2 | 2.08 | 8.9 | * ... | ... |
| 4 | 1.20 | 2.6 | 0.70 | 0.2 | 1.20 | 2.6 | 2.09 | 9.0 | 1.51 | 4.5 |
| 5 | 1.10 | 2.0 | 0.72 | 0.3 | 5.00 | 53.0 | 2.07 | 8.8 | 1.43 | 4.0 |
| 6 | 1.05 | 1.8 | 0.79 | 0.5 | 6.45 | 92.0 | 2.03 | 8.5 | 1.34 | 3.4 |
| 7 | 1.04 | 1.7 | 0.83 | 0.6 | 6.50 | 94.0 | 1.90 | 7.4 | 1.29 | 3.1 |
| 8 | 1.03 | 1.6 | 1.45 | 4.1 | 5.75 | 72.0 | 1.86 | 7.1 | * | ... |
| 9 | 0.93 | 1.2 | 1.50 | 4.1 | 4.40 | 41.0 | 1.79 | 6.5 | .... | ... |
| 10 | 0.85 | 0.8 | 1.43 | 4.0 | 4.40 | 41.0 | 1.71 | 5.9 | .... | ... |
| 11 | 0.83 | 0.6 | 1.32 | 3.3 | 4.08 | 35.0 | 1.65 | 5.5 | .... | ... |
| 12 | 0.78 | 0.4 | 1.20 | 2.6 | 3.45 | 24.0 | 1.61 | 5.2 | .... | ... |
| 13 | 0.75 | 0.4 | 1.12 | 2.1 | 3.15 | 20.0 | 1.55 | 4.8 | .... | ... |
| 14 | 0.74 | 0.3 | 1.05 | 1.8 | 3.03 | 19.0 | 1.46 | 4.2 | .... | ... |
| 15 | 0.71 | 0.2 | 1.62 | 1.6 | 3.00 | 18.0 | 1.13 | 4.0 | .... | ... |
| 16 | 0.71 | 0.2 | 1.00 | 1.5 | 2.39 | 12.0 | 1.39 | 3.7 | .... | ... |
| 17 | 0.72 | 0.3 | 0.92 | 1.1 | 2.30 | 10.9 | 1.36 | 3.6 | ... | ... |
| 18 | 0.73 | 0.3 | 0.94 | 1.2 | 2.23 | 10.3 | 1.24 | 2.8 | ... | ... |
| 19 | 0.74 | 0.3 | 0.80 | 0.5 | 2.15 | 9.6 | 1.10 | 2.0 | ... | ... |
| 20 | 0.75 | 0.4 | 0.85 | 0.8 | 2.01 | 8.3 | 1.34 | 3.1 | ... | ... |
| 21 | 0.76 | 0.4 | 0.82 | 0.6 | 1.90 | 7.4 | 1.46 | 4.2 | .... | ... |
| 22 | 0.76 | 0.4 | 0.75 | 0.4 | 1.91 | 7.7 | 2.07 | 8.8 | .... | ... |
| 23 | 0.76 | 0.4 | 0.70 | 0.2 | 1.96 | 7.9 | 1.90 | 7.4 | ... | ... |
| 24 | 0.77 | 0.4 | 0.73 | 0.3 | 2.00 | 8.2 | 1.64 | 5.4 | ... | ... |
| 25 | 0.77 | 0.4 | 0.77 | 0.4 | 2.10 | 9.1 | 1.59 | 5.0 | ... | ... |
| 26 | 0.78 | 0.4 | 0.80 | 0.5 | 2.18 | 9.8 | 1.53 | 4.6 | .... | ... |
| 27 | 0.78 | 0.4 | 0.88 | 0.9 | 2.23 | 10.3 | 1.37 | 3.6 | ... | ... |
| 28 | 0.77 | 0.4 | 0.90 | 1.0 | 2.20 | 10.0 | 1.17 | 2.4 | ... | ... |
| 29 | 0.76 | 0.4 | 0.86 | 0.8 | 2.16 | 9.6 | 1.35 | 3.5 | ... | ... |
| 30 | 0.74 | 0.3 | 0.82 | 0.6 | 2.14 | 9.5 | 1.39 | 3.7 | ... | ... |
| 31 | 0.70 | 0.2 | 0.75 | 0.4 | ... | ... | 1.44 | 4.0 | ... | ... |

* Creek frozen over.

Plate No 24



Lindner Brothers' Ranche near Tenmile Police Detachment. Taken by M. H. French.

## Monthly Discharge of Sixmile Coulee at Spangler's Ranche, Sask., for 1911.

Drainage area, 44 square miles.

| Month. | Discharge in Second-Feet | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| July 3-31 | 3.0 | 0.2 | 0.8 | 0.018 | 0.019 | 44 |
| August | 4.4 | 0.2 | 1.2 | 0.027 | 0.031 | 74 |
| September | 94.0 | 0.2 | 21.8 | 0.495 | 0.552 | 1,297 |
| October | 9.3 | 2.0 | 5.6 | 0.127 | 0.146 | 344 |
| November 1 and 4-7 | 4.5 | 3.1 | 3.8 | 0.086 | 0.016 | 38 |
| The period | | | | | 0.764 | 1,797 |

Note—Creek frozen over on Nov. 2 and 3.

To get total run-off of this coulee add to above the run-off at Soderstrom's ranche five miles upstream.

There is also a period June 10 to July 1 for which there are no records, which must be taken into consideration as there was a heavy precipitation throughout that period. See discharge measurements during this period on Sixmile Coulee.

There was some water diverted above this station by Spangler's irrigation ditch.

## Lindner's Ditch near Battle Creek.

This station was established July 26, 1910, by H. R. Carscallen. It is located on Sec. 10, Tp. 6, Rge. 29, W. 3rd Mer., about 100 feet west of the surveyed trail to Maple Creek. It is about one quarter of a mile south of the Battle Creek post office., and about 500 yards below the intake of the ditch.

Discharge measurements are made by means of a 42-inch rectangular sharp-crested weir with complete end contractions.

The channel is straight for 200 feet above and 150 feet below the station, where it curves sharply to the right and enters Lindner Bros' hay-meadow, where it is diverted into a number of different laterals for irrigation purposes. The bed of the ditch is composed of clay and coarse gravel. The current is swift below the station.

The gauge is a plain staff graduated to feet and hundredths driven firmly into the bed of the ditch near the right bank, about twelve feet upstream from the weir. During 1911, it was read by John Lindner.

The discharge at this station must be added to that of Battle Creek at Tenmile police detachment, when computing the total run-off for the latter station.

## Discharge Measurements of Lindner's Ditch near Battle Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Aug. 2 | M. H. French | . . | . . | . | 2.9 | 0.056x |
| Aug. 2 | do | . | . . | . | 2.9 | 0.060x |
| Aug. 4 | do | .... | .... | . . | .... | Nil. x |

x Weir measurement.

DAILY GAUGE-HEIGHT AND DISCHARGE of Lindner's Ditch near Battle Creek, Sask., for 1911.

| Day. | May. Gauge Height. | May. Discharge. | June. Gauge Height. | June. Discharge. | July. Gauge Height. | July. Discharge. | August. Gauge Height. | August. Discharge. |
|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | | 3.40 | 2.67 | 3.05 | 0.06 | 2.90 | 0.06 |
| 2 | | | 3.40 | 2.67 | 3.05 | 0.06 | 2.90 | 0.06 |
| 3 | | | 3.40 | 2.67 | 3.05 | 0.06 | 2.90 | 0.06 |
| 4 | | | 3.40 | 2.67 | 3.05 | 0.06 | 2.90 | 0.06 |
| 5 | | | 3.40 | 2.67 | 3.05 | 0.06 | 2.90 | 0.06 |
| 6 | | | 3.40 | 2.67 | 2.90 | 0.06 | 2.90 | 0.06 |
| 7 | | | 3.40 | 2.67 | 2.90 | 0.06 | 2.90 | 0.06 |
| 8 | | | 3.40 | 2.67 | 2.90 | 0.06 | 2.90 | 0.06 |
| 9 | 3.35 | 2.17 | 3.40 | 2.67 | 2.90 | 0.06 | 2.88 | 0.00 |
| 10 | 3.35 | 2.17 | 3.40 | 2.67 | 2.90 | 0.06 | 2.89 | 0.04 |
| 11 | 3.35 | 2.17 | 3.40 | 2.67 | 2.90 | 0.06 | 2.89 | 0.04 |
| 12 | 3.35 | 2.17 | 3.05 | 0.06 | 2.90 | 0.06 | 2.89 | 0.04 |
| 13 | 3.35 | 2.17 | 3.05 | 0.06 | 2.90 | 0.06 | 2.89 | 0.04 |
| 14 | 3.35 | 2.17 | 3.05 | 0.06 | 2.90 | 0.06 | 2.89 | 0.04 |
| 15 | 3.45 | 3.21 | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 16 | 3.45 | 3.21 | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 17 | 3.45 | 3.21 | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 18 | 3.05 | 0.06 | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 19 | † | | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 20 | | | 3.05 | 0.06 | 3.10 | 1.27 | 2.89 | 0.04 |
| 21 | .. | | 3.05 | 0.06 | 3.10 | 1.27 | .... | ‡ |
| 22 | | | 3.05 | 0.06 | 2.90 | 0.06 | .. | .... |
| 23 | .. | | 3.05 | 0.06 | 2.90 | 0.06 | .. | .... |
| 24 | .. | | 3.05 | 0.06 | 2.90 | 0.06 | .. | .... |
| 25 | .. | | 3.05 | 0.06 | 2.90 | 0.06 | .. | .... |
| 26 | | | 3.05 | 0.06 | 2.90 | 0.06 | .... | .... |
| 27 | | | 3.05 | 0.06 | 2.90 | 0.06 | .... | .... |
| 28 | | | 3.05 | 0.06 | 2.90 | 0.06 | .... | .... |
| 29 | | | 3.05 | 0.06 | 2.90 | 0.06 | .... | .... |
| 30 | | | 3.05 | 0.06 | 2.90 | 0.06 | .... | .... |
| 31 | | | | . | 2.90 | 0.06 | .... | .... |

NOTE—This is a 12" Weir Station. Elevation of crest May 9 to July 6, is 3.02 above zero of gauge; July 6 to Aug. 20 2.87' above zero of gauge.
†Headgate closed May 19 to June 1st.
‡Closed for the season.

MONTHLY DISCHARGE of Lindner's Ditch near Battle Creek, Sask., for 1911.

| Month. | Discharge in Second-Feet. Maximum. | Minimum. | Mean. | Total Discharge in acre feet. |
|---|---|---|---|---|
| May (9-18) | 3.21 | 0.06 | 2.27 | 15 |
| June | 2.67 | 0.06 | 1.02 | 60 |
| July | 1.27 | 0.06 | 0.33 | 20 |
| August (1-20) | 0.06 | 0.04 | 0.05 | 2 |
| The period | | .. | | 127 |

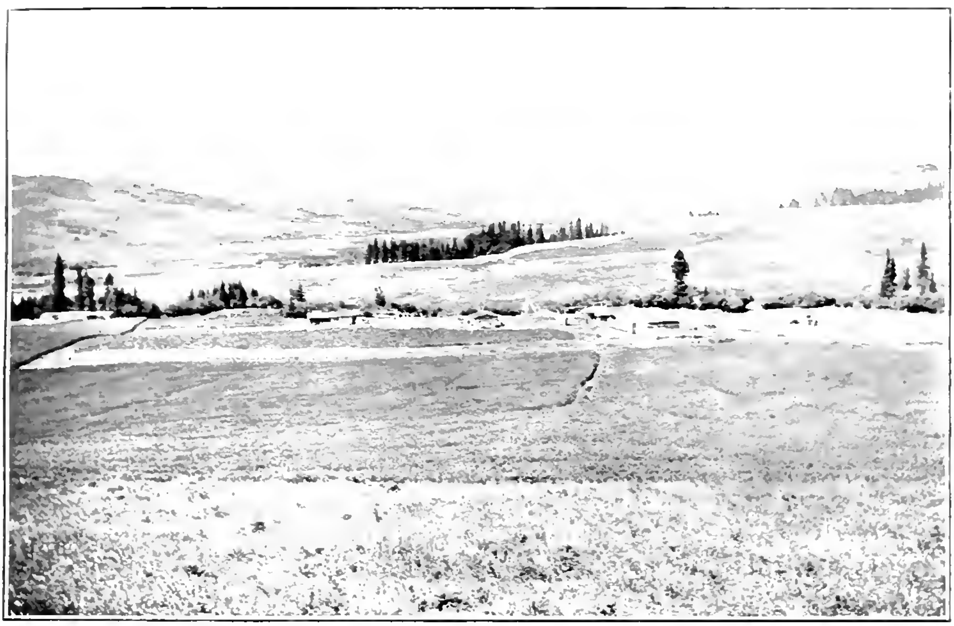
## TENMILE CREEK AT TENMILE POLICE DETACHMENT.

This station was established July 21, 1909, by H. R. Carscallen. It is located about 300 yards west of the Tenmile police detachment near the mouth of the stream. The station is very close to the south boundary of Sec. 4, Tp. 6, Rge. 29, W. 3rd Mer., almost on the quartering line of the section, and about two miles south of Battle Creek post office.

The channel is straight for fifteen feet above and twenty feet below the stream. Both banks are high, free from brush and not liable to overflow. The bed of the stream is composed of sand and coarse gravel. There is a small rapid above the station, but the current at the station is rather sluggish.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to and upright post sunk in the bed of the stream at the right bank and securely stayed to the bank. The gauge

PLATE No. 25.



Wood and Anderson's Ranche.

is referred to bench marks as follows: (1) the top of the initial-point stake driven close to the ground on the left bank and marked "B.M." in red paint (elevation, 5.84 feet above the zero of the gauge); (2) the head of a spike driven into the pointed top of a willow stump about 100 feet downstream from the station on the right bank, the stump blazed and marked "B.M." in red paint (elevation, 6.15 feet above the zero of the gauge.)

Discharge measurements are made at or near the gauge by wading, and at very low stages a weir is used. The initial point for soundings is a square stake, close to the ground on the left bank and marked "I.P." with red paint.

During 1911, the gauge was read by W. G. Patterson.

Discharge Measurements of Tenmile Creek at Tenmile Police Detachment, Sask., in 1911.

| Date. | Hydrographer | Width | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 22 | M. H. French | | | | 1.90 | 0.230 |
| May 18 | do | 5.20 | 2.94 | 0.151 | 0.62 | 0.444 |
| June 10 | do | 5.50 | 2.50 | 0.108 | 0.59 | 0.270 |
| July 5 | do | 5.80 | 3.24 | 0.091 | 0.63 | 0.296 |
| Sept. 2 | do | 5.06 | 3.32 | 0.067 | 0.69 | 0.224 |
| Sept. 15 | do | 5.50 | 3.50 | 0.121 | 0.76 | 0.423 |
| Sept. 30 | do | 5.80 | 4.79 | 0.083 | 0.98 | 0.400[c] |

[c] Beaver dams raising water

Daily Gauge-height and Discharge of Tenmile Creek, at Tenmile Police Detachment, Sask., for 1911.

| Day. | May. | | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | ... | 0.63 | 0.4 | 0.62 | 0.3 | 0.59 | 0.1 | 0.70 | 0.3 |
| 2 | .... | ... | 0.62 | 0.4 | 0.63 | 0.4 | 0.59 | 0.1 | 0.69 | 0.3 |
| 3 | .... | ... | 0.62 | 0.4 | 0.63 | 0.3 | 0.59 | 0.1 | 0.69 | 0.3 |
| 4 | .... | . | 0.63 | 0.4 | 0.62 | 0.3 | 0.59 | 0.1 | 0.90 | 1.6 |
| 5 | | ... | 0.64 | 0.5 | 0.64 | 0.4 | 0.60 | 0.1 | 1.00 | 2.6 |
| 6 | .... | ... | 0.64 | 0.5 | 0.63 | 0.3 | 0.85 | 1.4 | 2.00 | 26.0 |
| 7 | .... | ... | 0.65 | 0.5 | 0.62 | 0.2 | 0.65 | 0.2 | 1.73 | 19.0 |
| 8 | .... | ... | 0.63 | 0.4 | 0.62 | 0.2 | 0.67 | 0.3 | 1.67 | 17.0 |
| 9 | .... | ... | 0.63 | 0.4 | 0.62 | 0.2 | 0.65 | 0.2 | 1.50 | 12.0 |
| 10 | .... | ... | 0.59 | 0.2 | 0.63 | 0.3 | 0.61 | 0.1 | 1.29 | 5.4 |
| 11 | .... | ... | 0.58 | 0.2 | 0.63 | 0.3 | 0.61 | 0.1 | 1.00 | 2.5 |
| 12 | .... | ... | 0.59 | 0.2 | 0.62 | 0.2 | 0.60 | 0.1 | 0.90 | 1.4 |
| 13 | .... | ... | 0.59 | 0.2 | 0.64 | 0.3 | 0.59 | 0.1 | 0.86 | 1.1 |
| 14 | .... | ... | 0.60 | 0.2 | 0.64 | 0.3 | 0.59 | 0.1 | 0.80 | 0.7 |
| 15 | .... | ... | 0.59 | 0.2 | 0.63 | 0.2 | 0.58 | Nil. | 0.75 | 0.4 |
| 16 | .... | ... | 0.58 | 0.2 | 0.63 | 0.2 | 0.58 | ... | 0.70 | 0.1 |
| 17 | . | . | 0.58 | 0.2 | 0.62 | 0.2 | 0.58 | ... | 0.70 | 0.1 |
| 18 | 0.65 | 0.6 | 0.57 | 0.1 | 0.61 | 0.1 | 0.58 | . | 0.70 | 0.1 |
| 19 | 0.62 | 0.4 | 0.58 | 0.2 | 0.61 | 0.1 | 0.58 | ... | 0.69 | Nil. |
| 20 | 0.63 | 0.4 | 0.59 | 0.2 | 0.60 | 0.1 | 0.58 | ... | 0.67 | .. |
| 21 | 0.61 | 0.3 | 0.59 | 0.2 | 0.60 | 0.1 | 0.59 | ... | 0.67 | . |
| 22 | 0.60 | 0.3 | 0.61 | 0.3 | 0.61 | 0.1 | 0.58 | | 0.70 | 0.1 |
| 23 | 0.72 | 1.0 | 0.59 | 0.2 | 0.61 | 0.1 | 0.65 | 0.2 | 0.95 | 0.9 |
| 24 | 0.65 | 0.6 | 0.60 | 0.2 | 0.61 | 0.1 | 0.65 | 0.2 | 1.00 | 1.1 |
| 25 | 0.63 | 0.4 | 0.60 | 0.2 | 0.60 | 0.1 | 0.63 | 0.1 | 1.03 | 1.3 |
| 26 | 0.65 | 0.6 | 0.61 | 0.3 | 0.59 | 0.1 | 0.65 | 0.1 | 1.03 | 1.2 |
| 27 | 0.68 | 0.7 | 0.60 | 0.2 | 0.59 | 0.1 | 0.66 | 0.2 | 1.00 | 0.8 |
| 28 | 0.63 | 0.4 | 0.60 | 0.2 | 0.59 | 0.1 | 0.66 | 0.2 | 1.00 | 0.7 |
| 29 | 0.62 | 0.4 | 0.59 | 0.1 | 0.59 | 0.1 | 0.67 | 0.2 | 0.95 | 0.4 |
| 30 | 0.63 | 0.4 | 0.60 | 0.2 | 0.59 | 0.1 | 0.70 | 0.3 | 0.98 | 0.4 |
| 31 | 0.64 | 0.5 | .... | ... | 0.59 | 0.1 | 0.70 | 0.3 | | .. |

Note—Applied changing conditions from June 10 to September 30 because of beaver dams below. Gauge heights after Sept. 30 valueless but the approximate monthly discharge is 0.3 sec.-ft. or 18 acre-feet.

This creek would be dry all summer but for springs just above the station.

MONTHLY DISCHARGE of Tenmile Creek at Tenmile Police Detachment, Sask., for 1911.

Drainage area, 24 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| May 18-31 | 1.0 | 0.3 | 0.58 | 0.021 | 0.011 | 14 |
| June | 0.5 | 0.1 | 0.27 | 0.011 | 0.012 | 16 |
| July | 0.4 | 0.1 | 0.19 | 0.008 | 0.009 | 12 |
| August | 1.4 | 0.0 | 0.16 | 0.007 | 0.008 | 10 |
| September | 26.0 | 0.0 | 3.26 | 0.136 | 0.152 | 194 |
| The period | | | | | 0.192 | 246 |

NOTE—Run-off during October was approximately 0.3 sec.-ft., or 18 acre-feet.

## BATTLE CREEK AT TENMILE POLICE DETACHMENT.

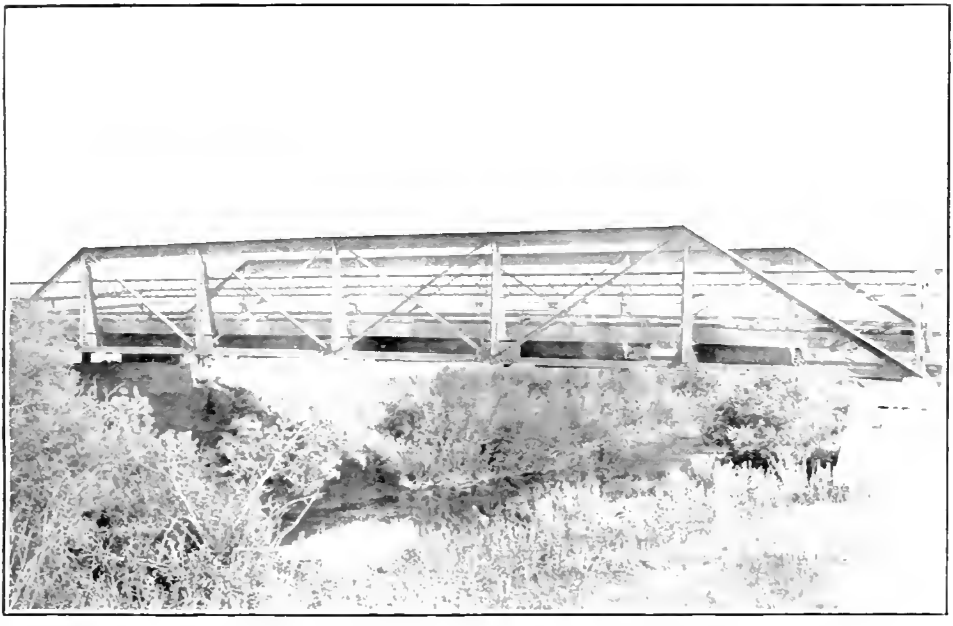
This station was established June 3, 1909, by F. T. Fletcher. It is located below the mouth of Tenmile Creek at the highway bridge on the surveyed trail from Maple Creek to Tenmile, and about 400 yards from the Tenmile police detachment. It is practically in the centre of N.E. ¼ Sec. 33, Tp. 5, Rge. 29, W. 3rd Mer., about two miles south of Battle Creek post office and 55 miles south of Maple Creek. The bridge is a steel structure of the pony-truss type, consisting of one eighty foot span, supported by two timber, rock-filled piers and having a twenty-foot approach at each end of the bridge. There is only one channel at all ordinary stages of the stream, but owing to the presence of the two piers supporting the truss there are three channels at times of floods.

The channel is straight for 500 feet above and 300 feet below the station. Both banks are high and not liable to overflow except in extreme floods, when the water breaks over the right bank some distance above the station and flows around the bridge. The right bank is free of brush for some distance above and below the station; the left bank is sparsely covered with willows near the station. The bed of the stream is sandy, and may shift somewhat in high stages of the stream. The current is very sluggish, and at very low stages vegetation appears in the bed of the stream at the station. During the summer months there is a heavy growth of weeds in the bottom of the channel which retards the water and alters conditions at the regular cross-section. Daily discharges for 1911 were obtained, therefore, by an indirect method, similar to that used for shifting channels. As there were several measurements obtained during the summer, the results may be considered fairly accurate.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the right abutment. Low-water measurements are made by wading near the bridge.

The gauge, which is of the standard chain type, is located about the centre of the steel truss and is securely fastened to the guard-rail on the downstream side of the bridge. The length of the chain from the bottom of the weight to the marker is 19.10 feet. The zero of the gauge (elev., 86.87) is referred to a permanent iron bench-mark (assumed elev., 100.00) at the northeast corner of the bridge. The bench-mark stands about three inches above ground and is well protected by rock. It is nine feet southwest of road diversion pin "R.V." and thirty feet northeast of the north end of the bridge pier.

During 1911, the gauge was read by Const. C. H. Green, of the R. N. W. M. Police.



Bridge over Battle Creek at Tenmile Police Detachment.

DISCHARGE MEASUREMENTS of Battle Creek at Tenmile Police Detachment, Sask., in 1911.

| Date. | Hydrographer | Width. | Area of Section | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 21 | M. H. French | 37.5 | 106.80 | 1.372 | 4.650 | 146.50 |
| May 18 | do | 33.3 | 64.11 | 0.875 | 3.390 | 55.81† |
| June 10 | do | 30.0 | 52.70 | 0.513 | 3.020 | 27.08‡ |
| July 5 | do | | 65.30 | 0.491 | 3.480 | 32.02 |
| July 13 | do | .. | 60.58 | 0.265 | 3.215 | 16.07 |
| July 19 | do | | 55.30 | 0.152 | 3.060 | 8.43 |
| Aug. 1 | do | 32.0 | 53.70 | 0.144 | 3.150 | 7.73 |
| Aug. 10 | do | 36.0 | 73.71 | 0.403 | 3.645 | 29.71▲ |
| Aug. 24 | do | | 53.02 | 0.149 | 3.000 | 7.94† |
| Sept. 2 | do | ... | 50.25 | 0.139 | 2.800 | 7.02 |
| Sept. 7 | do | 43.0 | 191.12 | 1.628 | 6.690 | 311.22 |
| Sept. 15 | do | 33.0 | 69.50 | 0.754 | 3.610 | 52.39‡ |
| Sept 25 | do | 32.0 | 63.60 | 0.706 | 3.430 | 44.89‡ |
| Oct. 26 | do | 32.0 | 58.50 | 0.721 | 3.270 | 42.19* |
| Oct 26 | do | 32.0 | 62.66 | 0.775 | 3.400 | 48.56* |

* Rapidly changing gauge height.
† Gauged 1,000 feet down stream from the bridge.
‡ Gauged 500 feet down stream from the bridge.
▲ Gauged 600 feet down stream from the bridge.

DAILY GAUGE-HEIGHT AND DISCHARGE of Battle Creek at Tenmile Police Detachment, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 3.48 | 56.0 | 3.03 | 32.0 | 3.90 | 57.0 |
| 2 | | | 3.57 | 60.0 | 2.97 | 29.0 | 3.81 | 51.0 |
| 3 | | | 3.61 | 64.0 | 2.83 | 23.0 | 3.76 | 48.0 |
| 4 | | | 3.72 | 70.0 | 2.84 | 22.0 | 3.78 | 39.0 |
| 5 | | | 3.80 | 76.0 | 2.90 | 24.0 | 3.48 | 32.0 |
| 6 | | | 3.75 | 74.0 | 2.94 | 26.0 | 3.49 | 33.0 |
| 7 | | | 3.55 | 61.0 | 2.91 | 23.0 | 3.34 | 25.0 |
| 8 | | | 3.40 | 53.0 | 3.03 | 28.0 | 3.31 | 23.0 |
| 9 | | | 3.21 | 43.0 | 2.96 | 25.0 | 3.37 | 25.0 |
| 10 | | | 3.16 | 41.0 | 3.01 | 27.0 | 3.34 | 23.0 |
| 11 | | | 3.17 | 42.0 | 2.92 | 23.0 | 3.31 | 22.0 |
| 12 | | | 3.16 | 41.0 | 2.86 | 20.0 | 3.29 | 20.0 |
| 13 | | | 3.08 | 38.0 | 2.83 | 18.0 | 3.20 | 16.0 |
| 14 | | | 3.01 | 34.0 | 2.83 | 18.0 | 3.17 | 14.0 |
| 15 | | | 3.06 | 37.0 | 2.76 | 15.0 | 3.16 | 13.0 |
| 16 | | | 3.27 | 48.0 | 2.67 | 11.0 | 3.01 | 8.5 |
| 17 | | | 3.57 | 67.0 | 2.54 | 7.5 | 3.00 | 8.0 |
| 18 | | | 3.40 | 56.0 | 2.57 | 8.0 | 3.05 | 9.0 |
| 19 | | | 3.21 | 45.0 | 2.60 | 8.0 | 3.09 | 9.5 |
| 20 | | | 3.26 | 48.0 | 2.60 | 8.0 | 3.05 | 8.4 |
| 21 | 4.65 | 146 | 3.20 | 45.0 | 2.61 | 8.0 | 3.14 | 11.0 |
| 22 | 4.39 | 122 | 3.11 | 39.0 | 2.70 | 9.5 | 3.19 | 12.5 |
| 23 | 4.10 | 98 | 3.32 | 49.0 | 2.76 | 11.0 | 3.17 | 11.5 |
| 24 | 3.96 | 87 | 3.42 | 55.0 | 2.78 | 12.0 | 3.30 | 15.0 |
| 25 | 3.82 | 77 | 3.33 | 49.0 | 3.20 | 26.0 | 3.25 | 13.0 |
| 26 | 3.80 | 76 | 3.40 | 53.0 | 4.35 | 93.0 | 3.20 | 11.0 |
| 27 | 3.86 | 80 | 3.46 | 56.0 | 4.00 | 69.0 | 3.12 | 8.0 |
| 28 | 3.63 | 64 | 3.44 | 54.0 | 3.53 | 39.0 | 3.08 | 7.5 |
| 29 | 3.45 | 54 | 3.30 | 47.0 | 3.51 | 37.0 | 3.01 | 5.0 |
| 30 | 3.30 | 45 | 3.22 | 41.0 | 3.55 | 39.0 | 3.03 | 5.5 |
| 31 | | | 3.13 | 36.0 | | | 3.17 | 9.0 |

## Daily Gauge-height and Discharge of Battle Creek at Tenmile Police Detachment, Sask., for 1911.—*Continued.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.14 | 9.0 | 2.93 | 7.0 | 3.22 | 36.0 | 3.06 | 32.0 |
| 2 | 3.12 | 8.5 | 2.86 | 6.0 | 3.22 | 36.0 | 3.08 | 33.0 |
| 3 | 3.12 | 9.0 | 2.85 | 6.0 | 3.26 | 38.0 | 3.10 | 34.0 |
| 4 | 3.14 | 10.0 | 3.35 | 25.0 | 3.62 | 56.0 | 3.04 | 31.0 |
| 5 | 3.16 | 11.0 | 6.06 | 245.0 | 3.45 | 49.0 | 3.12 | 35.0 |
| 6 | 3.94 | *43.0 | 7.60 | 415.0 | 3.39 | 45.0 | 3.04 | 31.0 |
| 7 | 3.55 | 25.0 | 6.74 | 321.0 | 3.27 | 39.5 | 3.15 | 36.0 |
| 8 | 3.70 | 32.0 | 6.13 | 255.0 | 3.22 | 38.0 | .... | .... |
| 9 | 3.75 | 34.0 | 5.40 | 181.0 | 3.20 | 37.0 | .... | .... |
| 10 | 3.63 | 29.0 | 4.87 | 133.0 | 3.18 | 36.0 | .... | .... |
| 11 | 3.50 | 23.0 | 4.27 | 87.0 | 3.13 | 34.0 | .... | .... |
| 12 | 3.39 | 20.0 | 4.03 | 73.0 | 3.10 | 33.0 | .... | .... |
| 13 | 3.31 | 17.5 | 3.90 | 67.0 | 3.06 | 31.0 | .... | .... |
| 14 | 3.30 | 17.5 | 3.71 | 58.0 | 3.04 | 30.0 | .... | .... |
| 15 | 3.20 | 14.0 | 3.60 | 52.0 | 3.02 | 29.0 | .... | .... |
| 16 | 3.10 | 11.0 | 3.49 | 46.0 | 3.00 | 28.0 | .... | .... |
| 17 | 3.10 | 11.0 | 3.46 | 45.0 | 2.90 | 24.0 | .... | .... |
| 18 | 3.07 | 10.0 | 3.44 | 44.0 | 3.06 | 32.0 | .... | .... |
| 19 | 2.98 | 8.0 | 3.40 | 42.0 | 3.12 | 34.0 | .... | .... |
| 20 | 2.96 | 7.0 | 3.30 | 38.0 | 3.10 | 33.0 | .... | .... |
| 21 | 2.92 | 6.0 | 3.18 | 32.0 | 3.09 | 33.0 | .... | .... |
| 22 | 2.93 | 6.4 | 3.60 | 54.0 | 3.10 | 33.0 | .... | .... |
| 23 | 3.00 | 8.0 | 3.40 | 43.0 | 3.33 | 44.0 | .... | .... |
| 24 | 3.02 | 8.5 | 3.40 | 43.0 | 3.25 | 41.0 | .... | .... |
| 25 | 2.99 | 7.5 | 3.44 | 45.0 | 3.17 | 37.0 | .... | .... |
| 26 | 2.99 | 7.5 | 3.43 | 45.0 | 3.10 | 34.0 | .... | .... |
| 27 | 3.02 | 9.0 | 3.42 | 45.0 | 3.13 | 36.0 | .... | .... |
| 28 | 3.00 | 8.0 | 3.38 | 42.0 | 3.27 | 42.0 | .... | .... |
| 29 | 3.00 | 8.5 | 3.30 | 39.0 | 3.55 | 57.0 | .... | .... |
| 30 | 2.96 | 7.5 | 3.27 | 38.0 | 3.10 | 34.0 | .... | .... |
| 31 | 2.98 | 8.0 | .... | .... | 3.04 | 31.0 | .... | .... |

*Increase in discharge due to rain in hills.

NOTE—Applied shifting conditions throughout the summer due to growth of grass in the channel. There was a considerable daily flow at this point during the latter part of March and the early part of April.

## Monthly Discharge of Battle Creek at Tenmile Police Detachment, Sask., for 1911.

Drainage area, 201 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| April 21-30 | 146 | 45 | 84.9 | 0.422 | 0.157 | 1,684 |
| May | 76 | 34 | 50.9 | 0.253 | 0.292 | 3,130 |
| June | 93 | 8 | 24.6 | 0.122 | 0.136 | 1,464 |
| July | 57 | 5 | 19.1 | 0.095 | 0.110 | 1,174 |
| August | 43 | 6 | 14.0 | 0.070 | 0.080 | 861 |
| September | 415 | 6 | 85.7 | 0.426 | 0.475 | 5,100 |
| October | 56 | 28 | 36.8 | 0.183 | 0.211 | 2,263 |
| November 1-7 | 36 | 31 | 33.1 | 0.165 | 0.041 | 460 |
| The period | | | | | 1.502 | 16,136 |

NOTE—There was some water diverted by Lindner's ditch during 1911. See records for Lindner's ditch elsewhere.

### Marshall's Ditch near Tenmile Police Detachment.

This station was established on July 11, 1911, by W. A. Fletcher. It is located in the N.E. ¼ Sec. 33, Tp. 5, Rge. 29, W. 3rd Mer., about half a mile below the regular station upon Battle Creek near the Tenmile police detachment.

The channel is straight for 100 feet above and 40 feet below the station. The bottom of the channel is muddy, and covered with a rank growth of weeds which will alter conditions at the station.

The gauge, which is a plain staff graduated to feet and inches, is nailed to a post sunk in the ditch near the right bank. The zero is referred to a bench-mark upon a three-inch stake upon the right bank above the gauge.

Measurements are made either with a current-meter or a weir.

This station was established too late to secure records of the amount of water diverted in the season of 1911.

Discharge Measurements of Marshall's Ditch near Tenmile Police Detachment, Sask., in 1911.

| Date | Hydrographer. | Width. | Area of Section | Mean Velocity | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| Aug. 2 | M. H. French | 0 6 | 2 92 | 0 106 | .... | 0 309 |
| Aug. 25 | do | .. | .. | .... | .... | Nil |
| Sept 20 | do | 7 5 | 4 75 | 0 465 | 4¼ | 2 210 |

### Gaff's Ditch near Tenmile Police Detachment.

This station was established on July 11, 1911, by W. A. Fletcher. It is located in the S.W. ¼ Sec. 25, Tp. 5, Rge. 29, W. 3rd. Mer.

The channel is straight for 200 feet above and 300 feet below the station. The bottom of the ditch is composed of a sandy loam.

The gauge, which is a plain staff divided into feet and inches, is nailed to a post near the right bank. The zero (elev. 97.29) is referred to a bench-mark (assumed elev., 100.00) situated three feet southwest of the gauge.

This station was established too late to secure records of the amount of water appropriated in 1911.

Discharge Measurements of Gaff's Ditch near Tenmile Police Detachment, Sask., in 1911.

| Date | Hydrographer. | Width | Area of Section | Mean Velocity | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Inches* | *Sec.-ft* |
| May 19 | M. H French | 8 0 | 8 36 | 1.580 | .... | 13 21 |
| Aug. 2 | do | .. | .... | .. . | .... | Nil. |
| Aug. 25 | do | .. | .... | ..... | .... | Nil. |
| Sept. 25 | do | 5 5 | 2.47 | 0 647 | 5 25 | 1 60x |

x Melting snow only.

### Battle Creek at Wilson's Ranche.

This station was established July 5, 1910, by H. R. Carscallen. It is located in the S.W. ¼ Sec. 2, Tp. 6, Rge. 28, W. 3rd Mer., about three quarters of a mile south of Wilson's house and below his irrigation ditch. It is about ten miles east of Battle Creek post office.

The channel is straight for about 200 feet above and 125 feet below the station. Both banks are high, sparsely covered with brush and not liable to overflow. The bed is composed of sand and gravel, and is liable to shift.

Discharge measurements are made at the station by wading. The initial point for soundings is a squared stake, driven within one foot of the ground in the left bank, 73 feet from the gauge-height and marked "I.P. OO."

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to a post sunk in the bed of the stream on the left bank. It is referred to a bench-mark upon a spike-head in a hub driven close to the final point stake on the right bank; elevation 12.58 feet above the zero of the gauge.

During 1911, the gauge was read by W. S. Wilson.

This station is important, as it is the nearest point upon Battle Creek to Cypress Lake at which an observer can be obtained. The storage possibilities of Cypress Lake are under investigation.

DISCHARGE MEASUREMENTS of Battle Creek at Wilson's Ranche, Sask., in 1911.

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | Feet | Sq. ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 17 | M. H. French | 37.0 | 40.39 | 1.876 | 3.855 | 75.79‡ |
| May 10 | do | 36.4 | 42.01 | 1.039 | 1.850 | 43.70 |
| June 3 | do | 35.6 | 25.81 | 0.712 | 1.420 | 18.39 |
| July 12 | do | 36.0 | 26.52 | 0.543 | 1.150 | 14.41 |
| Aug. 4 | do | 36.0 | 24.94 | 0.458 | 1.370 | 11.13 |
| Aug. 26 | do | 35.0 | 24.31 | 0.468 | 1.330 | 11.40 |
| Sept. 23 | do | 37.5 | 58.30 | 0.773 | 1.890 | 45.09 |
| Oct. 26 | do | 37.0 | 56.01 | 0.788 | 1.910 | 44.19* |

* Poor conditions
‡ Ice in channel

DAILY GAUGE-HEIGHT AND DISCHARGE of Battle Creek at Wilson's Ranche, Sask., 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 4.80 | ‡ | 2.05 | 57 | 1.60 | 28.0 |
| 2 | | | 5.00 | ‡ | 2.20 | 69 | 1.55 | 25.0 |
| 3 | | | 5.00 | ‡ | 2.26 | 74 | 1.40 | 17.0 |
| 4 | | | 5.00 | ‡ | 2.27 | 75 | 1.30 | 13.0 |
| 5 | | | 5.00 | ‡ | 2.50 | 94 | 1.60 | 29.0 |
| 6 | | | 5.00 | ‡ | 2.50 | 94 | 1.60 | 28.0 |
| 7 | | | 4.90 | ‡ | 2.40 | 85 | 1.55 | 25.0 |
| 8 | | | 4.55 | ‡ | 2.10 | 61 | 1.65 | 31.0 |
| 9 | | | 4.50 | ‡ | 2.08 | 59 | 1.62 | 29.0 |
| 10 | | | 4.52 | ‡ | 1.82 | 41 | 1.58 | 26.0 |
| 11 | | | 4.50 | ‡ | 1.79 | 39 | 1.55 | 25.0 |
| 12 | | | 4.47 | ‡ | 1.80 | 40 | 1.44 | 18.0 |
| 13 | | | 4.37 | ‡ | 1.80 | 40 | 1.35 | 15.0 |
| 14 | | | 4.30 | ‡ | 1.66 | 31 | 1.17 | 7.0 |
| 15 | | | 4.15 | ‡ | 1.60 | 27 | 1.10 | 5.0 |
| 16 | | | 4.00 | ‡ | 1.60 | 27 | 1.08 | 4.0 |
| 17 | | | 3.85 | 76.0* | 1.85 | 44 | 1.05 | 3.5 |
| 18 | | | 4.66 | 178.0* | 2.00 | 55 | 1.05 | 3.5 |
| 19 | | | 4.65 | 208.0* | 1.82 | 42 | 1.04 | 3.3 |
| 20 | | | 3.70 | 146.0* | 1.80 | 41 | 1.04 | 3.3 |
| 21 | | | 3.30 | 140.0* | 1.95 | 51 | 1.03 | 3.0 |
| 22 | | | 3.20 | 158.0* | 1.90 | 48 | 1.04 | 3.2 |
| 23 | | | 2.87 | 126.0 | 1.84 | 44 | 1.05 | 3.3 |
| 24 | | | 2.65 | 106.0 | 1.86 | 46 | 1.33 | 12.0 |
| 25 | 5.70 | ‡ | 2.30 | 77.0 | 1.85 | 45 | 1.85 | 42.0 |
| 26 | 5.68 | ‡ | 2.39 | 84.0 | 1.86 | 46 | 2.60 | 103.0 |
| 27 | 5.68 | ‡ | 2.25 | 73.0 | 1.87 | 47 | 2.20 | 69.0 |
| 28 | 5.69 | ‡ | 2.30 | 77.0 | 1.88 | 48 | 1.88 | 43.0 |
| 29 | 5.60 | ‡ | 2.10 | 61.0 | 1.85 | 45 | 1.70 | 31.0 |
| 30 | 5.40 | ‡ | 2.05 | 57.0 | 1.84 | 44 | 1.72 | 32.0 |
| 31 | 4.70 | ‡ | .... | .... | 1.70 | 35 | .... | .... |

DAILY GAUGE-HEIGHT AND DISCHARGE of Battle Creek at Wilson's Ranche, Sask., for 1911. *Continued,*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.04 | 54.0 | 1.33 | 10.0 | 1.26 | 9.4 | 1.85 | 42 | 2.00 | 53 |
| 2 | 2.00 | 52.0 | 1.32 | 9.5 | 1.25 | 9.0 | 1.82 | 40 | 1.91 | 47 |
| 3 | 2.00 | 52.0 | 1.33 | 10.0 | 1.24 | 8.7 | 1.80 | 39 | 1.80 | 39 |
| 4 | 1.86 | 41.0 | 1.34 | 10.5 | 2.00 | 53.0 | 2.00 | 53 | 1.74 | 35 |
| 5 | 1.80 | 37.0 | 1.35 | 11.0 | 3.80 | 241.0 | 2.01 | 54 | 1.70 | 32 |
| 6 | 1.70 | 30.0 | 1.36 | 11.0 | 5.30 | 490.0 | 1.94 | 49 | 1.85 | 42 |
| 7 | 1.61 | 24.0 | 1.70 | 28.0 | 5.00 | 440.0 | 1.80 | 39 | 2.00 | 53 |
| 8 | 1.58 | 22.0 | 1.84 | 38.0 | 4.72 | 388.0 | 1.86 | 43 | ... | ... |
| 9 | 1.54 | 19.0 | 1.80 | 35.0 | 3.80 | 241.0 | 1.85 | 42 | ... | ... |
| 10 | 1.50 | 17.0 | 1.84 | 38.0 | 3.35 | 182.0 | 1.84 | 42 | | ... |
| 11 | 1.48 | 16.0 | 1.70 | 28.0 | 2.70 | 112.0 | 1.81 | 40 | ... | |
| 12 | 1.45 | 14.0 | 1.60 | 23.0 | 2.40 | 85.0 | 1.80 | 39 | | |
| 13 | 1.39 | 12.0 | 1.53 | 19.0 | 2.41 | 86.0 | 1.79 | 38 | | |
| 14 | 1.35 | 10.0 | 1.50 | 18.0 | 2.30 | 77.0 | 1.78 | 38 | | |
| 15 | 1.30 | 8.6 | 1.47 | 16.0 | 2.21 | 70.0 | 1.77 | 37 | | |
| 16 | 1.30 | 8.6 | 1.44 | 15.0 | 2.00 | 53.0 | 1.77 | 37 | | |
| 17 | 1.30 | 8.6 | 1.39 | 13.0 | 1.90 | 46.0 | 1.74 | 35 | | |
| 18 | 1.30 | 8.6 | 1.37 | 12.0 | 1.92 | 47.0 | 1.75 | 36 | | |
| 19 | 1.30 | 8.6 | 1.35 | 12.0 | 1.95 | 50.0 | 1.78 | 38 | | |
| 20 | 1.30 | 8.6 | 1.31 | 11.0 | 2.00 | 53.0 | 1.79 | 38 | | |
| 21 | 1.30 | 8.6 | 1.28 | 9.0 | 1.96 | 50.0 | 1.82 | 40 | | |
| 22 | 1.30 | 8.6 | 1.25 | 8.5 | 1.93 | 48.0 | 1.80 | 39 | | |
| 23 | 1.35 | 11.0 | 1.24 | 8.0 | 1.91 | 47.0 | 1.90 | 46 | | |
| 24 | 1.43 | 14.0 | 1.25 | 8.5 | 1.94 | 49.0 | 1.95 | 50 | | |
| 25 | 1.45 | 15.0 | 1.28 | 9.5 | 1.82 | 40.0 | 1.93 | 48 | | |
| 26 | 1.50 | 17.0 | 1.33 | 12.0 | 1.81 | 40.0 | 1.90 | 46 | | |
| 27 | 1.40 | 13.0 | 1.32 | 11.6 | 1.82 | 40.0 | 1.88 | 45 | | |
| 28 | 1.35 | 11.0 | 1.30 | 10.7 | 1.82 | 40.0 | 2.07 | 59 | | |
| 29 | 1.30 | 8.8 | 1.28 | 10.0 | 1.86 | 43.0 | 2.00 | 53 | | |
| 30 | 1.30 | 8.8 | 1.27 | 9.7 | 1.85 | 42.0 | 1.94 | 49 | | |
| 31 | 1.31 | 9.0 | 1.27 | 9.7 | | | 1.98 | 52 | | |

‡ Ice conditions for which no data is available.
* Applied shifting conditions because of ice in bottom of channel.
NOTE—Applied shifting conditions because of grass in bottom of channel from May 10 to Aug. 26.

MONTHLY DISCHARGE of Battle Creek at Wilson's Ranche, Sask., for 1911.

Drainage area, 260 square miles.

| MONTH. | DISCHARGE IN SECOND-FEET. | | | | RUN-OFF. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| April 17-30 | 208 | 57.0 | 111.9 | 0.430 | 0.224 | 3,107 |
| May | 94 | 27.0 | 51.4 | 0.198 | 0.228 | 3,160 |
| June | 103 | 3.0 | 22.7 | 0.087 | 0.097 | 1,351 |
| July | 54 | 8.6 | 18.6 | 0.072 | 0.083 | 1,144 |
| August | 38 | 8.0 | 15.3 | 0.059 | 0.068 | 941 |
| September | 490 | 8.7 | 106.0 | 0.408 | 0.455 | 6,307 |
| October | 59 | 35.0 | 43.4 | 0.167 | 0.192 | 2,669 |
| November 1-7 | 53 | 33.0 | 43.0 | 0.165 | 0.043 | 597 |
| The period | ...... | ...... | ...... | ...... | 1.390 | 19,276 |

NOTE—There was considerable run-off in April, March and November that is not included in above data. The water diverted by Marshall & Gaff's irrigation ditch during the months of April, May and June must be included in above when comparing it with the corresponding data for Battle creek at Tenmile Police Detachment.

## Gilchrist Brothers' Ditch near Kelvinhurst.

This station was established on October 16, 1911, by F. T. Fletcher. It is located on the S.W. ¼ Sec. 11, Tp. 5, Rge. 29, W. 3rd Mer., at the intake to the ditch.

The gauge, which is a plain staff graduated to feet and inches, is nailed to the right side of a flume at a point 15 feet from the intake gate. The zero of the gauge (elev., 96.92) is referred to the top of a post at the lower end of the flume (assumed elev., 100.00).

Discharge measurements may be made with a meter in the flume or with a weir below the flume.

No water was diverted after the gauge had been installed.

## Richardson's Ditch near Kelvinhurst.

This station was established on October 11, 1911, by F. T. Fletcher. It is located on the S.E. ¼ Sec. 2, Tp. 5, Rge. 27, W. 3rd Mer., 192 feet east and twelve feet north of the southwest corner of the quarter section.

The gauge, which is a plain staff graduated to feet and inches, is nailed to a post at the right bank of the ditch. The top of the gauge (elev., 99.70) is referred to the top of the pin in the "mound" on the north boundary of Sec. 35, Tp. 4, Rge. 27, W. 3rd Mer.

The ditch is straight for 200 feet above and 500 feet below the gauge. The cross-section is uniform, and the banks are in good condition.

Discharge measurements may be made with a weir or a meter by wading near the gauge.

No water was diverted after the gauge had been installed.

Discharge Measurements of Richardson's Ditch near Kelvinhurst, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec. ft.* |
| June 3 | M. H. French | .... | .... | .... | .... | 1.347 |
| July 11 | do | .... | .... | .... | .... | 0.545x |
| Aug. 4 | do | .... | .... | .... | .... | 0.300x |

x Weir measurement.

## McKinnon's Ditch near Kelvinhurst.

This station was established on October 20, 1911, by F. T. Fletcher. It is located on the N.W. ¼ Sec. 20, Tp. 4, Rge. 26, W. 3rd Mer., about 364 feet south and 127 feet east of the northwest corner of Sec. 20 and near James McKinnon's house.

The gauge, which is a plain staff graduated to feet and inches, is nailed to a post near the left bank of the ditch. The top of the gauge (elev., 100.59) is referred to the top of a stake on the left bank, and thirteen feet downstream from the gauge.

The ditch is straight for 75 feet above and 1500 feet below the gauge. The bed and banks of the ditch are composed of clay. The cross-section is uniform, and the banks in good condition at the gauge. The fall is one and a half feet per mile.

Discharge measurements may be made with either a meter or a weir, according to the quantity of water in the ditch.

No water was diverted after the gauge had been installed.

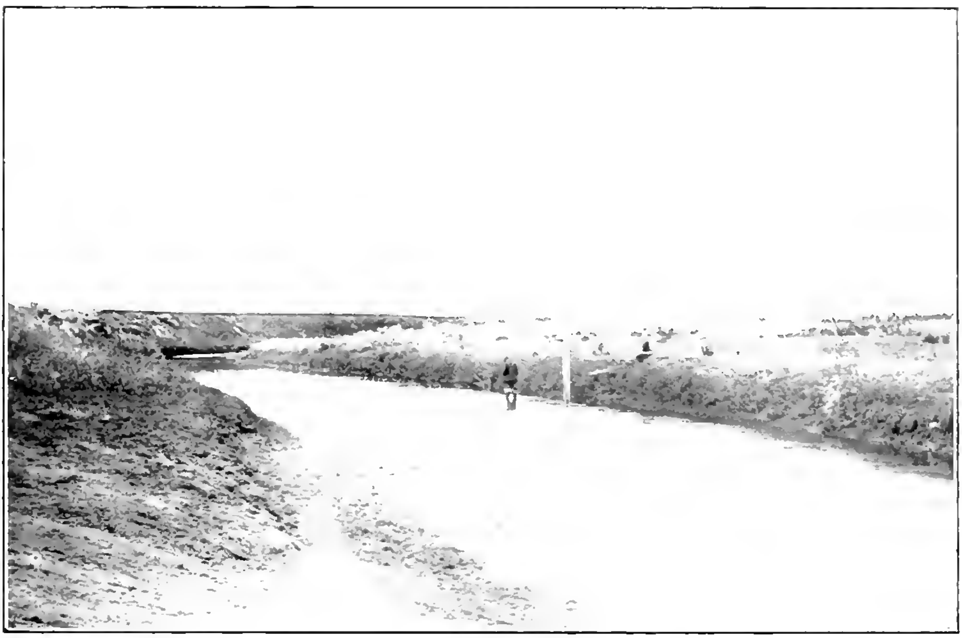
Discharge Measurements of McKinnon's Ditch near Kelvinhurst, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Aug. 28 | M. H. French | 9.0 | 6.45 | 0.813 | .... | 5.35 |

## Stirling and Nash's Ditch near Kelvinhurst.

This station was established on July 11, 1911, by M. H. French. It is located on Sec. 22, Tp. 3, Rge. 7, W. 3rd Mer., and is about one mile from the head-gate of the ditch and 1,000 feet east of Stirling Brothers' house.

PLATE No. 27.



Gauging Station on Battle Creek at Nash's Ranche. Taken by M. H. French.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post and braced to a small bridge near the centre of the ditch. The zero of the gauge (elev., 94.81) is referred to the top of a stake on the right bank (assumed elev., 100.00).

The ditch is straight for 1,000 feet above and 600 feet below the gauge. The cross-section is uniform, and the bed and banks of the ditch are in good condition at this point.

Discharge measurements are made with a current-meter by wading near the gauge at ordinary stages but during low water a weir is used.

DISCHARGE MEASUREMENTS of Stirling and Nash's Ditch near Kelvinhurst, Sask., in 1911

| Date | Hydrographer. | Width. | Area of Section. | Mean Velocity | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 11 | M. H. French | | 6 82 | 0 904 | | 6 17 |
| June 5 | do | 9 0 | 6 40 | 1 200 | | 7 67 |
| July 10 | do | 8 3 | 8 27 | 1 240 | 1 35 | 10 24 |
| Aug. 5 | do | | | | 0 50 | Nil. |

MEAN DAILY GAUGE-HEIGHT, in feet, of Stirling and Nash's Ditch, near Kelvinhurst, Sask., for 1911.

| Day. | July. | August. |
|---|---|---|
| 1 | | 0 56 |
| 2 | | 0 55 |
| 3 | | 0 52 |
| 4 | | 0 50 |
| 5 | | 0 50 |
| 6 | | 0 53 |
| 7 | | 0 55 |
| 8 | | 0 55 |
| 9 | | 0 50 |
| 10 | | 0 42 |
| 11 | 1 29 | 0 34 |
| 12 | 1 29 | 0 26 |
| 13 | 1 30 | 0 18 |
| 14 | 1 27 | 0 14 |
| 15 | 1 25 | 0 09 |
| 16 | 1 25 | 0 06 |
| 17 | 1 22 | 0 02 |
| 18 | 1 14 | |
| 19 | 1 14 | |
| 20 | 1 14 | |
| 21 | 1 14 | |
| 22 | 1 14 | |
| 23 | 1 12 | |
| 24 | 1 10 | |
| 25 | 0 80 | |
| 26 | 0 72 | |
| 27 | 0 70 | |
| 28 | 0 66 | |
| 29 | 0 64 | |
| 30 | 0 62 | |
| 31 | 0 58 | |

## BATTLE CREEK AT NASH'S RANCHE.

This station was established May 11, 1910, by N. M. Sutherland. It is located on the N.E. 1/4 Sec. 3, Tp. 3, Rge. 27, W. 3rd Mer., and is 270 feet west of E. R. Nash's house. It is is about seventy miles by trail from Maple Creek.

The stream flows in one channel 45 feet wide at ordinary stages. The channel is straight for about 250 feet above and 300 feet below the station. The right bank is solid clay, high and not liable to overflow. The left bank is also of clay, but is low, and liable to overflow during high stages of the stream. The bed of the stream is composed of sand and gravel and may shift in high stages of the stream.

Discharge measurements are made at low and ordinary stages, by wading, but during high water the stream cannot be waded and the discharge is computed by slope measurements. The initial point for soundings is the face of a post on the left bank, marked "O O O" in red paint.

The gauge, which is a plain staff graduated to feet and hundredths, is fastened to a post sunk in the bed of the stream at the left bank. The zero (elev., 90.23) is referred to a permanent iron bench-mark (assumed elev., 100.00) on the left bank, seven feet east of the initial point of soundings, and in the line of the cross-section. The bench-mark is also 1902.6 feet S. 81°. 28'. W from the northeast corner of Sec. 3, Tp. 3, Rge. 27, W. 3rd Mer. It is about eight inches above ground and is protected by a mound of rock.

During 1911, the gauge was read by E. R. Nash.

With the exception of Badger's irrigation ditch, this station is below all the irrigation ditches on Battle Creek. During 1911, Stirling and Nash's ditch diverted a small quantity of water during May, June and July, and Richardson's ditch was running an average of one cubic foot per second all summer.

DISCHARGE MEASUREMENTS OF BATTLE CREEK at Nash's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 18 | M. H. French | 44.3 | 65.00 | 1.390 | 1.910 | 90.22† |
| May 12 | do | 44.0 | 34.90 | 1.071 | 1.250 | 37.41 |
| June 5 | do | 40.0 | 15.20 | 0.700 | 0.730 | 10.61‡ |
| July 10 | do | 40.0 | 16.10 | 0.627 | 0.720 | 10.10 |
| Aug. 6 | do | 40.0 | 16.16 | 0.564 | 0.710 | 9.12 |
| Aug. 28 | do | 32.0 | 6.92 | 0.319 | 0.470 | 2.21▲ |
| Sept. 13 | do | 77.0 | 30.50 | 2.330 | 6.150 | 711.00* |
| Sept 19 | do | 43.5 | 41.79 | 1.124 | 1.375 | 46.93 |
| Oct. 21 | do | 43.5 | 36.30 | 0.921 | 1.180 | 33.45 |

† Gauged 300 ft. down stream.
‡ Gauged 1,000 ft. up stream.
▲ Gauged 500 ft up stream.
* Slope measurement.

DAILY GAUGE-HEIGHT AND DISCHARGE of Battle Creek at Nash's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.95 | 94 | 1.65 | 68 | 1.17 | 33.0 | 1.25 | 38.0 |
| 2 | 2.45 | 140 | 1.55 | 60 | 1.05 | 26.0 | 0.87 | 16.0 |
| 3 | 1.98 | 96 | 1.54 | 59 | 0.90 | 18.0 | 0.93 | 20.0 |
| 4 | 1.95 | 94 | 1.65 | 68 | 0.85 | 15.0 | 1.04 | 25.0 |
| 5 | 1.85 | 84 | 1.75 | 76 | 0.80 | 13.0 | 1.05 | 26.0 |
| 6 | 1.90 | 89 | 1.85 | 84 | 0.68 | 8.3 | 1.03 | 25.0 |
| 7 | 1.75 | 76 | 1.90 | 89 | 0.65 | 7.3 | 0.94 | 20.0 |
| 8 | 2.74 | 169 | 1.75 | 76 | 0.75 | 11.0 | 0.90 | 18.0 |
| 9 | 1.56 | 61 | 1.68 | 70 | 0.80 | 13.0 | 0.80 | 13.0 |
| 10 | 1.70 | 72 | 1.42 | 50 | 0.75 | 11.0 | 0.74 | 11.0 |
| 11 | 1.65 | 68 | 1.30 | 42 | 0.83 | 14.5 | 0.65 | 7.3 |
| 12 | 1.65 | 68 | 1.25 | 38 | 0.80 | 13.0 | 0.60 | 5.5 |
| 13 | 1.92 | 91 | 1.20 | 35 | 0.80 | 13.0 | 0.55 | 4.2 |
| 14 | 2.47 | 142 | 1.10 | 29 | 0.70 | 9.0 | 0.55 | 4.2 |
| 15 | 2.80 | 175 | 1.05 | 26 | 0.65 | 7.3 | 0.53 | 3.8 |
| 16 | 1.80 | 80 | 1.06 | 27 | 0.54 | 4.0 | 0.46 | 2.4 |
| 17 | 1.85 | 84 | 1.05 | 26 | 0.44 | 2.0 | 0.45 | 2.2 |
| 18 | 1.85 | 84 | 1.05 | 26 | 0.38 | 1.2 | 0.45 | 2.2 |
| 19 | 2.79 | 174 | 1.18 | 34 | 0.40 | 1.4 | 0.54 | 4.0 |
| 20 | 2.85 | 180 | 1.30 | 42 | 0.44 | 2.0 | 0.44 | 2.0 |
| 21 | 2.45 | 140 | 1.10 | 29 | 0.48 | 2.7 | 0.45 | 2.2 |
| 22 | 2.65 | 160 | 1.10 | 29 | 0.52 | 3.5 | 0.34 | 0.7 |
| 23 | 2.25 | 120 | 1.30 | 42 | 0.50 | 3.0 | 0.34 | 0.7 |
| 24 | 2.18 | 114 | 1.15 | 32 | 0.44 | 2.0 | 0.35 | 0.8 |
| 25 | 2.00 | 98 | 1.10 | 29 | 0.40 | 1.4 | 0.40 | 1.4 |
| 26 | 1.85 | 84 | 1.25 | 38 | 0.45 | 2.2 | 0.55 | 4.2 |
| 27 | 1.68 | 70 | 1.30 | 42 | 0.40 | 1.4 | 0.56 | 4.5 |
| 28 | 1.67 | 70 | 1.25 | 38 | 0.48 | 2.7 | 0.57 | 4.8 |
| 29 | 1.69 | 71 | 1.25 | 38 | 1.20 | 35.0 | 0.64 | 6.9 |
| 30 | 1.74 | 75 | 1.25 | 38 | 1.30 | 42.0 | 0.64 | 6.9 |
| 31 | .. | .... | 1.20 | 35 | | ... | 0.64 | 6.9 |

## Daily Gauge-height and Discharge of Battle Creek at Nash's Ranche, Sask., for 1911.—*Con.*

| Day. | August. | | September | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0 63 | 6 6 | 0 38 | 1 2 | 1 32 | 43 0 | 1 35 | 46 0 |
| 2 | 0 65 | 7 3 | 0 50 | 3 0 | 1 30 | 42 0 | 1 44 | 52 0 |
| 3 | 0 67 | 8 0 | 0 60 | 5 5 | 1 28 | 41 0 | 1 43 | 51 0 |
| 4 | 0 67 | 8 0 | 0 70 | 9 0 | 1 25 | 38 0 | 1 45 | 52 0 |
| 5 | 0 64 | 6 9 | 1 19 | 34 0 | 1 25 | 38 0 | 1 34 | 45 0 |
| 6 | 0 71 | 9 4 | 5 47 | 566 0 | 1 28 | 41 0 | 1 25 | 38 0 |
| 7 | 0 73 | 10 3 | 5 43 | 558 0 | 1 44 | 52 0 | 1 24 | 38 0 |
| 8 | 0 75 | 11 0 | 4 75 | 434 0 | 1 34 | 45 0 | 1 50 | 56 0 |
| 9 | 0 85 | 16 0 | 4 00 | 320 0 | 1 30 | 42 0 | 1 32 | 43 0 |
| 10 | 0 90 | 18 0 | 3 25 | 225 0 | 1 25 | 38 0 | 1 25 | 38 0 |
| 11 | 0 98 | 22 0 | 2 65 | 160 0 | 1 25 | 38 0 | 1 30 | 42 0 |
| 12 | 1 00 | 23 0 | 2 35 | 130 0 | 1 24 | 38 0 | 1 43 | 51 0 |
| 13 | 1 02 | 24 0 | 2 10 | 107 0 | 1 20 | 35 0 | 1 38 | 48 0 |
| 14 | 0 76 | 11 0 | 1 90 | 89 0 | 1 20 | 35 0 | 1 40 | 49 0 |
| 15 | 0 88 | 17 0 | 1 75 | 76 0 | 1 20 | 35 0 | 1 42 | 50 0 |
| 16 | 0 84 | 15 0 | 1 65 | 68 0 | 1 17 | 33 0 | | |
| 17 | 0 84 | 15 0 | 1 57 | 62 0 | 1 10 | 29 0 | | |
| 18 | 0 75 | 11 0 | 1 50 | 56 0 | 1 12 | 30 0 | | |
| 19 | 0 70 | 9 0 | 1 40 | 49 0 | 1 15 | 32 0 | | |
| 20 | 0 68 | 8 3 | 1 35 | 46 0 | 1 20 | 35 0 | | |
| 21 | 0 65 | 7 3 | 1 42 | 50 0 | 1 21 | 36 0 | | |
| 22 | 0 63 | 6 6 | 1 43 | 51 0 | 1 24 | 38 0 | | |
| 23 | 0 57 | 4 8 | 1 55 | 60 0 | 1 20 | 35 0 | | |
| 24 | 0 50 | 3 0 | 1 40 | 49 0 | 1 18 | 34 0 | | |
| 25 | 0 40 | 1 4 | 1 43 | 51 0 | 1 20 | 35 0 | | |
| 26 | 0 53 | 3 8 | 1 50 | 56 0 | 1 20 | 35 0 | | |
| 27 | 0 50 | 3 0 | 1 53 | 58 0 | 1 05 | 26 0 | | |
| 28 | 0 48 | 2 7 | 1 55 | 60 0 | 1 08 | 28 0 | | |
| 29 | 0 45 | 2 2 | 1 44 | 52 0 | 1 34 | 45 0 | | |
| 30 | 0 43 | 1 9 | 1 40 | 49 0 | 1 44 | 52 0 | | |
| 31 | 0 38 | 1 2 | | | 1 33 | 44 0 | | |

## Monthly Discharge of Battle Creek at Nash's Ranche, Sask., for 1911.

Drainage area, 500 square miles.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per Square Mile. | Depth in Inches on Drainage Area. | Total in Acre-Feet. |
| April | 180 | 61 0 | 104 1 | 0 208 | 0 232 | 6,194 |
| May | 89 | 26 0 | 45 6 | 0 091 | 0 105 | 2,804 |
| June | 42 | 1 2 | 10 6 | 0 021 | 0 023 | 631 |
| July | 38 | 0 7 | 9 3 | 0 019 | 0 022 | 572 |
| August | 24 | 1 2 | 9 5 | 0 019 | 0 022 | 584 |
| September | 566 | 1 2 | 117 8 | 0 236 | 0 263 | 7,009 |
| October | 52 | 26 0 | 37 7 | 0 075 | 0 086 | 2,318 |
| November 1-15 | 56 | 38 0 | 46 6 | 0 093 | 0 052 | 1,386 |
| The period | | | | | 0 805 | 21,498 |

Note—To the above must be added the water diverted by Stirling & Nash's ditch, McKinnon's ditch and Richardson's ditch.

MISCELLANEOUS DISCHARGE MEASUREMENTS in Battle Creek, drainage basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. ft.* | *Feet per Sec.* | *Sec.-ft.* |
| April 18 | M. H. French | Battle Creek | Sec. 31-5-27-3 | 23 1 | 31 49 | 3 200 | 100 840 |
| May 11 | " | " | " 36-4-27-3 | 25 1 | 28 92 | 1 470 | 42 520 |
| June 5 | " | " | " " | | | | 18 730 |
| July 11 | " | " | " " | 28 0 | 17 61 | 1 030 | 18 250 |
| Aug 10 | J. Kay | " | S.E 1-6-28-3 | 31 0 | 40 08 | 0 817 | 32 640 |
| Aug. 16 | M. H. French | " | Sec 13-8-1-4 | | 1 50 | 1 360 | 2 040 |
| June 26 | J Kay | Fourmile Coulee | " 11-8-29-3 | 4 25 | 3 51 | 3 660 | 12 840 |
| June 26 | R J Burley | " | " " | 4 40 | 2 87 | 3 400 | 9 760 |
| July 1 | M H French | " | " " | 4 50 | 2 91 | 2 520 | 7.330 |
| June 16 | " | Grayburn Creek .. | " 13-8-1-4 | | 4 04 | 0 559 | 2 260 |
| Aug. 16 | " | " ... | " " | 7 80 | 3 44 | 0 540 | 1 860 |
| Aug. 15 | " | Mink Creek | " 31-7-29-3 | x | | | 0 213 |
| June 9 | " | Marshall Gaff's Ditch | " 26-5-29-3 | | 4 77 | 1 270 | 6 070 |
| July 6 | " | " | " 34-5-29-3 | 6 00 | 7 13 | 0 808 | 5 760 |
| June 16 | " | Ninemile Coulee .. | " 36-7-30-3 | | 2 34 | 0 777 | 1 820 |
| Aug. 15 | " | " ... | " " | 5 23 | 2 29 | 0 663 | 1 450 |
| Aug. 17 | " | Sixmile Coulee.. | " 12-8-29-3 | | 1 63 | 0 687 | 1 100 |
| June 17 | " | Spring Creek ... | " 21-7-29-3 | x | | | 0 227 |
| June 17 | " | " ... | " 31-7-29-3 | x | | | 0 295 |

x Weir measurement.

## FRENCHMAN RIVER DRAINAGE BASIN.

### *General Description.*

Frenchman River drains the greater portion of southwestern Saskatchewan. It rises in Cypress Lake in Tp. 6, Rge. 26, W. 3rd Mer., and follows a southeasterly course for some 150 miles, crossing into the United States in Tp. 1, Rge. 10, west of the 3rd Meridian. It eventually finds its way into Milk River near Salt, Montana, and therefore forms a part of the general drainage basin of the Missouri.

Cypress Lake is on the southern slope of the Cypress Hills at an elevation of about 3240 feet above sea level. It occupies what is probably a portion of an abandoned watercourse, or channel, of an ancient river, which joined Battle Creek to the Frenchman River. The water of the lake is fresh, and is supplied by a number of coulees and small streams which head in the hills to the north. The largest of these are Oxarart and Sucker Creeks, both of which have a small continuous flow.

During dry years Cypress Lake does not overflow and the whole discharge of the Frenchman River is derived from Belanger, Davis and Fairwell Creeks and the north branch. From Tp. 6, Rge. 23, W. 3rd Mer., where the north branch joins the main stream, there is no appreciable supply to the river while in Canada. Mule Creek, which joins the river in Tp. 5, Rge. 17, W. 3rd Mer., and Snake Creek in Tp. 3, Rge. 13, W. 3rd Mer., however, have a small flow.

The country surrounding Cypress Lake is of rolling prairie much broken by coulees. In many of these there is considerable tree growth but for the most part the country is devoid of all vegetation other than grasses. All the streams in the upper section of the drainage basin, with the exception of the north branch, rise on the plateau at the top of the hills. Flowing southward they break through deep, well-wooded gorges before reaching the lower flats along the river. The north branch, however, is in a deep valley throughout its entire length, its feeders, like the western tributaries of the main stream, cutting through from the bench to the valley, in deep, well-wooded coulees. Below the mouth of the north branch there is little tree growth. Here and there along the river may be found small growths of shrubs and maple, while up on the hill-sides in some of the coulees there are small clumps of poplar covering an acre or so. Most of these coulees are rapidly becoming cleared by the settlers who are taking up the benches above the river valley. The benchlands are well covered with grasses, but the hills and sides of the valley are almost devoid of all vegetation. In the flats along the river, except where irrigated, the chief vegetation consists of sage brush and cactus.

When the Frenchman River leaves the lake it flows through a wide flat valley as far as the mouth of Fairwell Creek. Most of this land is under proposed or constructed irrigation ditches, covering an area of about 500 acres. Below this point the valley becomes more broken and narrows considerably, while the hillsides become higher. Small portions of this bottom will no doubt be brought under irrigation, but as yet little has been done in that direction.

Below the junction of the north branch the valley becomes rough and rugged, the sides being cut with buttes and deep coulees. Here numerous outcroppings of lignite may be seen and also a wide band of light-colored clay and sand. This band, which has been bleached almost a pure white, may be seen at many points along the river's entire course and is one of the most conspicuous objects in this region. From its color and nature the river receives its local name of the "Whitemud."

At East End, some miles lower down, the valley again breaks out into wide flats. Here is located the largest irrigation project in the Cypress Hills district. Messrs. Enright and Strong have constructed a large dam across the river and a system of ditches and storage reservoirs enabling them to irrigate about 2870 acres. Directly above this project there are two smaller schemes covering 690 acres. Just below, Messrs. Morrison Bros. have a dam and ditch which will irrigate 1200 acres. Their ditch is carried across the river and continued by Messrs. Duncan and Watson, who irrigate some 865 acres more.

This East End flat is of a sandy nature and when under irrigation it has been found that considerable portions of the water used finds its way back to the stream in a short distance. A series of measurements made August 31, 1911, after the flat had been well soaked by rains and irrigation, shows this to be true. Measurements made at Morrison's dam showed that about fifty per cent of the water flowing in Enright and Strong's ditch had again reached the river at this point. At Duncan's house it was found that eighty per cent of the discharge of Morrison's ditch had returned to the river. From Duncan's house to the mouth of Mule Creek there was a loss of about 45 per cent, due, no doubt, to seepage and evaporation.

Below the East End flat none of the flats, which occur at various points along the river, are irrigated as yet. A short distance below the mouth of Snake Creek the river enters bad lands which continue into the United States.

The mean annual rainfall of this basin is not well established, but it is estimated that it would range from 12 to 16 inches, most of which falls in May, June and July. From November to April streams are frozen over and usually there is an abundant snow-fall.

In order to get better records of the discharge of Frenchman River, two cable stations were erected on the upper part of the river, late in the fall of 1911. On account of the winter setting in, they were not quite completed and as no discharge measurements were made, the descriptions are not given in this report. They will be used during the season of 1912. The upper station is located at Gordon's ranche in Tp. 6, Rge. 24, W. 3rd Mer., which is above the mouth of the north branch. The lower station is located at Phillip's ranche in Tp. 6, Rge. 23, W. 3rd Mer., and is below the junction of the north branch but above the irrigation ditches in the vicinity of East End.

## Oxarart Creek at Wylie's Ranche.

This station was established June 15, 1909, by H. R. Carscallen. It is located on N.W. ¼ Sec. 20, Tp. 6, Rge. 27, W. 3rd Mer., near the mouth of the creek and about thirty-five miles south of Maple Creek. It is above the intake of Joseph Wylie's irrigation ditch.

The channel is straight for ten feet upstream and then divides into four small courses. It is straight for about twenty feet down-stream, then strikes an earth dam used in diverting water into Mr. Wylie's irrigation ditch. The stream has a considerable fall, and is subject to sudden and extreme floods, necessitating the replacing of the dam below the station after every flood. This brings the records of gauge-height observations under new sets of conditions, and a different rating curve must be constructed for each change of conditions. The creek has several channels during high stages, and the station, although unsatisfactory, is the only section to be found, within reach of an observer, where the total flow is contained in one channel during the low water period. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station during low water.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a vertical post sunk in the bed of the stream at the left bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) a spike-head in the top of the final-point stake on the right bank (elevation 5.75 feet above the zero of the gauge); (2) the top of three nails driven horizontally into a large willow tree, blazed and marked "B.M.," and about twenty feet from the gauge (elevation 4.41 feet above the zero of the gauge).

Discharge measurements are made a short distance above the station by wading. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

During 1911, the gauge was read by Frank Wylie.

### Discharge Measurements of Oxarart Creek at Wylie's Ranche, Sask., in 1911.

| Date. | Hydrographer | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 16 | M. H. French | 37.0 | 44.06 | 0.347 | 1.78 | 15.280 |
| May 9 | do | 25.0 | 16.88 | 0.146 | 1.06 | 2.460 |
| June 3 | do | 28.5 | 14.48 | 0.142 | 1.12 | 2.064* |
| July 12 | do | | 11.96 | 0.113 | 1.00 | 1.354* |
| Aug. 3 | do | | 10.26 | 0.096 | 0.89 | 0.986* |
| Aug 26 | do | | 8.88 | 0.084 | 0.85 | 0.738* |
| Sept. 21 | do | | 8.65 | 0.086 | 0.85 | 0.748* |
| Oct. 25 | do | 24.0 | 8.92 | 0.087 | 0.85 | 0.781* |

* Discharge measured with a weir.

### Daily Gauge Height and Discharge of Oxarart Creek at Wylie's Ranche, Sask., for 1911.

| Day. | April | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.80 | 15.8 | 1.20 | 3.3 | 1.12 | 2.5 | 1.06 | 2.0 |
| 2 | 1.80 | 15.8 | 1.45 | 7.2 | 1.12 | 2.5 | 1.07 | 2.1 |
| 3 | 1.80 | 15.8 | 1.87 | 18.0 | 1.12 | 2.5 | 1.07 | 2.1 |
| 4 | 1.80 | 15.8 | 1.90 | 18.9 | 1.11 | 2.4 | 1.07 | 2.1 |
| 5 | 1.80 | 15.8 | 1.74 | 14.1 | 1.11 | 2.4 | 1.06 | 2.0 |
| 6 | 1.80 | 15.8 | 1.48 | 7.8 | 1.12 | 2.5 | 1.05 | 1.9 |
| 7 | 1.90 | 18.9 | 1.20 | 3.3 | 1.12 | 2.5 | 1.05 | 1.9 |
| 8 | 1.90 | 18.9 | 1.15 | 2.8 | 1.10 | 2.3 | 1.05 | 1.9 |
| 9 | 1.90 | 18.9 | 1.15 | 2.8 | 1.10 | 2.3 | 1.04 | 1.8 |
| 10 | 1.90 | 18.9 | 1.10 | 2.3 | 1.08 | 2.1 | 1.03 | 1.7 |
| 11 | 1.80 | 15.8 | 1.08 | 2.1 | 1.08 | 2.1 | 1.02 | 1.7 |
| 12 | 1.80 | 15.8 | 1.05 | 1.9 | 1.07 | 2.1 | 1.00 | 1.5 |
| 13 | 1.90 | 18.9 | 1.05 | 1.9 | 1.07 | 2.1 | 1.00 | 1.5 |
| 14 | 1.90 | 18.9 | 1.05 | 1.9 | 1.07 | 2.1 | 1.00 | 1.5 |
| 15 | 1.90 | 18.9 | 1.05 | 1.9 | 1.07 | 2.1 | 1.00 | 1.5 |
| 16 | 1.80 | 15.8 | 1.05 | 1.9 | 1.07 | 2.1 | 0.99 | 1.4 |
| 17 | 1.84 | 17.0 | 1.05 | 1.9 | 1.08 | 2.1 | 0.99 | 1.4 |
| 18 | 1.50 | 8.2 | 1.10 | 2.3 | 1.08 | 2.1 | 0.98 | 1.4 |
| 19 | 1.69 | 12.7 | 1.10 | 2.3 | 1.07 | 2.1 | 0.98 | 1.4 |
| 20 | 1.75 | 14.4 | 1.05 | 1.9 | 1.08 | 2.1 | 0.98 | 1.4 |
| 21 | 1.70 | 13.0 | 1.10 | 2.3 | 1.09 | 2.2 | 0.96 | 1.3 |
| 22 | 1.66 | 12.0 | 1.12 | 2.5 | 1.09 | 2.2 | 0.96 | 1.3 |
| 23 | 1.21 | 3.4 | 1.12 | 2.5 | 1.09 | 2.2 | 0.94 | 1.2 |
| 24 | 1.18 | 3.1 | 1.10 | 2.3 | 1.10 | 2.3 | 0.93 | 1.2 |
| 25 | 1.15 | 2.8 | 1.10 | 2.3 | 1.08 | 2.1 | 0.92 | 1.1 |
| 26 | 1.12 | 2.5 | 1.11 | 2.4 | 1.08 | 2.1 | 0.92 | 1.1 |
| 27 | 1.08 | 2.1 | 1.11 | 2.4 | 1.07 | 2.1 | 0.92 | 1.1 |
| 28 | 1.05 | 1.9 | 1.11 | 2.4 | 1.07 | 2.1 | 0.90 | 1.0 |
| 29 | 1.03 | 1.7 | 1.10 | 2.3 | 1.07 | 2.1 | 0.90 | 1.0 |
| 30 | 1.00 | 1.5 | 1.10 | 2.3 | 1.06 | 2.0 | 0.90 | 1.0 |
| 31 | ... | | 1.10 | 2.3 | .... | | 0.89 | 1.0 |

DAILY GAUGE HEIGHT AND DISCHARGE of Oxarart Creek at Wylie's Ranche, Sask., for 1911—*Con.*

| Day. | August. | | September. | | October. | | November | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 2 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 3 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 4 | 0.89 | 1.0 | 1.38 | 5.9 | 0.85 | 0.8 | 0.85 | 0.8 |
| 5 | 0.89 | 1.0 | 1.38* | 5.9 | 0.85 | 0.8 | 0.85 | 0.8 |
| 6 | 0.89 | 1.0 | 1.38* | 5.9 | 0.85 | 0.8 | 0.85 | 0.8 |
| 7 | 0.89 | 1.0 | 1.36 | 5.6 | 0.85 | 0.8 | 0.85 | 0.8 |
| 8 | 0.89 | 1.0 | 1.30 | 4.6 | 0.85 | 0.8 | 0.85 | 0.8 |
| 9 | 0.89 | 1.0 | 1.10 | 2.3 | 0.85 | 0.8 | 0.85 | 0.8 |
| 10 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 11 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 12 | 0.89 | 1.0 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 13 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 14 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 15 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 |
| 16 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 17 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 18 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 19 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 20 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 21 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 22 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 23 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 24 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 25 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 26 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 27 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 28 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 29 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 30 | 0.85 | 0.8 | 0.85 | 0.8 | 0.85 | 0.8 | | |
| 31 | 0.85 | 0.8 | | | 0.85 | 0.8 | | |

* Gauge-height only approximate.
NOTE.—Discharge during October and November from Springs just above the Station.

MONTHLY DISCHARGE of Oxarart Creek at Wylie's Ranche, Sask., for 1911.

(Drainage area, 73 square miles.)

| Month. | Discharge in Second-Feet | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Mean. | Per square mile. | Depth in inches on Drainage Area | Total in acre-feet. |
| April | 18.9 | 1.5 | 12.4 | 0.170 | 0.190 | 738 |
| May | 18.9 | 1.9 | 4.1 | 0.056 | 0.065 | 252 |
| June | 2.5 | 2.0 | 2.2 | 0.030 | 0.034 | 131 |
| July | 2.1 | 1.0 | 1.5 | 0.021 | 0.024 | 92 |
| August | 1.0 | 0.8 | 0.9 | 0.013 | 0.015 | 55 |
| September | 5.9 | 0.8 | 1.6 | 0.022 | 0.024 | 95 |
| October | 0.8 | 0.8 | 0.8 | 0.011 | 0.013 | 49 |
| November (1-15) | 0.8 | 0.8 | 0.8 | 0.011 | 0.006 | 24 |
| The period | | | | | 0.371 | 1436 |

NOTE—Run-off for October and November caused by springs just above the gauging station.

## SUCKER CREEK AT WHITECOMB AND ZEIGLER'S RANCHE.

This station was established May 26, 1909, by H. R. Carscallen. It is located on the N.W. ¼ Sec. 24, Tp. 6, Rge. 26, W. 3rd Mer., about five miles south of Belanger post office and about thirty-two miles south of Maple Creek.

The channel is straight for 25 feet above and 45 feet below the station. The right bank is comparatively low, sparsely covered with brush, and will overflow at high stages. The left bank is high, free from brush at the station, and not liable to overflow. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station, but swift immediately below.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a vertical post sunk in the bed of the stream at the left bank and securely stayed to the bank It is referred to bench marks as follows:—(1) a circle of nail-heads in a log near the ground at the northeast corner of a stable (elevation, 12.27 feet above the zero of the gauge); (2) a spike-head in the top of the initial-point stake on the left bank, marked "B.M." (elevation 5.30 feet above the zero of the gauge).

Discharge measurements are made at or near the gauge by wading and at very low stages a weir is used. High-water measurements cannot be made, as the right bank overflows. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

During 1911, the gauge was read by Mrs. P. A. Zeigler.

Discharge Measurements of Sucker Creek at Whitcomb and Zeigler's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 20 | G. H. Whyte | 13.9 | 15.60 | 1.783 | 1.42 | 27.99 |
| May 18 | do | 11.0 | 8.10 | 0.658 | 0.81 | 5.33 |
| June 14 | do | 10.6 | 10.60 | 0.276 | 0.60 | 2.02 |
| July 13 | do | 8.41 | 3.60 | 0.494 | 0.58 | 1.78 |
| Aug. 16 | do | 6.61 | 2.05 | 0.707 | 0.56 | 1.45 |
| Sept 29 | do | 9.1 | 2.66 | 1.011 | 0.655 | 2.69 |

Daily Gauge Height and Discharge of Sucker Creek at Whitcomb and Zeigler's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.20 | 17.6 | 0.90 | 7.4 | 0.61 | 2.1 |
| 2 | | | 0.90 | 7.4 | 1.00 | 10.1 | 0.60 | 2.0 |
| 3 | | | 0.70 | 3.3 | 1.10 | 13.5 | 0.60 | 2.0 |
| 4 | | | 0.70 | 3.3 | 1.18 | 16.7 | 0.60 | 2.0 |
| 5 | | | 0.70 | 3.3 | 1.15 | 15.5 | 0.65 | 2.6 |
| 6 | | | 0.75 | 4.2 | 1.05 | 11.7 | 0.63 | 2.4 |
| 7 | | | 0.79 | 4.9 | 0.83 | 5.8 | 0.70 | 3.3 |
| 8 | | | 0.82 | 5.5 | 0.75 | 4.2 | 0.69 | 3.1 |
| 9 | | | 2.60 | 87.0 | 0.79 | 4.9 | 0.65 | 2.6 |
| 10 | | | 3.12 | 113.0 | 0.77 | 4.6 | 0.63 | 2.4 |
| 11 | | | 2.80 | 97.0 | 0.75 | 4.2 | 0.60 | 2.0 |
| 12 | | | 1.50 | 32.0 | 0.72 | 3.7 | 0.56 | 1.5 |
| 13 | | | 1.30 | 22.2 | 0.71 | 3.5 | 0.58 | 1.8 |
| 14 | | | 1.20 | 17.6 | 0.70 | 3.3 | 0.55 | 1.4 |
| 15 | | | 1.13 | 14.7 | 0.71 | 3.5 | 0.53 | 1.2 |
| 16 | | | 1.10 | 13.5 | 0.90 | 7.4 | 0.45 | 0.6 |
| 17 | | | 2.02 | 58.0 | 0.95 | 8.7 | 0.40 | 0.3 |
| 18 | | | 2.31 | 72.0 | 0.76 | 4.4 | 0.50 | 0.9 |
| 19 | | | 1.75 | 44.5 | 0.75 | 4.2 | 0.50 | 0.9 |
| 20 | | | 1.45 | 29.5 | 0.71 | 3.5 | 0.53 | 1.2 |
| 21 | | | 1.55 | 34.5 | 0.70 | 3.3 | 0.65 | 2.6 |
| 22 | | | 1.43 | 28.5 | 0.71 | 3.5 | 0.63 | 2.4 |
| 23 | | | 1.28 | 21.3 | 0.72 | 3.7 | 0.58 | 1.8 |
| 24 | | | 1.02 | 10.7 | 0.71 | 3.5 | 0.56 | 1.5 |
| 25 | | | 1.00 | 10.1 | 0.75 | 4.2 | 0.70 | 3.3 |
| 26 | 3.3 | ice | 0.95 | 8.7 | 0.73 | 3.8 | 1.68 | 41.0 |
| 27 | 2.6 | " | 0.85 | 6.2 | 0.72 | 3.7 | 1.00 | 10.1 |
| 28 | 2.0 | " | 0.90 | 7.4 | 0.7 | 3.3 | 0.80 | 5.1 |
| 29 | 1.1 | 13.5 | 0.85 | 6.2 | 0.69 | 3.1 | 0.70 | 3.3 |
| 30 | 1.3 | 22.2 | 0.87 | 6.7 | 0.67 | 2.9 | 0.72 | 3.7 |
| 31 | 1.1 | 13.5 | | | 0.65 | 2.6 | | ....... |

DAILY GAUGE HEIGHT AND DISCHARGE of Sucker Creek at Whitcomb and Zeigler's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.82 | 5.5 | 0.51 | 1.0 | 0.50 | 0.9 | 0.68 | 3.0 | 0.68 | 3.0 |
| 2 | 1.00 | 10.1 | 0.53 | 1.2 | 0.50 | 0.9 | 0.71 | 3.5 | | |
| 3 | 0.75 | 4.2 | 0.54 | 1.3 | 0.50 | 0.9 | 0.70 | 3.3 | | |
| 4 | 0.70 | 3.3 | 0.55 | 1.4 | 0.70 | 3.3 | 0.69 | 3.2 | | |
| 5 | 0.65 | 2.6 | 0.55 | 1.4 | 0.95 | 8.7 | 0.69 | 3.2 | | |
| 6 | 0.55 | 1.4 | 0.70 | 3.3 | 1.00 | 10.1 | 0.68 | 3.0 | | |
| 7 | 0.54 | 1.3 | 0.70 | 3.3 | 1.15 | 15.5 | 0.68 | 3.0 | | |
| 8 | 0.60 | 2.0 | 0.60 | 2.0 | 0.98 | 9.5 | 0.67 | 2.9 | | |
| 9 | 0.60 | 2.0 | 0.68 | 1.8 | 0.80 | 5.1 | 0.67 | 2.9 | | |
| 10 | 0.60 | 2.0 | 0.57 | 1.6 | 0.70 | 3.3 | 0.67 | 2.9 | | |
| 11 | 0.55 | 1.4 | 0.56 | 1.5 | 0.66 | 2.7 | 0.67 | 2.9 | | |
| 12 | 0.55 | 1.4 | 0.56 | 1.5 | 0.63 | 2.4 | 0.67 | 2.9 | | |
| 13 | 0.55 | 1.4 | 0.55 | 1.4 | 0.71 | 3.5 | 0.66 | 2.7 | | |
| 14 | 0.50 | 0.9 | 0.52 | 1.1 | 0.69 | 3.2 | 0.66 | 2.7 | | |
| 15 | 0.53 | 1.2 | 0.55 | 1.4 | 0.64 | 2.5 | 0.66 | 2.7 | | |
| 16 | 0.50 | 0.9 | 0.53 | 1.2 | 0.61 | 2.1 | 0.66 | 2.7 | | |
| 17 | 0.50 | 0.9 | 0.51 | 1.0 | 0.65 | 2.6 | 0.66 | 2.7 | | |
| 18 | 0.53 | 1.2 | 0.50 | 0.9 | 0.67 | 2.9 | 0.68 | 3.0 | | |
| 19 | 0.53 | 1.2 | 0.50 | 0.9 | 0.65 | 2.6 | 0.68 | 3.0 | | |
| 20 | 0.51 | 1.0 | 0.50 | 0.9 | 0.62 | 2.2 | 0.68 | 3.0 | | |
| 21 | 0.50 | 0.9 | 0.50 | 0.9 | 0.62 | 2.2 | 0.68 | 3.0 | | |
| 22 | 0.50 | 0.9 | 0.50 | 0.9 | 0.65 | 2.6 | 0.68 | 3.0 | | |
| 23 | 0.50 | 0.9 | 0.50 | 0.9 | 0.70 | 3.3 | 0.68 | 3.0 | | |
| 24 | 0.50 | 0.9 | 0.50 | 0.9 | 0.75 | 4.2 | 0.70 | 3.3 | | |
| 25 | 0.45 | 0.6 | 0.55 | 1.4 | 0.72 | 3.7 | 0.71 | 3.5 | | |
| 26 | 0.45 | 0.6 | 0.60 | 2.0 | 0.70 | 3.3 | 0.71 | 3.5 | | |
| 27 | 0.45 | 0.6 | 0.56 | 1.5 | 0.70 | 3.3 | 0.70 | 3.3 | | |
| 28 | 0.45 | 0.6 | 0.51 | 1.0 | 0.70 | 3.3 | 0.68 | 3.0 | | |
| 29 | 0.45 | 0.6 | 0.50 | 0.9 | 0.70 | 3.3 | 0.68 | 3.0 | | |
| 30 | 0.50 | 0.9 | 0.50 | 0.9 | 0.70 | 3.3 | 0.68 | 3.0 | | |
| 31 | 0.50 | 0.9 | 0.50 | 0.9 | | | 0.68 | 3.0 | | |

MONTHLY DISCHARGE of Sucker Creek at Whitcomb and Zeigler's Ranche, Sask., for 1911.

(Drainage area, 30 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square mile. | Depth in inches on Drainage Area | Total in acre-feet. |
| March (26-31) | 22.2 | 13.5 | 16.4 | 0.547 | 0.061 | 98 |
| April | 113.0 | 3.3 | 26.4 | 0.880 | 0.982 | 1571 |
| May | 16.7 | 2.6 | 5.8 | 0.193 | 0.222 | 357 |
| June | 41.0 | 0.3 | 3.7 | 0.123 | 0.137 | 229 |
| July | 10.1 | 0.6 | 1.4 | 0.047 | 0.054 | 86 |
| August | 3.3 | 0.9 | 1.4 | 0.047 | 0.054 | 86 |
| September | 15.5 | 0.9 | 3.9 | 0.130 | 0.145 | 232 |
| October | 3.5 | 2.7 | 3.0 | 0.100 | 0.115 | 184 |
| November 1 | 3.0 | 3.0 | 3.0 | 0.100 | 0.004 | 61 |
| The period | | | | | 1.774 | 2895 |

## LONEPINE CREEK AT HEWITT'S RANCHE.

This station was established July 17, 1909, by H. R. Carscallen. It is located on Sec. 27, Tp. 7, Rge. 26, W. 3rd Mer., about two miles west of the surveyed trail from Belanger post office to Maple Creek and about four miles west of Belanger.

The channel is straight for about 35 feet above and 45 feet below the station. The right bank is high and not liable to overflow; the left bank is comparatively low and will overflow at high stages of the stream. The surface of the ground on the left bank is very rough and broken.

The bed of the stream is composed of sand and coarse gravel. The current is smooth and swift.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a vertical post sunk in the bed of the stream at the right bank and securely stayed to the bank. It is referred to bench marks as follows:—(1) a spike-head in the top of the final stake driven close to the ground on the right bank, marked "B.M." in red paint (elevation, 5.63 feet above the zero of the gauge); (2) the head of a spike in the top of a pointed willow stump, blazed and marked "B.M.," on the left bank, 97 feet north of the gauge (elevation, 4.59 feet above the zero of the gauge); (3) the head of a spike in the top of a post driven close to the ground at the east side of a wire corral on the right bank (elevation 10.10 feet above the zero of the gauge).

Discharge measurements are made near the gauge by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

This station is below ditches constructed by A. P. McDonald and S. W. Hewitt, and in the case of water being used in these ditches the records at the gauge would not give the complete discharge of the creek.

During 1911, the gauge was read by S. W. Hewitt.

Discharge Measurements of Lonepine Creek at Hewitt's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 20 | G. H. Whyte | 3.2 | 3.05 | 1.409 | 1.395 | 4.30 |
| May 18 | do | 3.6 | 2.68 | 0.798 | 1.150 | 2.14 |
| June 15 | do | 3.5 | 1.04 | 0.317 | 0.620 | 0.33 |
| July 13 | do | ... | .... | ..... | 0.830 | 0.76* |
| Aug. 15 | do | ... | .... | ..... | 0.820 | 0.84* |
| Sept. 20 | do | ... | .... | ..... | 0.950 | 1.18* |

* Weir measurement.

Daily Gauge Height and Discharge of Lonepine Creek at Hewitt's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | ...... | ...... | 1.45 | 4.7 | 0.98 | 1.4 |
| 2 | ...... | ...... | 1.40 | 4.3 | 0.95 | 1.2 |
| 3 | ...... | ...... | 1.40 | 4.3 | 0.90 | 1.0 |
| 4 | ...... | ...... | 1.45 | 4.7 | 1.10 | 2.0 |
| 5 | ...... | ...... | 1.45 | 4.7 | 1.60 | 5.9 |
| 6 | ...... | ...... | 1.35 | 3.9 | 1.25 | 3.1 |
| 7 | ...... | ...... | 1.21 | 2.8 | 1.25 | 3.1 |
| 8 | ...... | ...... | 1.23 | 2.9 | 1.18 | 2.6 |
| 9 | ...... | ...... | 1.23 | 2.9 | 1.13 | 2.2 |
| 10 | ...... | ...... | 1.30 | 3.5 | 0.89 | 1.0 |
| 11 | ...... | ...... | 1.27 | 3.3 | 0.70 | 0.5 |
| 12 | ...... | ...... | 1.21 | 2.8 | 0.68 | 0.5 |
| 13 | ...... | ...... | 1.13 | 2.2 | 0.63 | 0.4 |
| 14 | 1.11 | 2.1 | 1.14 | 2.3 | 0.62 | 0.3 |
| 15 | 1.15 | 2.4 | 1.20 | 2.7 | 0.62 | 0.3 |
| 16 | 1.15 | 2.4 | 1.75 | 7.1 | 0.62 | 0.3 |
| 17 | 1.15 | 2.4 | 1.40 | 4.3 | 0.54 | 0.2 |
| 18 | 1.15 | 2.4 | 1.15 | 2.4 | 0.56 | 0.3 |
| 19 | 1.45 | 4.7 | 1.45 | 4.7 | 0.56 | 0.3 |
| 20 | 1.33 | 3.7 | 1.24 | 3.0 | 0.62 | 0.3 |
| 21 | 1.30 | 3.5 | 1.15 | 2.4 | 0.61 | 0.3 |
| 22 | 1.35 | 3.9 | 1.60 | 5.9 | 1.05 | 1.8 |
| 23 | 1.35 | 3.9 | 1.31 | 3.6 | 1.05 | 1.8 |
| 24 | 1.44 | 4.6 | 1.24 | 3.0 | 1.06 | 1.8 |
| 25 | 1.44 | 4.6 | 1.34 | 3.8 | 1.86 | 8.0 |
| 26 | 1.35 | 3.9 | 1.30 | 3.5 | 1.51 | 5.2 |
| 27 | 2.40 | 12.9 | 1.15 | 2.4 | 1.00 | 1.5 |
| 28 | 2.20 | 11.1 | 1.25 | 3.1 | 1.00 | 1.5 |
| 29 | 2.00 | 9.3 | 1.10 | 2.0 | 0.87 | 0.9 |
| 30 | 1.80 | 7.5 | 1.05 | 1.8 | 0.86 | 0.9 |
| 31 | ...... | ...... | 1.00 | 1.5 | ...... | ...... |

Daily Gauge Height and Discharge of Lonepine Creek at Hewitt's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.86 | 0.9 | 0.75 | 0.6 | 0.69 | 0.5 | 0.94 | 1.2 |
| 2 | 1.57 | 5.7 | 0.75 | 0.6 | 0.69 | 0.5 | 0.95 | 1.2 |
| 3 | 1.00 | 1.5 | 0.75 | 0.6 | 0.70 | 0.5 | 1.44 | 4.6 |
| 4 | 0.90 | 1.0 | 0.76 | 0.6 | 1.05 | 1.8 | 1.04 | 1.7 |
| 5 | 0.88 | 0.9 | 0.78 | 0.7 | 1.70 | 6.7 | 0.99 | 1.4 |
| 6 | 0.88 | 0.9 | 1.74 | 7.0 | 1.78 | 7.3 | 0.99 | 1.4 |
| 7 | 0.88 | 0.9 | 1.34 | 3.8 | 1.30 | 3.5 | 0.99 | 1.4 |
| 8 | 0.87 | 0.9 | 1.34 | 3.8 | 1.05 | 1.8 | 0.94 | 1.2 |
| 9 | 0.90 | 1.0 | 0.88 | 0.9 | 0.90 | 1.0 | 0.93 | 1.2 |
| 10 | 0.88 | 0.9 | 0.87 | 0.9 | 0.87 | 0.9 | 0.93 | 1.2 |
| 11 | 0.88 | 0.9 | 0.85 | 0.8 | 0.86 | 0.9 | 0.93 | 1.2 |
| 12 | 0.84 | 0.8 | 0.81 | 0.7 | 0.85 | 0.8 | 0.93 | 1.2 |
| 13 | 0.84 | 0.8 | 0.79 | 0.7 | 0.90 | 1.0 | 0.93 | 1.2 |
| 14 | 0.82 | 0.8 | 0.79 | 0.7 | 0.86 | 0.9 | 0.93 | 1.2 |
| 15 | 0.81 | 0.7 | 0.81 | 0.7 | 0.86 | 0.9 | 0.90 | 1.0 |
| 16 | 0.80 | 0.7 | 0.76 | 0.6 | 0.85 | 0.8 | 0.90 | 1.0 |
| 17 | 0.75 | 0.6 | 0.75 | 0.6 | 1.00 | 1.5 | 0.98 | 1.4 |
| 18 | 0.85 | 0.8 | 0.75 | 0.6 | 1.04 | 1.7 | 1.14 | 2.3 |
| 19 | 0.86 | 0.9 | 0.73 | 0.6 | 1.04 | 1.7 | 1.16 | 2.4 |
| 20 | 0.84 | 0.8 | 0.70 | 0.5 | 1.00 | 1.5 | 1.16 | 2.4 |
| 21 | 0.79 | 0.7 | 0.86 | 0.9 | 1.04 | 1.7 | 1.16 | 2.4 |
| 22 | 0.80 | 0.7 | 0.76 | 0.6 | 1.04 | 1.7 | 1.16 | 2.4 |
| 23 | 0.95 | 1.2 | 0.74 | 0.6 | 0.98 | 1.4 | 1.16 | 2.4 |
| 24 | 0.85 | 0.8 | 0.70 | 0.5 | 0.98 | 1.4 | 1.16 | 2.4 |
| 25 | 0.78 | 0.7 | 0.72 | 0.5 | 0.96 | 1.3 | 1.24 | 3.0 |
| 26 | 0.76 | 0.6 | 0.95 | 1.2 | 0.96 | 1.3 | 1.24 | 3.0 |
| 27 | 0.84 | 0.8 | 0.74 | 0.6 | 0.96 | 1.3 | 1.29 | † |
| 28 | 0.77 | 0.6 | 0.72 | 0.5 | 0.95 | 1.2 | 1.29 | ...... |
| 29 | 0.75 | 0.6 | 0.70 | 0.5 | 0.94 | 1.2 | 1.29 | ...... |
| 30 | 0.74 | 0.6 | 0.70 | 0.5 | 0.94 | 1.2 | 1.29 | ...... |
| 31 | 0.75 | 0.6 | 0.70 | 0.5 | | | 1.29 | ...... |

† Stream frozen.

Monthly Discharge of Lonepine Creek at Hewitt's Ranche, Sask., for 1911.

(Drainage area, 8 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in acre-feet. |
| April (14-30) | 12.9 | 2.1 | 5.020 | 0.628 | 0.400 | 169 |
| May | 7.1 | 1.5 | 3.440 | 0.430 | 0.496 | 211 |
| June | 8.0 | 0.3 | 1.690 | 0.211 | 0.235 | 101 |
| July | 5.7 | 0.6 | 0.917 | 0.122 | 0.141 | 60 |
| August | 7.0 | 0.5 | 1.060 | 0.132 | 0.152 | 65 |
| September | 7.3 | 0.5 | 1.660 | 0.208 | 0.232 | 99 |
| October (1-26) | 4.6 | 1.0 | 1.820 | 0.228 | 0.220 | 94 |
| The period | | | | | 1.876 | 799 |

## Belanger Creek at Garissere's Ranche.

This station was established June 12, 1909, by H. R. Carscallen. It is located on S.W. ¼ Sec. 18, Tp. 7, Rge. 25, W. 3rd Mer., one hundred and fifty yards west of Garissere's ranche (Belanger post office), and about twenty-seven miles south of Maple Creek.

The channel is straight for 100 feet above and 125 feet below the station. Both banks are comparatively high, but will overflow at time of extreme flood. The ground on the left bank is very rough and broken. Both banks are covered with low underbrush at the station and with large willow brush above and below. The bed of the stream is composed of sand and coarse gravel. The current is moderate at low stages.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a vertical post sunk in the bed of the creek at the left bank and securely stayed to the bank. It is referred to a bench-mark consisting of the head of a spike surrounded by a circle of nail-heads in the top of the initial-point stake on the left bank, marked "B.M." in red paint (elevation, 7.27 feet above the zero of the gauge).

Discharge measurements are made at the station by wading. No measurements can be made at extreme flood stage, as the banks overflow and make wading impossible. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

During 1911, the gauge was read by G. C. Garissere.

DISCHARGE MEASUREMENTS of Belanger Creek at Garissere's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge. Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 20 | G. H. Whyte | 18 3 | 16 76 | 1 160 | 1 755 | 19 42 |
| May 18 | do | 18 4 | 11 75 | 0 517 | 1 540 | 6 08 |
| June 15 | do | 17 5 | 13 40 | 0 456 | 1 500 | 6 11 |
| July 13 | do | 17 8 | 12 72 | 0 390 | 1 500 | 4 97 |
| Aug. 16 | do | 17 0 | 12 34 | 0 283 | 1 420 | 3 49 |
| Sept. 20 | do | 17 0 | 11 10 | 0 309 | 1.405 | 3 43 |

DAILY GAUGE HEIGHT AND DISCHARGE of Belanger Creek at Garissere's Ranche, Sask., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1 40 | 3 2 | | | | |
| 2 | | | 1 40 | 3 2 | | | | |
| 3 | | | 1 50 | 6 1 | | | | |
| 4 | | | 1 50 | 6 1 | | | | |
| 5 | | | 1 60 | 10 4 | | | | |
| 6 | | | 1 60 | 10 4 | | | | |
| 7 | | | 1 60 | 10 4 | | | | |
| 8 | | | 1 70 | 16 0 | | | | |
| 9 | | | 2 00 | 36 5 | | | | |
| 10 | | | 2 10 | 43 5 | | | | |
| 11 | | | 2 00 | 36 5 | | | | |
| 12 | | | 1 90 | 29 5 | | | | |
| 13 | | | 1 70 | 16 0 | | | | |
| 14 | | | 1 70 | 16 0 | | | | |
| 15 | 2 55 | 75 0 | 1 70 | 16 0 | | | | |
| 16 | 2 30 | 57 5 | 1 70 | 16 0 | | | | |
| 17 | 2 00 | 36 5 | | † | | | | |
| 18 | 2 00 | 36 5 | | | | | | |
| 19 | 2 10 | 43 5 | | | | | | |
| 20 | 2 10 | 43 5 | | | | | | |
| 21 | 1 90 | 29 5 | | | | | | |
| 22 | 1 90 | 29 5 | | | | | | |
| 23 | 1 80 | 22 6 | | | | | | |
| 24 | 1 80 | 22 6 | | | | | | |
| 25 | 1 60 | 10 4 | | | | | | |
| 26 | 1 60 | 10 4 | | | | | | |
| 27 | 1 50 | 6 1 | | | | | | |
| 28 | 1 50 | 6 1 | | | | | | |
| 29 | 1 50 | 6 1 | | | | | | |
| 30 | 1 40 | 3 2 | | | | | | |
| 31 | 1 40 | 3.2 | | | | | | |

DAILY GAUGE HEIGHT AND DISCHARGE of Belanger Creek at Garissere's Ranche, Sask., for 1911.—*Continued.*

| DAY. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | | | 1.28 | 1.1 | 1.42 | 3.8 | 1.28 | 1.1 |
| 2 | | | | | 1.28 | 1.1 | 1.43 | 4.0 | 1.28 | 1.1 |
| 3 | | | | | 1.40 | 3.2 | 1.43 | 4.0 | 1.28 | 1.1 |
| 4 | | | | | 1.40 | 3.2 | 1.43 | 4.0 | 1.29 | 1.2 |
| 5 | | | | | 1.43 | 4.0 | 1.43 | 4.0 | 1.29 | 1.2 |
| 6 | | | | | 1.43 | 4.0 | 1.43 | 4.0 | 1.29 | 1.2 |
| 7 | | | | | 1.43 | 4.0 | 1.30 | 1.3 | 1.28 | 1.1 |
| 8 | | | | | 1.30 | 1.3 | 1.29 | 1.2 | 1.28 | 1.1 |
| 9 | | | | | 1.30 | 1.3 | 1.29 | 1.2 | 1.27 | 0.9 |
| 10 | | | | | 1.31 | 1.5 | 1.29 | 1.2 | 1.27 | 0.9 |
| 11 | | | | | 1.31 | 1.5 | 1.29 | 1.2 | 1.28 | 1.1 |
| 12 | | | † | | 1.32 | 1.6 | 1.40 | 3.2 | 1.29 | 1.2 |
| 13 | | | 1.43 | 3.8 | 1.33 | 1.8 | 1.40 | 3.2 | 1.27 | 0.9 |
| 14 | | | 1.43 | 3.7 | 1.33 | 1.8 | 1.40 | 3.2 | 1.28 | 1.1 |
| 15 | | | 1.42 | 3.6 | 1.33 | 1.8 | 1.42 | 3.8 | 1.28 | 1.1 |
| 16 | | | 1.42 | 3.5 | 1.33 | 1.8 | 1.44 | 4.3 | 1.28 | 1.1 |
| 17 | | | 1.42 | 3.8 | 1.34 | 1.9 | 1.44 | 4.3 | 1.28 | 1.1 |
| 18 | | | 1.43 | 4.0 | 1.34 | 1.9 | 1.42 | 3.8 | 1.29 | 1.2 |
| 19 | | | 1.43 | 4.0 | 1.33 | 1.8 | 1.42 | 3.8 | 1.27 | 0.9 |
| 20 | | | 1.41 | 3.5 | 1.35 | 2.1 | 1.42 | 3.8 | | |
| 21 | | | 1.41 | 3.5 | 1.39 | 3.0 | 1.44 | 4.3 | | |
| 22 | | | 1.40 | 3.2 | 1.40 | 3.2 | 1.44 | 4.3 | | |
| 23 | | | 1.40 | 3.2 | 1.40 | 3.2 | 1.44 | 4.3 | | |
| 24 | | | 1.40 | 3.2 | 1.40 | 3.2 | 1.30 | 1.3 | | |
| 25 | | | 1.39 | 3.0 | 1.40 | 3.2 | 1.30 | 1.3 | | |
| 26 | | | 1.39 | 3.0 | 1.42 | 3.8 | 1.30 | 1.3 | | |
| 27 | | | 1.29 | 1.2 | 1.41 | 3.5 | 1.30 | 1.3 | | |
| 28 | | | 1.29 | 1.2 | 1.39 | 3.0 | 1.29 | 1.2 | | |
| 29 | | | 1.29 | 1.2 | 1.39 | 3.0 | 1.29 | 1.2 | | |
| 30 | | | 1.28 | 1.1 | 1.39 | 3.0 | 1.29 | 1.2 | | |
| 31 | | | 1.28 | 1.1 | | | 1.28 | 1.1 | | |

† No observations of Gauge height between 16 April and August 13. No observer.

MONTHLY DISCHARGE of Belanger Creek at Garissere's Ranche, Sask., for 1911.

(Drainage area, 43 square miles.)

| MONTH. | DISCHARGE IN SECOND-FEET. | | | RUN-OFF. | | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area | Total in acre-feet. |
| March (15-31) | 75.0 | 3.2 | 26.0 | 0.605 | 0.382 | 877 |
| April (1-16) | 43.0 | 3.2 | 17.2 | 0.400 | 0.238 | 546 |
| August (13-31) | 4.0 | 1.1 | 2.9 | 0.067 | 0.047 | 109 |
| September | 4.0 | 1.1 | 2.5 | 0.058 | 0.065 | 149 |
| October | 4.3 | 1.1 | 2.8 | 0.065 | 0.075 | 172 |
| November (1-19) | 1.2 | 0.9 | 1.1 | 0.026 | 0.018 | 41 |
| The period | | | | | .825 | 1894 |

NOTE.—No records for period from April 17th to Aug. 12th.

## DAVIS CREEK AT DRURY'S RANCHE.

This station was established May 24, 1909, by H. R. Carscallen. It is located on N.E. ¼ Sec. 29, Tp. 6, Rge. 25, W. 3rd Mer., about five miles southeast of Belanger post office, and about half a mile from the mouth of the creek.

The channel is straight for 150 feet above and 200 feet below the station. The right bank is comparatively high and will not overflow except in cases of extreme flood; the left bank is low and will overflow at high-water stages of the stream. Both banks are covered with brush. The bed of the stream is composed of sand and coarse gravel, and there may be a slight sub-surface flow at this point. The current is swift.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post in the bed of the stream at the right bank and securely stayed to the bank. It is referred to bench marks as follows:—(1) the head of a spike in the top of a pointed willow stump about fifteen feet below the gauge on the right bank, the stump blazed and marked "B.M." with red paint (elevation 5.05 feet above gauge zero); (2) the head of a spike surrounded by a circle of nail-heads in the top of a log projecting from the southeast corner of Mr. Drury's house (elevation, 9.05 feet above gauge zero).

Discharge measurements are made at or near the gauge by wading. Owing to the left bank being low, high-water measurements cannot be made. Considerable annoyance is experienced by the construction of dams below the gauge by beavers.

There are one or two proposed irrigation schemes on the head-waters of this stream, but as yet there has been no diversion of water.

During 1911, the gauge was read by T. A. Drury.

DISCHARGE MEASUREMENTS of Davis Creek at Drury's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 20 | G. H. Whyte | 19 5 | 21 42 | 2 668 | 1 47 | 57 16 |
| May 18 | do | 12 0 | 7 97 | 1.590 | 0 90 | 12 74 |
| June 15 | do | 8.8 | 3.48 | 0.557 | 0.58 | 1 94 |
| July 13 | do | 8 6 | 3 48 | 0.583 | 0.61 | 2 03 |
| Aug. 15 | do | 9 0 | 2.61 | 0 417 | 0.54 | 1.07 |
| Sept. 20 | do | 11 0 | 5 62 | 1.617 | 0.78 | 9 09 |

DAILY GAUGE HEIGHT AND DISCHARGE of Davis Creek at Drury's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.02 | 20 0 | 0 8 | 8 1 |
| 2 | | | 1.05 | 22 0 | 0.74 | 5 9 |
| 3 | | | 1 09 | 25 0 | 0.70 | 4 6 |
| 4 | | | 1.10 | 25 0 | 0 68 | 4 1 |
| 5 | | | 1.08 | 24 0 | 0 70 | 4.6 |
| 6 | | | 1.01 | 19 0 | 0.80 | 8.1 |
| 7 | | | 0 85 | 10 0 | 0.82 | 9 0 |
| 8 | | | 0.83 | 9 4 | 0.77 | 7.0 |
| 9 | | | 0.80 | 8 1 | 0.76 | 6 6 |
| 10 | | | 0 79 | 7 7 | 0.76 | 6.6 |
| 11 | | | 0.80 | 8 1 | 0.67 | 3.8 |
| 12 | | | 0.81 | 8.5 | 0.60 | 2.2 |
| 13 | | | 0.79 | 7 7 | 0.57 | 1.7 |
| 14 | | | 0.79 | 7 7 | 0.55 | 1.3 |
| 15 | | | 0.81 | 8.5 | 0.55 | 1.3 |
| 16 | | | 1.00 | 19 0 | 0.52 | 0.9 |
| 17 | | | 1.00 | 19 0 | 0.50 | 0.7 |
| 18 | | | 0.90 | 13.0 | 0.55 | 1.3 |
| 19 | | | 0.90 | 13 0 | 0.51 | 1 2 |
| 20 | | | 0.90 | 13.0 | 0.55 | 1.3 |
| 21 | | | 0.83 | 9.4 | 0.57 | 1.7 |
| 22 | † | | 0 75 | 6 2 | 0.56 | 1 5 |
| 23 | 1 89 | 95 | 0 83 | 9 4 | 0.56 | 1.5 |
| 24 | 1 87 | 93 | 0 88 | 12 0 | 0.56 | 1 5 |
| 25 | 1 86 | 92 | 0 87 | 11 0 | 0.57 | 1.7 |
| 26 | 1.73 | 81 | 0 87 | 11 0 | 0.95 | 16 0 |
| 27 | 1.32 | 44 | 0.90 | 13.0 | 0.90 | 13 0 |
| 28 | 1 01 | 19 | 0.87 | 11 0 | 0.77 | 7.0 |
| 29 | 1 00 | 19 | 0.85 | 10.0 | 0.70 | 4.6 |
| 30 | 1.00 | 19 | 0 84 | 9.8 | 6.74 | 5.9 |
| 31 | | | 0.82 | 9 0 | | |

Daily Gauge Height and Discharge of Davis Creek at Drury's Ranche, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-chatge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.84 | 9.8 | ....... | ....... | 0.40 | 0.3 | 0.73 | 7.1 |
| 2 | 1.40 | 51.0 | ....... | ....... | 0.41 | 0.4 | 0.72 | 6.8 |
| 3 | 1.06 | 23.0 | ....... | ....... | 0.41 | 0.4 | 0.72 | 6.8 |
| 4 | 0.87 | 11.0 | ....... | ....... | 0.42 | 0.5 | 0.72 | 6.8 |
| 5 | ‡ | ....... | ....... | ....... | 0.42 | 0.5 | 0.72 | 6.8 |
| 6 | ....... | ....... | ....... | ....... | 0.45 | 0.8 | 0.71 | 6.4 |
| 7 | ....... | ....... | ....... | ....... | 0.65 | 4.9 | 0.70 | 6.1 |
| 8 | ....... | ....... | ....... | ....... | 0.64 | 4.5 | 0.70 | 6.1 |
| 9 | ....... | ....... | ....... | ....... | 0.60 | 3.4 | 0.69 | 5.8 |
| 10 | ....... | ....... | ....... | ....... | 0.56 | 2.8 | 0.67 | 5.1 |
| 11 | ....... | ....... | ....... | ....... | 0.50 | 1.4 | 0.65 | 4.5 |
| 12 | ....... | ....... | ....... | ....... | 0.47 | 1.0 | 0.63 | 4.0 |
| 13 | 0.54 | 1.2 | ....... | ....... | 0.48 | 1.0 | 0.62 | 3.8 |
| 14 | ....... | ....... | ....... | ....... | 0.50 | 1.4 | 0.61 | 3.5 |
| 15 | ....... | ....... | 0.54 | 1.1 | 0.54 | 2.0 | 0.61 | 3.5 |
| 16 | ....... | ....... | 0.53 | 1.2 | 0.54 | 2.0 | 0.60 | 3.2 |
| 17 | ....... | ....... | 0.50 | 1.0 | 0.54 | 1.9 | ....... | ....... |
| 18 | ....... | ....... | 0.49 | 0.9 | 0.84 | 12.9 | ....... | ....... |
| 19 | ....... | ....... | 0.48 | 0.9 | 0.90 | 15.0 | ....... | ....... |
| 20 | ....... | ....... | 0.48 | 0.9 | 0.78 | 9.1 | ....... | ....... |
| 21 | ....... | ....... | 0.45 | 0.6 | 0.70 | 6.1 | ....... | ....... |
| 22 | ....... | ....... | 0.45 | 0.6 | 0.76 | 8.4 | ....... | ....... |
| 23 | ....... | ....... | 0.45 | 0.6 | 0.75 | 8.0 | ....... | ....... |
| 24 | ....... | ....... | 0.44 | 0.6 | 0.75 | 8.0 | ....... | ....... |
| 25 | ....... | ....... | 0.42 | 0.4 | 0.84 | 12.0 | ....... | ....... |
| 26 | ....... | ....... | 0.42 | 0.4 | 0.84 | 12.0 | ....... | ....... |
| 27 | ....... | ....... | 0.42 | 0.4 | 0.80 | 10.0 | ....... | ....... |
| 28 | ....... | ....... | 0.42 | 0.4 | 0.75 | 8.0 | ....... | ....... |
| 29 | ....... | ....... | 0.42 | 0.4 | 0.75 | 8.0 | ....... | ....... |
| 30 | ....... | ....... | 0.42 | 0.4 | 0.74 | 7.5 | ....... | ....... |
| 31 | ....... | ....... | 0.40 | 0.3 | ....... | ....... | ....... | ....... |

† No gauge-height observations made until April 23. No observer.
‡ No gauge-height observations made between July 4 and August 15. Observer absent.

Monthly Discharge of Davis Creek at Drury's Ranche, Sask., for 1911.

(Drainage area, 45 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet |
| April (23-30) | 95.0 | 19.0 | 57.80 | 1.280 | 0.381 | 917 |
| May | 25.0 | 6.2 | 12.90 | 0.287 | 0.331 | 793 |
| June | 16.0 | 0.7 | 4.49 | 0.100 | 0.112 | 267 |
| July (1-4 and 13) | 51.0 | 1.2 | 19.20 | 0.427 | 0.079 | 190 |
| August (15-31) | 1.2 | 0.3 | 0.70 | 0.015 | 0.009 | 24 |
| September | 15.0 | 0.3 | 5.14 | 0.114 | 0.127 | 306 |
| October (1-16) | 7.1 | 3.2 | 5.36 | 0.119 | 0.071 | 171 |
| The period | ....... | ....... | ....... | ....... | 1.110 | 2668 |

Note.—No records for periods from July 5th to 12th and July 14th to 31st.

### Blacktail Coulee at Garissere's Ranche.

This station was established August 13, 1909, by H. R. Carscallen. It is located in N.W. ¼ Sec. 30, Tp. 6, Rge. 23, W. 3rd Mer., forty miles southeast of Maple Creek and one-quarter mile upstream from J. Garissere's house.

The channel is straight for 75 feet above and 200 feet below the station. Both banks are high and well wooded. The left bank has a gentle slope, but the right is quite steep. The bed of the stream is composed of rocks and gravel, allowing a quantity of water to be lost by seepage. The current is swift.

The gauge, which is a plain staff graduated to feet and hundredths, is securely fastened to a poplar post, sunk in the bed of the stream at the left bank and stayed. It is referred to bench-marks as follows:—(1) two spikes driven into a poplar tree on the right bank, 30 feet upstream, and marked "B.M." (elevation, 7.76 feet above gauge zero); (2) a spike in a stump on the right bank, 15 feet upstream, and marked "B.M." (elevation, 7.61 feet above gauge zero).

Discharge measurements are made during high water with a meter, and in low water a weir is used. The initial point of sounding is a stake driven into the left bank and marked "I.P."

Water is diverted for irrigation purposes by J. Garissere at a point about 150 yards below the station.

During 1911, the gauge was read by J. Garissere.

DISCHARGE MEASUREMENTS of Blacktail Coulee at Garissere's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 19 | G. H. Whyte | 6 0 | 1 81 | 0 453 | 1 28 | 0 820 |
| May 17 | do | 6 5 | 1 57 | 0 370 | 1 10 | 0 580* |
| June 14 | do | | | | 0 92 | 0 138* |
| July 12 | do | | | | 0 86 | Nil |
| Aug. 12 | do | | | | Dry | Nil |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Blacktail Coulee at Garissere's Ranche, Sask., for 1911.

| Day. | June. | | July. | | August. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 1 10 | 0 5 | Dry. | Nil. |
| 2 | | | 1 10 | 0 5 | " | " |
| 3 | | | 1 10 | 0 5 | " | " |
| 4 | | | 1 10 | 0 5 | " | " |
| 5 | | | 1 10 | 0 5 | " | " |
| 6 | | | 1 10 | 0 5 | " | " |
| 7 | | | 1 00 | 0 3 | " | " |
| 8 | | | 1 00 | 0 3 | " | " |
| 9 | | | 1 00 | 0.3 | " | " |
| 10 | | | 1.00 | 0 3 | " | " |
| 11 | | | 1 00 | 0 3 | " | " |
| 12 | | | 1 00 | 0 3 | " | " |
| 13 | | † | 1 00 | 0 3 | " | " |
| 14 | 1 10 | 0 5 | 0 90 | 0 1 | " | " |
| 15 | 1 10 | 0 5 | 0 90 | 0 1 | " | " |
| 16 | 1 10 | 0 5 | 0 90 | 0 1 | " | " |
| 17 | 1 10 | 0 5 | 0 90 | 0 1 | " | " |
| 18 | 1 10 | 0 5 | 0 90 | 0 1 | " | " |
| 19 | 1 00 | 0 4 | 0 80 | 0 | " | " |
| 20 | 1 00 | 0 4 | 0 80 | 0 | " | " |
| 21 | 1 00 | 0 4 | 0 80 | 0 | " | " |
| 22 | 1 00 | 0 4 | 0 80 | 0 | " | " |
| 23 | 1 00 | 0 4 | 0 80 | 0 | " | " |
| 24 | 1 10 | 0 5 | 0 80 | 0 | " | " |
| 25 | 1 10 | 0 5 | 0 80 | 0 | " | " |
| 26 | 1 20 | 0 7 | 0 60 | 0 | * " | " |
| 27 | 1 20 | 0 7 | 0 60 | 0 | | |
| 28 | 1 20 | 0 7 | 0 20 | 0 | | |
| 29 | 1 20 | 0 7 | 0 20 | 0 | | |
| 30 | 1 10 | 0.5 | 0.10 | 0 | | |
| 31 | | | 0 10 | 0 | | |

† Could not secure an observer before June 14th.
* No observations after this date. Probably a small flow in early part of September but dry during the rest of the Fall.

MONTHLY DISCHARGE of Blacktail Coulee at Garissere's Ranche, Sask., for 1911.

(Drainage area, 20 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet |
| June (14-30) | 0 7 | 0 4 | 0 520 | 0 026 | 0 016 | 18 |
| July | 0 5 | 0 0 | 0 181 | 0 009 | 0 010 | 11 |
| The period | .... | ... | ... | . | 026 | 29 |

## FAIRWELL CREEK AT BEWLEY'S RANCHE.

This station was established June 10, 1909, by H. R. Carscallen. It is located about eleven miles southeast of Belanger Post Office, at Bewley's ranche, on N.W. ¼ Sec. 30, Tp. 6, Rge. 24 W. 3rd Mer.

The channel is straight for 75 feet upstream, but curves slightly to the right for 50 feet downstream. Both banks are comparatively low, and will overflow at high stages of the stream. The banks are covered with brush above and below the station. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station, but is swift a short distance below.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post sunk in the bed of the stream at the left bank and securely stayed to the bank. It is referred to bench-marks as follows:—(1) the head of a spike driven into the pointed top of a willow stump about 50 feet southeast of the gauge, the stump blazed and marked "B.M." with red paint (elevation, 6.25 feet above the datum of the gauge); (2) the head of a spike surrounded by a circle of nail-heads in a notch cut in a large poplar tree 60 feet southeast of the gauge, the tree blazed and marked "B.M." with red paint (elevation, 5.08 feet above the datum of the gauge).

Discharge measurements are made by wading a short distance below the gauge. Owing to the low banks high-water measurements cannot be made. The initial point for soundings is a square stake driven close to the ground at the left bank and marked "I.P."

Within a mile upstream from the gauge, the stream is often perfectly dry, while at the gauge and a few miles below it, there is a continuous flow. This disappearance of the stream flow, which occurs for a distance of three or four miles, is due to the loose gravelly character of the stream bed. Beaver dams below the station have given some trouble.

There are a number of proposed irrigation schemes which will take their supply from this stream at points above the gauging station.

During 1911, the gauge was read by R. L. Bewley.

DISCHARGE MEASUREMENTS of Fairwell Creek at Bewley's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 19 | G. H. Whyte | 63 5 | 91 95 | 2 143 | 3 055 | 197 14 |
| May 17 | do | 28 5 | 18 73 | 2 243 | 2 300 | 42 01 |
| June 14 | do | 52 0 | 22 18 | 0 473 | 1 980 | 10 83 |
| July 12 | do | | | | 1 960 | 8 66 |
| Aug. 12 | do | 8 4 | 5 91 | 0 648 | 1 87 | 3 83 |
| Sept. 25 | do | 8 2 | 7 93 | 0 322 | 1 750 | 2 55 |
| Oct. 19 | do | 9 4 | 7.48 | 1 111 | 1 920 | 8 31 |

DAILY GAUGE HEIGHT AND DISCHARGE of Fairwell Creek at Bewley's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 2.30 | 42.0 | 2.20 | 30 | 1.98 | 11.0 |
| 2 | | | 2.17 | 27.0 | 2.12 | 22 | 1.98 | 11.0 |
| 3 | | | 2.23 | 34.0 | 2.12 | 22 | 1.98 | 11.0 |
| 4 | | | 2.10 | 20.0 | 2.11 | 21 | 1.98 | 11.0 |
| 5 | | | 2.15 | 25.0 | 2.14 | 24 | 1.98 | 11.0 |
| 6 | | | 2.09 | 19.0 | 2.11 | 21 | 1.98 | 11.0 |
| 7 | | | 1.96 | 9.6 | 2.10 | 20 | 1.98 | 11.0 |
| 8 | | | 2.00 | 12.0 | 2.10 | 20 | 1.98 | 11.0 |
| 9 | | | 2.82 | 140.0 | 2.06 | 17 | 1.98 | 11.0 |
| 10 | | | 4.37 | 512.0 | 2.06 | 17 | 1.98 | 11.0 |
| 11 | | | 3.94 | 409.0 | | x | 1.98 | 11.0 |
| 12 | | | 2.80 | 135.0 | | | 1.98 | 11.0 |
| 13 | | | 2.71 | 115.0 | | | 1.98 | 11.0 |
| 14 | | | 2.71 | 115.0 | | | 1.98 | 11.0 |
| 15 | | | 2.70 | 113.0 | | | 1.98 | 11.0 |
| 16 | | | 4.00 | 423.0 | | | | 11.0 |
| 17 | | | 3.62 | 332.0 | 2.30 | 42 | 1.99 | 11.0 |
| 18 | | | 3.09 | 205.0 | 2.23 | 34 | 1.99 | 11.0 |
| 19 | | | 3.00 | 183.0 | | x | 1.89 | 11.0 |
| 20 | 1.77 | 2.9 | 3.10 | 207.0 | | | 1.99 | 11.0 |
| 21 | 1.80 | 3.5 | 2.97 | 176.0 | | | 1.98 | 11.0 |
| 22 | 1.95 | 9.0 | 2.90 | 159.0 | | | 1.97 | 10.0 |
| 23 | 2.60 | 92.0 | 2.68 | 109.0 | | | 1.97 | 10.0 |
| 24 | 4.10 | 447.0 | 2.50 | 73.0 | | | 1.97 | 10.0 |
| 25 | 3.90 | 399.0 | 2.50 | 73.0 | | | 1.98 | 11.0 |
| 26 | 3.31 | 257.0 | 2.40 | 56.0 | | | 1.98 | 11.0 |
| 27 | 3.20 | 231.0 | 2.41 | 58.0 | | | 1.98 | 11.0 |
| 28 | 2.85 | 147.0 | 2.26 | 37.0 | | | 1.98 | 11.0 |
| 29 | 2.96 | 173.0 | 2.20 | 30.0 | | | 1.98 | 11.0 |
| 30 | 2.70 | 113.0 | 2.20 | 30.0 | | | 1.98 | 11.0 |
| 31 | 2.72 | 117.0 | | | | | | |

DAILY GAUGE HEIGHT AND DISCHARGE of Fairwell Creek at Bewley's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.98 | 11.0 | 1.83 | 4.4 | 1.76 | 2.7 | 1.75 | 2.5 |
| 2 | 1.98 | 11.0 | 1.82 | 4.1 | 1.77 | 2.9 | 1.76 | 2.7 |
| 3 | 1.98 | 11.0 | 1.83 | 4.4 | 1.78 | 3.1 | 1.78 | 3.1 |
| 4 | 1.98 | 11.0 | 1.83 | 4.4 | 1.79 | 3.3 | 1.94 | 8.6 |
| 5 | 1.98 | 11.0 | 1.84 | 4.7 | 1.80 | 3.5 | 1.95 | 9.0 |
| 6 | 1.99 | 11.0 | 1.85 | 5.0 | 1.83 | 4.4 | 1.96 | 9.6 |
| 7 | 1.99 | 11.0 | 1.85 | 5.0 | 1.82 | 4.1 | 1.96 | 9.6 |
| 8 | 1.99 | 11.0 | 1.85 | 5.0 | 1.77 | 2.9 | 1.96 | 9.6 |
| 9 | 1.98 | 11.0 | 1.84 | 4.7 | 1.77 | 2.9 | 1.96 | 9.6 |
| 10 | 1.97 | 10.0 | 1.84 | 4.7 | 1.75 | 2.5 | 1.96 | 9.6 |
| 11 | 1.96 | 9.6 | 1.83 | 4.4 | 1.74 | 2.3 | 1.96 | 9.6 |
| 12 | 1.96 | 9.6 | 1.82 | 4.1 | 1.75 | 2.5 | 1.96 | 9.6 |
| 13 | 1.95 | 9.0 | 1.81 | 3.8 | 1.75 | 2.5 | 1.94 | 8.6 |
| 14 | 1.95 | 9.0 | 1.81 | 3.8 | 1.76 | 2.7 | 1.93 | 8.1 |
| 15 | 1.94 | 8.6 | 1.80 | 3.5 | 1.76 | 2.7 | 1.94 | 8.6 |
| 16 | 1.94 | 8.6 | 1.81 | 3.8 | 1.77 | 2.9 | 1.94 | 8.6 |
| 17 | 1.94 | 8.6 | 1.81 | 3.8 | 1.78 | 3.1 | 1.95 | 9.0 |
| 18 | 1.93 | 8.1 | 1.79 | 3.3 | 1.79 | 3.3 | 1.95 | 9.0 |
| 19 | 1.93 | 8.1 | 1.79 | 3.3 | 1.80 | 3.5 | 1.94 | 8.6 |
| 20 | 1.92 | 7.7 | 1.79 | 3.3 | 1.80 | 3.5 | 1.94 | 8.6 |
| 21 | 1.92 | 7.7 | 1.78 | 3.1 | 1.79 | 3.3 | 1.94 | 8.6 |
| 22 | 1.91 | 7.2 | 1.78 | 3.1 | 1.78 | 3.1 | 1.94 | 8.6 |
| 23 | 1.90 | 6.8 | 1.77 | 2.9 | 1.77 | 2.9 | 1.94 | 8.6 |
| 24 | 1.89 | 6.4 | 1.77 | 2.9 | 1.76 | 2.7 | 1.95 | 9.0 |
| 25 | 1.88 | 6.1 | 1.78 | 3.1 | 1.75 | 2.5 | 1.97 | 10.0 |
| 26 | 1.87 | 5.7 | 1.78 | 3.1 | 1.74 | 2.3 | 1.96 | 9.6 |
| 27 | 1.87 | 5.7 | 1.77 | 2.9 | 1.75 | 2.5 | 1.97 | 10.0 |
| 28 | 1.86 | 5.4 | 1.77 | 2.9 | 1.75 | 2.5 | 1.97 | 10.0 |
| 29 | 1.85 | 5.0 | 1.76 | 2.7 | 1.75 | 2.5 | ... | ... |
| 30 | 1.84 | 4.7 | 1.75 | 2.5 | 1.75 | 2.5 | ... | ... |
| 31 | 1.84 | 4.7 | 1.75 | 2.5 | ... | ... | ... | ... |

x No observations between May 11 to 16 and May 19 to 31 owing to absence of observer.

MONTHLY DISCHARGE of Fairwell Creek at Bewley's Ranche, Sask., for 1911.

(Drainage area, 125 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (20-31) | 447.0 | 2.9 | 166.00 | 1.330 | 0.594 | 3951 |
| April | 512.0 | 9.5 | 129.00 | 1.030 | 1.150 | 7676 |
| May (1-10 and 17-18) | 42.0 | 17.0 | 24.20 | 0.194 | 0.087 | 576 |
| June | 11.0 | 10.0 | 10.90 | 0.087 | 0.097 | 649 |
| July | 11.0 | 4.7 | 8.43 | 0.067 | 0.077 | 518 |
| August | 5.0 | 2.5 | 3.72 | 0.030 | 0.035 | 229 |
| September | 4.4 | 2.3 | 2.94 | 0.024 | 0.027 | 175 |
| October (1-28) | 10.0 | 2.5 | 8.45 | 0.068 | 0.071 | 469 |
| The period | | | | | 2.138 | 14243 |

## ROSE CREEK AT EAST END.

This station was established on May 1, 1911, by G. H. Whyte. It is located on the N.E. ¼ Sec. 26, Tp. 7, Rge. 22, W. 3rd Mer., at East End post office.

The channel of the stream is straight for about 40 feet above and 75 feet below the station. The right bank is low and liable to overflow, but the left is high and not liable to overflow. The bed of the stream is composed of sand, which is clear of vegetation, but shifts slightly.

Discharge measurements are made during low water with a weir at a point 100 feet below the gauge, but, at high-water stages, with a current-meter by wading at the gauge. The initial point for soundings is a stake on the left bank.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to bench-marks as follows:—(1) a spike-head on the southwest corner of Mr. Rose's barn (elev., 7.67 above the zero of the gauge); (2) a spike-head on the final plug on the right bank and about four inches above ground (elev., 4.97 above the zero of the gauge).

During 1911, the gauge was read by B. E. Rose, postmaster at East End.

### Discharge Measurements of Rose Creek at East End, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 2 | G. H. Whyte | | | | 1 120 | 0.684* |
| June 3 | do | | | | 0 960 | 0 420* |
| July 5 | do | | | | 1 040 | 0 520* |
| July 26 | do | | | | 0 770 | 0 857* |
| Aug. 31 | do | | | | 0 765 | 0 536* |
| Oct. 4 | do | | | | 1 130 | 0 714* |

* Weir measurement.

### Daily Gauge Height and Discharge of Rose Creek at East End, P.O. Sask., for 1911.

| Day. | May. | | June. | | July. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1 00 | 0 45 | 0 99 | 0 43 | 1 22 | 0.90 |
| 2 | 1 12 | 0 69 | 0 98 | 0 41 | 1 24 | 0.94 |
| 3 | 1 09 | 0 63 | 1 00 | 0 45 | 1 05 | 0 55 |
| 4 | 1 07 | 0 59 | 0 98 | 0 41 | 1 04 | 0.53 |
| 5 | 1 04 | 0.53 | 1 20 | 0 86 | 1 04 | 0.53 |
| 6 | 1 05 | 0 55 | 1 06 | 0 57 | 1.04 | 0.53 |
| 7 | 1 05 | 0 55 | 1 04 | 0 53 | 0 95 | 0.35 |
| 8 | 1 05 | 0 55 | 1 05 | 0 55 | 0 94 | 0.33 |
| 9 | 1 05 | 0.55 | 1 00 | 0 45 | 1.01 | 0.47 |
| 10 | 1 06 | 0 57 | 0 95 | 0 35 | 1.00 | 0.45 |
| 11 | 1 11 | 0 67 | 0 93 | 0 31 | 0 93 | 0.31 |
| 12 | 1 06 | 0 57 | 0 90 | 0 26 | 0 90 | 0 26 |
| 13 | 1 05 | 0 55 | 0 90 | 0 26 | 0 86 | 0.19 |
| 14 | 1 26 | 0 98 | 0 90 | 0 26 | 0.85 | 0.17 |
| 15 | 1 20 | 0.86 | 0.90 | 0 26 | 0.83 | 0.14 |
| 16 | 1 33 | 1 13 | 0 85 | 0 17 | 0 82 | 0.13 |
| 17 | 1 23 | 0 92 | 0 85 | 0 17 | 0 80 | 0 10 |
| 18 | 1 15 | 0 75 | 0 85 | 0 17 | 0 80 | 0 10 |
| 19 | 1 14 | 0 73 | 0 95 | 0 35 | 0.85 | 0.17 |
| 20 | 1 15 | 0 75 | 1 45 | 1 38 | 0 85 | 0.17 |
| 21 | 1 10 | 0 65 | 1 33 | 1 13 | 0 80 | 0.10 |
| 22 | 1 05 | 0 55 | 1 14 | 0 73 | 0 75 | 0 04 |
| 23 | 1 24 | 0 94 | 1 00 | 0 45 | 0 78 | 0.08 |
| 24 | 1 15 | 0 75 | 1 25 | 0 96 | 0 75 | 0.04 |
| 25 | 1 23 | 0 92 | 1 17 | 0 79 | 0.73 | 0.02 |
| 26 | 1 20 | 0 86 | 1 15 | 0 75 | 0 75 | 0 04 |
| 27 | 1 15 | 0 75 | 1 00 | 0 45 | 0 75 | 0 04 |
| 28 | 1 10 | 0 65 | 1 12 | 0 69 | 0 75 | 0.04 |
| 29 | 1 09 | 0 63 | 1.04 | 0 53 | 0 75 | 0.04 |
| 30 | 1 05 | 0 55 | 1 25 | 0 96 | 0 76 | 0 05 |
| 31 | 1 01 | 0 47 | .... | ..... | 0.75 | 0.04 |

DAILY GAUGE HEIGHT AND DISCHARGE of Rose Creek at East End, P.O. Sask., for 1911.—Con.

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.75 | 0.04 | 0.74 | 0.03 | 0.95 | 0.35 | 0.95 | 0.35 |
| 2 | 0.75 | 0.04 | 0.75 | 0.04 | 1.10 | 0.65 | 0.95 | 0.35 |
| 3 | 0.75 | 0.04 | 0.74 | 0.03 | 1.21 | 0.88 | 0.95 | 0.35 |
| 4 | 0.75 | 0.04 | 1.01 | 0.47 | 1.10 | 0.65 | 0.95 | 0.35 |
| 5 | 0.81 | 0.11 | x | | 1.05 | 0.55 | 0.95 | 0.35 |
| 6 | 0.87 | 0.21 | x | | 1.00 | 0.45 | 0.96 | 0.37 |
| 7 | 1.02 | 0.49 | 1.25 | 0.96 | 0.98 | 0.41 | 0.96 | 0.37 |
| 8 | 1.00 | 0.45 | 1.15 | 0.75 | 0.95 | 0.35 | 0.90 | 0.26 |
| 9 | 0.90 | 0.26 | 1.05 | 0.55 | 0.95 | 0.35 | 0.91 | 0.28 |
| 10 | 0.85 | 0.17 | 0.95 | 0.35 | 0.95 | 0.35 | 0.90 | 0.26 |
| 11 | 0.89 | 0.23 | 0.94 | 0.33 | 0.93 | 0.31 | 0.91 | 0.28 |
| 12 | 0.80 | 0.10 | 0.85 | 0.17 | 0.94 | 0.33 | 0.85 | 0.17 |
| 13 | 0.75 | 0.04 | 0.95 | 0.35 | 0.94 | 0.33 | 0.85 | 0.17 |
| 14 | 0.75 | 0.04 | 0.95 | 0.35 | 0.94 | 0.33 | 0.88 | 0.22 |
| 15 | 0.85 | 0.17 | 0.90 | 0.26 | 0.94 | 0.33 | 0.85 | 0.17 |
| 16 | 0.75 | 0.04 | 0.85 | 0.17 | 0.93 | 0.31 | ... | ... |
| 17 | 0.76 | 0.05 | 0.85 | 0.17 | 0.93 | 0.31 | ... | ... |
| 18 | 0.75 | 0.04 | 0.95 | 0.35 | 0.94 | 0.33 | ... | ... |
| 19 | 0.75 | 0.04 | 0.92 | 0.30 | 0.98 | 0.41 | ... | ... |
| 20 | 0.74 | 0.03 | 0.90 | 0.26 | 1.00 | 0.45 | ... | ... |
| 21 | 0.75 | 0.04 | 0.86 | 0.19 | 0.99 | 0.43 | ... | ... |
| 22 | 0.75 | 0.04 | 0.98 | 0.41 | 1.05 | 0.55 | ... | ... |
| 23 | 0.75 | 0.04 | 1.04 | 0.53 | 1.00 | 0.45 | ... | ... |
| 24 | 0.75 | 0.04 | 1.05 | 0.55 | 1.05 | 0.55 | ... | ... |
| 25 | 0.74 | 0.03 | 1.05 | 0.55 | 0.95 | 0.35 | ... | ... |
| 26 | 0.75 | 0.04 | 1.10 | 0.65 | 0.94 | 0.33 | ... | ... |
| 27 | 0.79 | 0.09 | 1.04 | 0.53 | 0.94 | 0.33 | ... | ... |
| 28 | 0.74 | 0.03 | 0.95 | 0.35 | 0.94 | 0.33 | ... | ... |
| 29 | 0.75 | 0.04 | 0.95 | 0.35 | 0.94 | 0.33 | ... | ... |
| 30 | 0.75 | 0.04 | 0.95 | 0.35 | 0.94 | 0.33 | ... | ... |
| 31 | 0.74 | 0.03 | ... | ... | 0.95 | 0.35 | ... | ... |

MONTHLY DISCHARGE of Rose Creek at East End, Sask., for 1911.

(Drainage area, 13 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| May | 1.13 | 0.45 | 0.69 | 0.053 | 0.061 | 42 |
| June | 1.38 | 0.17 | 0.53 | 0.041 | 0.046 | 32 |
| July | 0.94 | 0.02 | 0.25 | 0.019 | 0.022 | 15 |
| August | 0.49 | 0.03 | 0.10 | 0.008 | 0.009 | 6 |
| September (1-4 and 7-30)* | 0.96 | 0.03 | 0.37 | 0.028 | 0.029 | 21 |
| October | 0.88 | 0.31 | 0.41 | 0.032 | 0.037 | 25 |
| November...(1-15) | 0.37 | 0.17 | 0.29 | 0.022 | 0.012 | 9 |
| The period | | | | | 216 | 150 |

* High Water Sept. 5th and 6th. Discharge not available on these dates but would have been greater than the mean.

## Frank Cross Ditch near East End.

This station was established September 9, 1911, by G. R. Elliott on the irrigation ditch of Frank Cross, which diverts water from the north branch of Frenchman River on the N.W. ¼ Sec. 15, Tp. 7, Rge. 22, W. 3rd Mer.

The gauge is located on the N.W. ¼ Sec. 15, and about 130 feet from the intake of the ditch. It is a plain staff 4 in. x 1 in., graduated to feet and inches, and is on the left side of the sluice flume. The zero of the gauge (elev., 91.45) is referred to a nut on the northwest corner of a bridge at that point (assumed elev., 100.00).

The station is five feet from the end of the sluice flume of the ditch, which has a bottom width of 2.85 feet, with sides 1.8 feet in height.

As this station was established after the irrigation season was over, no gauge-height records were obtained during 1911.

## North Branch of Frenchman River at Cross's Ranche.

This station was established July 25, 1908, by F. T. Fletcher. It is located on N.E. ¼ Sec. 16, Tp. 7, Rge. 22, W. 3rd Mer., about two and one half miles from East End post office, and about forty-five miles southeast of Maple Creek, by trail.

The channel is straight for about 100 feet above and 400 feet below the station. Both banks are high and liable to overflow. The bed of the stream is sandy and may shift at high stages. The current is smooth and fairly swift.

The gauge is a plain staff graduated to feet and hundredths, placed vertically at the right bank, about one mile downstream from the intake of Frank Cross's irrigation ditch, and one hundred yards below his house. The zero of the gauge (elev., 91.28) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated 260 feet northeast of the gauge and about 1315 feet S. 5°36′ W. from the northeast corner of Sec. 16, Tp. 7, Rge. 22, W. 3rd Mer.

Discharge measurements are made at or near the gauge by wading. The initial point for soundings is a square hardwood plug driven into the ground on the right bank of the stream and marked "B.M." with white paint.

Irrigation ditches owned by F. Cross, H. Cross and W. F. McNicol take their supply from the North Branch of Frenchman River at points above this station. A small quantity of water was diverted during 1911.

During 1911, the gauge was read by Frank Cross.

### Discharge Measurements of North Branch of Frenchman River at Cross's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 10 | G. H. Whyte. | 38 00 | 89 00 | 2 329 | 3 285 | 207 32 |
| April 18 | do | 14 40 | 12 49 | 1 794 | 0 780 | 22 40 |
| May 16 | do | 13 60 | 13 93 | 1 712 | 0 870 | 23.85 |
| June 13 | do | 10 70 | 5 36 | 1 076 | 0 460 | 5.77 |
| July 11 | do | 10 30 | 5.54 | 1 231 | 0 515 | 6 82 |
| Aug. 11 | do | 12 30 | 5 74 | 1 132 | 0 495 | 6 51 |
| Aug. 31 | G. R. Elliott | 13 25 | 4.87 | 0 786 | 0 350 | 3 83 |
| Sept. 6 | G. H. Whyte. | 13 50 | 20 44 | 2 307 | 1 255 | 49.37 |
| Oct. 16 | do | 11 00 | 6 39 | 1.058 | 0 540 | 6 76 |

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Frenchman River at Cross's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ...... | ...... | 0.7 | 15.0 | 0.45 | 5.8 | 0.7 | 15.0 |
| 2 | ...... | ...... | 0.7 | 15.0 | 0.45 | 5.8 | 0.78 | 19.0 |
| 3 | ...... | ...... | 0.7 | 15.0 | 0.45 | 5.8 | 0.58 | 9.8 |
| 4 | ...... | ...... | 0.7 | 15.0 | 0.42 | 5.0 | 0.55 | 8.8 |
| 5 | ...... | ...... | 0.7 | 15.0 | 0.55 | 8.8 | 0.57 | 9.4 |
| 6 | ...... | ...... | 0.6 | 10.5 | 0.50 | 7.0 | 0.55 | 8.8 |
| 7 | ...... | ...... | 0.6 | 10.5 | 0.53 | 8.0 | 0.55 | 8.8 |
| 8 | ...... | ...... | 0.6 | 10.5 | 0.53 | 8.0 | 0.55 | 8.8 |
| 9 | ...... | † | 0.6 | 10.5 | 0.53 | 8.0 | 0.60 | 10.5 |
| 10 | 3.5 | 225.0 | 0.6 | 10.5 | 0.53 | 8.0 | 0.60 | 10.5 |
| 11 | 2.2 | 121.0 | 0.6 | 10.5 | 0.50 | 7.0 | 0.55 | 8.8 |
| 12 | 1.9 | 97.0 | 0.6 | 10.5 | 0.50 | 7.0 | 0.50 | 7.0 |
| 13 | 1.7 | 81.0 | 0.6 | 10.5 | 0.50 | 7.0 | 0.50 | 7.0 |
| 14 | 1.6 | 73.0 | 0.7 | 15.0 | 0.48 | 6.5 | 0.48 | 6.5 |
| 15 | 1.0 | 31.0 | 0.7 | 15.0 | 0.43 | 5.2 | 0.48 | 6.5 |
| 16 | 1.2 | 45.0 | 0.75 | 17.5 | 0.40 | 4.5 | 0.47 | 6.2 |
| 17 | 1.3 | 52.0 | 0.70 | 15.0 | 0.40 | 4.5 | 0.47 | 6.2 |
| 18 | 1.0 | 31.0 | 0.70 | 15.0 | 0.40 | 4.5 | 0.47 | 6.2 |
| 19 | 1.0 | 31.0 | 0.65 | 12.8 | 0.40 | 4.5 | 0.50 | 7.0 |
| 20 | 1.0 | 31.0 | 0.65 | 12.8 | 0.48 | 6.5 | 0.50 | 7.0 |
| 21 | 0.9 | 25.0 | 0.63 | 11.8 | 0.52 | 7.7 | 0.50 | 7.0 |
| 22 | 1.0 | 31.0 | 0.63 | 11.8 | 0.53 | 8.0 | 0.50 | 7.0 |
| 23 | 0.7 | 15.0 | 0.75 | 17.5 | 0.48 | 6.5 | 0.50 | 7.0 |
| 24 | 0.7 | 15.0 | 0.67 | 13.6 | 0.40 | 4.5 | 0.48 | 6.5 |
| 25 | 0.7 | 15.0 | 0.67 | 13.6 | 0.40 | 4.5 | 0.47 | 6.2 |
| 26 | 0.7 | 15.0 | 0.70 | 15.0 | 0.70 | 15.0 | 0.45 | 5.8 |
| 27 | 0.7 | 15.0 | 0.70 | 15.0 | 0.52 | 7.7 | 0.45 | 5.8 |
| 28 | 0.7 | 15.0 | 0.65 | 12.8 | 0.50 | 7.0 | 0.43 | 5.2 |
| 29 | 0.7 | 15.0 | 0.65 | 12.8 | 0.50 | 7.0 | 0.43 | 5.2 |
| 30 | 0.7 | 15.0 | 0.65 | 12.8 | 0.70 | 15.0 | 0.48 | 6.5 |
| 31 | ..... | ..... | 0.60 | 10.5 | ... | ..... | 0.48 | 6.5 |

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Frenchman River at Cross's Ranche, Sask., for 1911.—Continued.

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.47 | 6.2 | 0.46 | 6.0 | 0.57 | 9.4 | 0.85 | ‡ |
| 2 | 0.47 | 6.2 | 0.46 | 6.0 | 0.67 | 13.6 | 0.84 | ‡ |
| 3 | 0.47 | 6.2 | 0.45 | 5.8 | 0.71 | 15.5 | 0.86 | ‡ |
| 4 | 0.47 | 6.2 | 0.72 | 16.0 | 0.67 | 13.6 | 0.90 | ‡ |
| 5 | 0.54 | 8.4 | 0.77 | 18.5 | 0.58 | 9.8 | 0.84 | ‡ |
| 6 | 0.54 | 8.4 | 1.25 | 48.0 | 0.57 | 9.4 | 0.90 | ‡ |
| 7 | 0.55 | 8.8 | 0.75 | 17.5 | 0.55 | 8.8 | 0.98 | ‡ |
| 8 | 0.62 | 11.4 | 0.57 | 9.4 | 0.54 | 8.4 | 1.01 | ‡ |
| 9 | 0.56 | 9.1 | 0.52 | 7.7 | 0.53 | 8.0 | 1.04 | ‡ |
| 10 | 0.52 | 7.7 | 0.51 | 7.4 | 0.52 | 7.7 | 1.03 | ‡ |
| 11 | 0.50 | 7.0 | 0.49 | 6.8 | 0.53 | 8.0 | 1.23 | ‡ |
| 12 | 0.48 | 6.5 | 0.47 | 6.2 | 0.54 | 8.4 | 1.25 | ‡ |
| 13 | 0.45 | 5.8 | 0.53 | 8.0 | 0.54 | 8.4 | 1.35 | ‡ |
| 14 | 0.44 | 5.5 | 0.52 | 7.7 | 0.55 | 8.8 | 1.54 | ‡ |
| 15 | 0.49 | 6.8 | 0.50 | 7.0 | 0.55 | 8.8 | 1.55 | ‡ |
| 16 | 0.48 | 6.5 | 0.50 | 7.0 | 0.54 | 8.4 | *a* | .... |
| 17 | 0.46 | 6.0 | 0.55 | 8.8 | 0.54 | 8.4 | .... | .... |
| 18 | 0.46 | 6.0 | 0.56 | 9.1 | 0.58 | 9.8 | .... | .... |
| 19 | 0.45 | 5.8 | 0.55 | 8.8 | 0.62 | 11.4 | .... | .... |
| 20 | 0.45 | 5.8 | 0.53 | 8.0 | 0.60 | 10.5 | .... | .... |
| 21 | 0.45 | 5.8 | 0.52 | 7.7 | 0.60 | 10.5 | .... | .... |
| 22 | 0.45 | 5.8 | 0.60 | 10.5 | 0.58 | 9.8 | .... | .... |
| 23 | 0.48 | 6.5 | 0.61 | 11.0 | 0.61 | 11.0 | .... | .... |
| 24 | 0.48 | 6.5 | 0.62 | 11.4 | 0.65 | 12.8 | .... | .... |
| 25 | 0.45 | 5.8 | 0.62 | 11.4 | 0.73 | 16.5 | .... | .... |
| 26 | 0.54 | 8.4 | 0.63 | 11.8 | 0.74 | 17.0 | .... | .... |
| 27 | 0.53 | 8.0 | 0.60 | 10.5 | 1.02 | 32.0 | .... | .... |
| 28 | 0.48 | 6.5 | 0.59 | 10.2 | 0.95 | 28.0 | .... | .... |
| 29 | 0.47 | 6.2 | 0.58 | 9.8 | 0.93 | 27.0 | .... | .... |
| 30 | 0.46 | 6.0 | 0.57 | 9.4 | 0.90 | 25.0 | | |
| 31 | 0.46 | 6.0 | | | 0.84 | | | |

† No observations previous to April 10.
‡ Ice in stream not sufficient data to compute daily discharge.

MONTHLY DISCHARGE of North Branch of Frenchman River at Cross's Ranche, Sask., for 1911.

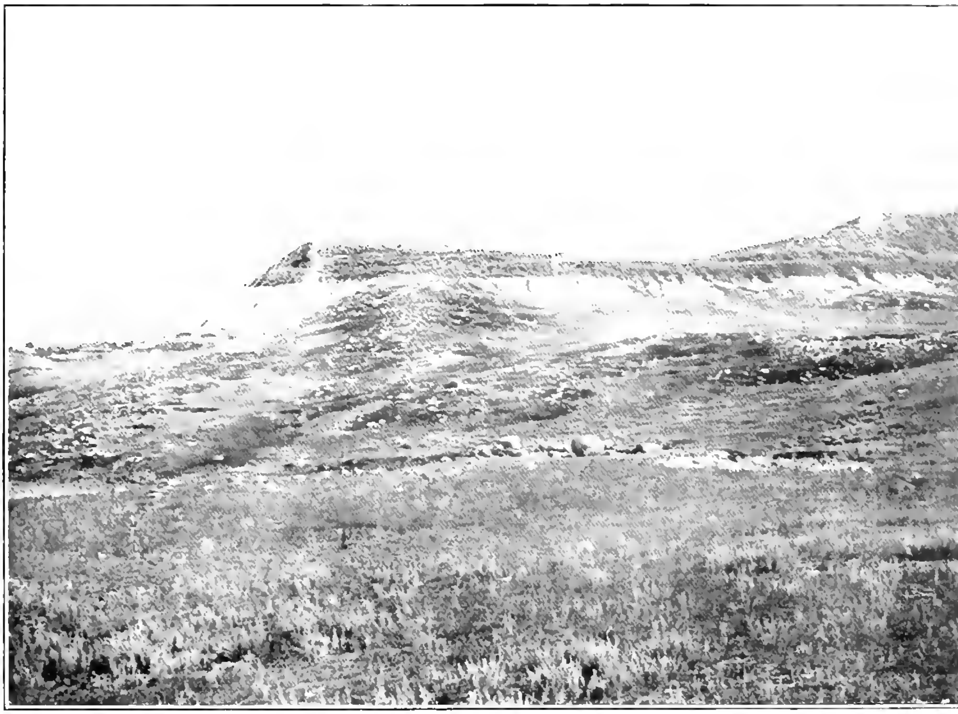
(Drainage area, 53 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (10-30) | 225.0 | 15.0 | 47.30 | 0.892 | 0.696 | 1973 |
| May | 17.5 | 10.5 | 13.20 | 0.249 | 0.287 | 812 |
| June | 15.0 | 4.5 | 7.01 | 0.132 | 0.147 | 417 |
| July | 19.0 | 5.2 | 7.95 | 0.150 | 0.173 | 489 |
| August | 11.4 | 5.5 | 6.83 | 0.129 | 0.149 | 420 |
| September | 48.0 | 5.8 | 10.80 | 0.204 | 0.228 | 643 |
| October | 32.0 | 7.7 | 13.40 | 0.253 | 0.292 | 824 |
| The period | | | | | 1.972 | 5578 |

## ENRIGHT AND STRONG'S DITCH.

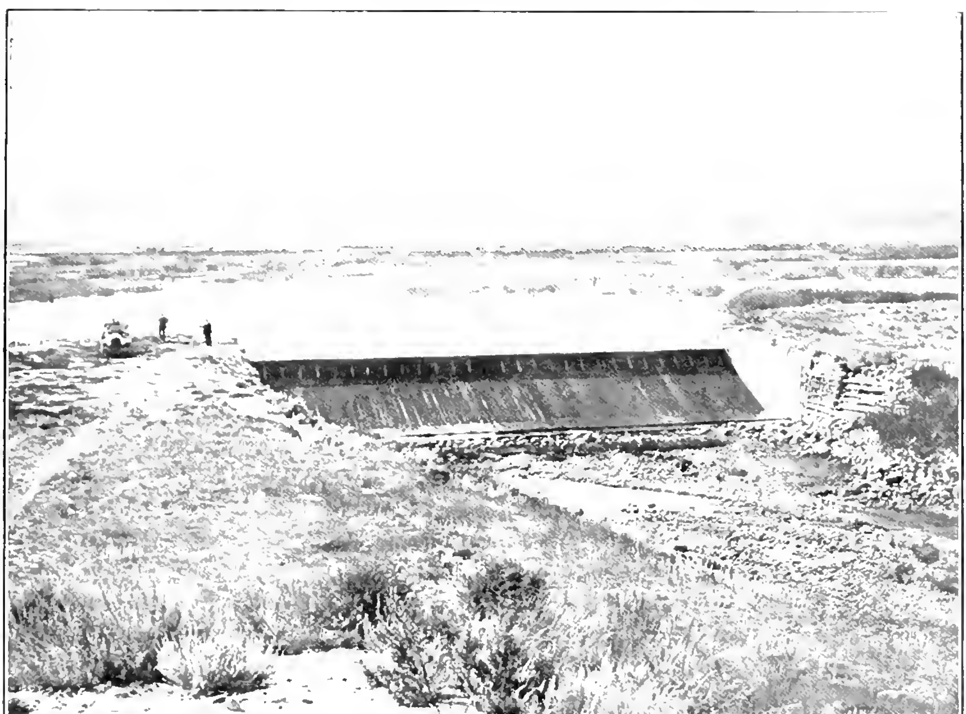
This station was established April 17, 1911, by G. H. Whyte, to replace the station on Sec. 36, Tp. 6, Rge. 22, W. 3rd Mer. The new station, which is located on N.E. ¼ sec. 25, Tp. 6, Rge. 22, W. 3rd Mer., is three-quarters of a mile above the old station and about half a mile below the head-gate of the ditch.

PLATE No. 28.



White Clay from which Frenchman River gets its local name "Whitemud." Taken by R. J. Burley.

PLATE No. 29.



Enright and Strong's Dam in Frenchman River. Taken by R. J. Burley.

Discharge measurements are made at the rod by wading, or from the old bridge station (for description see previous reports). The initial point for soundings at the station is a plug on the left bank, 23 feet from the rod.

The ditch is straight for about 250 feet above and 100 feet below the station. The current is rather sluggish, and during a greater part of the season, vegetation in the ditch causes considerable trouble in making discharge measurements.

The gauge, which is a plain staff graduated to feet and hundredths, is on a post at the right side of the ditch. It is referred to bench marks as follows:—(1) a spike on the initial post, which is about six inches above ground, on the left bank of the ditch (elevation 5.49 feet above the datum of the gauge); (2) the top of a plug, about four inches above ground, on the top of the right bank and about fifty feet downstream from the gauge (elevation 7.52 feet above the datum of the gauge).

During 1911, the gauge was read by J. C. Strong.

DISCHARGE MEASUREMENTS of Enright & Strong's Ditch near East End, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 17 | G. H. Whyte | | | | | Nil. |
| May 15 | do | 14.3 | 14.70 | 0.857 | 1.29 | 12.60 |
| June 5 | do | 14.0 | 12.49 | 0.817 | 1.16 | 10.20 |
| June 12 | do | 16.0 | 18.74 | 1.116 | 1.49 | 20.93 |
| July 5 | do | 12.5 | 7.98 | 0.494 | 0.95 | 3.95 |
| July 10 | do | 10.6 | 5.96 | 0.490 | 0.70 | 2.92 |
| July 27 | do | 16.0 | 19.66 | 0.210 | 0.92 | 4.14 |
| Aug. 3 | do | 14.0 | 10.40 | 0.460 | 1.16 | 4.79 |
| Aug. 31 | do | 11.7 | 7.78 | 0.848 | 0.91 | 6.60 |
| Oct. 14 | do | | | | | Nil. |

DAILY GAUGE HEIGHT AND DISCHARGE of Enright & Strong's Ditch near East End, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 3.8 | 0.90 | 6.4 |
| 2 | | | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.01 | 3.4 | 0.95 | 7.2 |
| 3 | | | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.16 | 4.8 | 0.92 | 6.7 |
| 4 | | | | | 1.00 | 6.6 | 0.90 | 5.1 | 1.01 | 3.3 | 1.00 | 8.2 |
| 5 | | | | | 1.16 | 9.6 | 0.95 | 5.8 | 1.02 | 3.5 | 0.70 | 3.8 |
| 6 | | | | | 1.00 | 6.6 | 0.90 | 5.1 | 1.03 | 3.7 | 0.72 | 4.0 |
| 7 | | | | | 1.00 | 6.6 | 0.90 | 5.1 | 1.04 | 4.0 | 0.50 | 2.1 |
| 8 | | | | | 1.00 | 6.6 | 0.91 | 5.2 | 1.03 | 4.1 | ** | |
| 9 | | | | | 1.00 | 6.6 | 0.90 | 5.1 | 1.20 | 6.5 | | |
| 10 | | | 0.80 | 3.9 | 0.50 | 1.5 | 0.70 | 2.9 | 1.20 | 6.7 | | |
| 11 | | | 0.90 | 5.1 | 0.30 | 0.1 | 0.90 | 5.0 | 1.24 | 7.7 | | |
| 12 | | | 0.90 | 5.1 | 1.49 | 21.0 | 0.90 | 4.9 | 1.20 | 7.2 | | |
| 13 | | | 1.00 | 6.6 | 0.90 | 5.1 | 0.90 | 4.9 | 1.22 | 7.9 | | |
| 14 | | | 1.00 | 6.6 | 1.00 | 6.6 | 0.91 | 4.8 | 1.00 | 4.7 | | |
| 15 | | | 1.29 | 13.2 | 1.00 | 6.6 | 1.00 | 6.1 | 0.90 | 3.7 | | |
| 16 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.00 | 6.1 | 0.75 | 2.4 | | |
| 17 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 6.1 | 1.00 | 5.1 | | |
| 18 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 6.2 | 1.02 | 5.7 | | |
| 19 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.03 | 6.3 | 1.00 | 5.6 | | |
| 20 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 6.1 | 1.02 | 6.1 | | |
| 21 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 6.0 | 1.01 | 6.1 | | |
| 22 | *0.70 | 2.9 | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 5.9 | 1.03 | 6.6 | | |
| 23 | 0.60 | 2.1 | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 5.5 | 1.02 | 6.7 | | |
| 24 | 0.60 | 2.1 | 1.00 | 6.6 | 1.00 | 6.6 | 1.04 | 6.0 | 1.02 | 6.9 | | |
| 25 | 0.60 | 2.1 | 1.00 | 6.6 | 1.00 | 6.6 | 1.03 | 5.7 | 1.00 | 6.8 | | |
| 26 | 0.60 | 2.1 | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 5.5 | 1.02 | 7.4 | | |
| 27 | 0.60 | 2.1 | 1.00 | 6.6 | 1.00 | 6.6 | 0.92 | 4.1 | 1.00 | 7.3 | | |
| 28 | ‡ | | 1.00 | 6.6 | 1.00 | 6.6 | 1.02 | 5.1 | 1.00 | 7.5 | | |
| 29 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.03 | 4.9 | 1.02 | 8.1 | | |
| 30 | | | 1.00 | 6.6 | 1.00 | 6.6 | 1.04 | 4.6 | 1.04 | 8.7 | | |
| 31 | | | 1.00 | 6.6 | | | 1.02 | 4.0 | 0.91 | 6.6 | | |

* Water turned on.
‡ Water shut off.
** Closed for season.

MONTHLY DISCHARGE of Enright & Strong's Ditch near East End, Sask., for 1911.

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (22-27) | 2.9 | 2.1 | 2.23 | | | 26 |
| May (20-31) | 13.2 | 3.9 | 6.64 | | | 290 |
| June | 21.0 | 0.4 | 6.75 | | | 402 |
| July | 6.6 | 2.9 | 5.44 | | | 334 |
| August | 8.7 | 2.4 | 5.76 | | | 354 |
| September (1-7) | 8.2 | 2.1 | 5.49 | | | 76 |
| The period | | | | | | 1482 |

## FRENCHMAN RIVER AT ENRIGHT AND STRONG'S RANCHE.

This station was established July 31, 1908, by F. T. Fletcher. It is located at the Enright and Strong highway bridge on the N.E. ¼ Sec. 31, Tp. 6, Rge. 21, W. 3rd Mer. It is about eight miles south of East End post office and a mile above the East End police detachment. Three miles above the station are the dam and head-gates of Messrs. Enright and Strong's ditch, and hence the discharge of the stream at the station does not include that of the ditch and the latter must be added in order to obtain the total flow of the Frenchman River. The bridge is a single-span, wooden structure set upon timber rock-filled abutments.

The channel is straight for 300 feet above and 600 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of sand and gravel. The current is sluggish.

The gauge, which is of the standard chain type, is fixed to the floor of the east end of the upstream side of the bridge. The length of chain from the marker to the bottom of the weight is 16.80 feet. The zero of the gauge (elev., 85.54) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated 240 feet N 11° E from the gauge. This gauge reads one foot higher than the staff-gauge used during previous years and the early part of 1911.

Discharge measurements are made from the lower side of the bridge during high-water stages, and at a wading section a short distance upstream during low-water stages. The initial point for soundings is the inner face of the left abutment. The bridge is not quite at right angles to the direction of the current.

During 1911, the gauge was read twice each day by J. C. Strong. All gauge-heights for 1911 have been reduced to the datum of the old staff-gauge, so that they can be compared directly with records of previous years.

DISCHARGE MEASUREMENTS of Frenchman River at Enright & Strong's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 13 | G. H. Whyte | 38.0 | 179.00 | 2.603 | 4.520 | 465.95 |
| April 17 | do | 38.0 | 204.45 | 2.723 | 5.155 | 556.83 |
| April 17 | do | 38.0 | 239.90 | 3.933 | 6.280 | 943.67 |
| May 3 | do | 40.0 | 38.78 | 2.223 | 2.360 | 86.21 |
| June 5 | do | 36.0 | 41.50 | 0.600 | 1.550 | 24.89 |
| July 5 | do | 38.0 | 60.99 | 0.709 | 1.900 | 49.36 |
| July 10 | do | 37.5 | 51.87 | 0.598 | 1.660 | 31.04 |
| July 27 | do | 34.0 | 38.85 | 0.221 | 1.320 | 8.59 |
| Aug. 3 | do | 14.1 | 4.77 | 1.180 | 1.270 | 5.64 |
| Aug. 31 | do | 13.5 | 4.00 | 1.072 | 1.230 | 4.31 |
| Oct. 14 | do | 38.6 | 38.51 | 0.743 | 2.530 | 29.26 |

DAILY GAUGE HEIGHT AND DISCHARGE of Frenchman River at Enright & Strong's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height | Discharge |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 4 60 | 4 85 | 2 50 | 102 | 2 00 | 57 | 1 85 | 45 |
| 2 | 4 40 | 4 39 | 2 40 | 112 | 2 05 | 62 | 1 95 | 53 |
| 3 | 4 40 | 4 39 | 2 45 | 98 | 2 10 | 66 | 1 95 | 53 |
| 4 | 3 90 | 3 36 | 2 35 | 88 | 1 90 | 49 | 2 05 | 62 |
| 5 | 3 70 | 3 00 | 2 45 | 98 | 2 00 | 57 | 2 05 | 62 |
| 6 | 3 20 | 2 23 | 2.40 | 93 | 1 90 | 49 | 1 95 | 53 |
| 7 | 3 30 | 2 38 | 2 30 | 84 | 1 90 | 49 | 2 00 | 57 |
| 8 | 2 70 | 1 57 | 2 05 | 62 | 1 85 | 45 | 1 85 | 45 |
| 9 | 2 70 | 1 57 | 1 70 | 34 | 1 80 | 41 | 1 72 | 35 |
| 10 | 6 50 | 9 04 | 1 80 | 41 | 2 00 | 51 | 1 62 | 28 |
| 11 | 8 40 | 18 70 | 8 30 | 84 | 2 00 | 57 | 1 61 | 28 |
| 12 | 6 50 | 11 26 | 2 30 | 84 | 1 90 | 49 | 1 62 | 28 |
| 13 | 4 70 | 5 16 | 2 40 | 93 | 1 75 | 38 | 1 62 | 28 |
| 14 | 4 00 | 3 44 | 2 30 | 84 | 1 55 | 24 | 1 63 | 29 |
| 15 | 3 80 | 2 95 | 2 30 | 84 | 1 65 | 30 | 1 62 | 28 |
| 16 | 2 80 | 1 44 | 2 40 | 93 | 1 60 | 27 | 1 59 | 26 |
| 17 | 5 74 | 7 38 | 2 40 | 93 | 1 90 | 53 | 1 54 | 23 |
| 18 | 5 75 | 7 42 | 2 30 | 84 | 1 75 | 38 | 1 53 | 22 |
| 19 | 4 45 | 3 88 | 2 25 | 80 | 1 65 | 30 | 1 52 | 21 |
| 20 | 4 10 | 3 19 | 2 30 | 84 | 1 75 | 38 | 1 53 | 22 |
| 21 | 4 05 | 3 10 | 2 20 | 75 | 2 55 | 107 | 1 52 | 21 |
| 22 | 3 90 | 2 84 | 2 15 | 70 | 1 80 | 41 | 1 52 | 21 |
| 23 | 3 70 | 2 51 | 2 10 | 66 | 1 75 | 38 | 1 53 | 22 |
| 24 | 3 30 | 1 94 | 2 20 | 75 | 1 90 | 53 | 1.53 | 22 |
| 25 | 3 10 | 1 68 | 2 20 | 75 | 1 80 | 41 | 1 50 | 20 |
| 26 | 3 00 | 1 56 | 2 10 | 66 | 1 70 | 34 | 1 48 | 19 |
| 27 | 2 90 | 1 44 | 2 10 | 66 | 1 75 | 38 | 1 49 | 19 |
| 28 | 2 75 | 1 28 | 2 10 | 66 | 1 75 | 38 | 1 42 | 14 |
| 29 | 2 65 | 1 17 | 2.00 | 57 | 1 75 | 38 | 1 49 | 19 |
| 30 | 2 45 | 0 98 | 2 10 | 66 | 1 90 | 49 | 1 50 | 20 |
| 31 | .... | ... | 2 10 | 66 | .... | ... | 1 50 | 20 |

Daily Gauge Height and Discharge of Frenchman River at Enright & Strong's Ranche, Sask., for 1911.—*Continued.*

| Day. | August. Gauge Height. | August. Discharge. | September. Gauge Height. | September. Discharge | October. Gauge Height. | October. Discharge. | November. Gauge Height. | November. Discharge. |
|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.47 | 18 | 1.31 | 7.6 | 2.21 | 9 | 1.92 | ...... |
| 2 | 1.44 | 16 | 1.26 | 5.0 | 2.31 | 16 | 1.68 | ...... |
| 3 | 1.39 | 12 | 1.25 | 4.5 | 2.35 | 18 | 1.62 | ...... |
| 4 | 1.41 | 11 | 1.26 | 5.0 | 2.46 | 25 | 1.60 | ...... |
| 5 | 1.50 | 20 | 1.90 | 49.0 | 2.52 | 28 | 1.52 | ...... |
| 6 | 1.48 | 19 | 2.00 | 57.0 | 2.51 | 27 | 1.82 | ...... |
| 7 | 1.46 | 17 | 1.70 | 34.0 | 2.54 | 30 | 2.25 | ...... |
| 8 | 1.46 | 17 | 1.48 | 19.0 | 2.62 | 36 | ...... | ...... |
| 9 | 1.42 | 14 | 1.45 | 16.0 | 2.62 | 36 | ...... | ...... |
| 10 | 1.45 | 16 | 1.42 | 14.0 | 2.59 | 32 | ...... | ...... |
| 11 | 1.50 | 20 | 1.42 | 14.0 | 2.62 | 36 | ...... | ...... |
| 12 | 1.42 | 19 | 1.40 | 13.0 | 2.61 | 35 | ...... | ...... |
| 13 | 1.46 | 17 | 1.36 | 11.0 | 2.62 | 36 | ...... | ...... |
| 14 | 1.44 | 16 | 1.38 | 12.0 | 2.61 | 35 | ...... | ...... |
| 15 | 1.49 | 19 | 1.50 | 20.0 | 2.60 | 34 | ...... | ...... |
| 16 | 1.51 | 21 | 1.52 | 21.0 | 2.58 | 32 | ...... | ...... |
| 17 | 1.47 | 18 | 1.52 | 21.0 | 2.45 | 23 | ...... | ...... |
| 18 | 1.49 | 19 | 1.51 | 21.0 | 2.51 | 27 | ...... | ...... |
| 19 | 1.50 | 20 | 1.49 | 19.0 | 2.50 | 26 | ...... | ...... |
| 20 | 1.50 | 20 | 1.48 | 19.0 | 2.51 | 27 | ...... | ...... |
| 21 | 1.47 | 18 | 1.50 | 20.0 | 2.55 | 30 | ...... | ...... |
| 22 | 1.44 | 16 | 1.48 | 19.0 | 2.59 | 33 | ...... | ...... |
| 23 | 1.41 | 14 | 1.45 | 16.0 | 2.65 | 38 | ...... | ...... |
| 24 | 1.40 | 13 | 1.40 | 13.0 | 2.71 | 42 | ...... | ...... |
| 25 | 1.45 | 16 | 1.38 | 12.0 | 2.70 | 41 | ...... | ...... |
| 26 | 1.48 | 19 | 1.34 | 9.4 | 2.72 | 43 | ...... | ...... |
| 27 | 1.44 | 16 | 1.31 | 7.6 | 2.67 | 39 | ...... | ...... |
| 28 | 1.42 | 14 | a2.30d | 41.0 | 2.64 | 38 | ...... | ...... |
| 29 | 1.40 | 13 | 2.95 | 60.0 | 2.62 | 36 | ...... | ...... |
| 30 | 1.37 | 11 | 2.45 | 23.0 | 2.64 | 38 | ...... | ...... |
| 31 | 1.31 | 7.6 | | | 2.66 | 39 | ...... | ...... |

*a.* Flash boards taken off dam.
*d.* From this date to the end of season, bearer affect gauge heights.

Monthly Discharge of Frenchman River at Enright & Strong's Ranche, Sask,. for 1911.

(Drainage area, 683 square miles.)

| Month. | Discharge in Second-Feet. Maximum | Minimum | Mean. | Per square Mile. | Run-Off. Depth in inches on Drainage Area. | Total in Acre-Feet. |
|---|---|---|---|---|---|---|
| April | 1870 | 98.0 | 401.0 | 0.587 | 0.655 | 23861 |
| May | 112 | 34.0 | 82.9 | 0.121 | 0.140 | 5097 |
| June | 114 | 31.0 | 53.2 | 0.078 | 0.087 | 3166 |
| July | 68 | 19.0 | 36.6 | 0.054 | 0.062 | 2250 |
| August | 28 | 14.0 | 22.2 | 0.033 | 0.038 | 1365 |
| September | 61 | 7.6 | 21.4 | 0.031 | 0.035 | 1273 |
| October | 43 | 9.0 | 31.8 | 0.047 | 0.054 | 1955 |
| The period | | | | | 1.071 | 38967 |

Note.—The Flow through Enright and Strong's ditch has been added to the Flow at the regular station to obtain the total monthly flow of Frenchman river given in this table.

### Morrison Brothers' Ditch.

This station was established August 22, 1911, by G. R. Elliott, on Morrison Brothers' irrigation ditch, which diverts water from the Frenchman River on S.E. ¼ Sec. 27, Tp. 6, Rge. 21, W. 3rd Mer.

The gauge is located on the S.W. ¼ Sec. 26, and about half a mile from the intake of the ditch. It is a plain staff 3 in. x 1 in., graduated to feet and inches, and is on the right side of the ditch. The zero of the gauge (elev., 97.36) is referred to the top of a rock 300 feet downstream on the right bank (assumed elev., 100.00) and marked "B.M." with red paint.

The station is at a uniform cross-section of the ditch, which is seven feet wide at the bottom with side slopes of 4 to 1.

As the gauge was established after the irrigation season, no gauge-height records were obtained during 1911.

Discharge Measurements of Morrison's Ditch on Frenchman River, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| Aug. 3 | G. H. Whyte | 7 0 | 3 90 | 0 703 | | 2 740 |
| Aug. 22 | F. T. Fletcher | 16 0 | 3 96 | 0 663 | 8 5 | 2 639 |

### Mule Creek at Erwin's Ranche.

This station was established May 12, 1911, by G. H. Whyte. It is located on the S.E. ¼ Sec. 34, Tp. 5, Rge. 17, W. 3rd Mer. It is about 48 miles by trail from East End and about one-quarter of a mile from the junction of the stream with Frenchman River.

The channel is straight for about 60 feet above and 100 feet below the station. Both banks are high and covered with greasewood and sage brush. The channel is composed of gravel and sand, and is liable to shift.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post near the right bank of the stream. It is referred to bench-marks as follows:—(1) a spike on top of the initial post on the left bank (elevation 5.83 feet above the datum of the gauge); (2) a spike on top of the final post on the right bank (elevation 6.88 feet above the datum of the gauge).

Discharge measurements are made at the rod by means of a current-meter or weir.

As only a few gauge-height observations were made during 1911, and these very unsatisfactory, tables of daily gauge-height and discharge, and monthly discharge could not be prepared.

Discharge Measurements of Mule Creek at Erwin's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 12 | G. H. Whyte | 5 1 | 1 25 | 0 696 | 0 910 | 0 870 |
| June 10 | do | 4 8 | 1 08 | 0 546 | 0 800 | 0 570 |
| Aug. 2 | do | | | | 0 820 | 0 736* |
| Sept. 13 | do | | | | 0 950 | 1 063* |
| Sept. 13 | do | 4 3 | 2 12 | 1 726 | 1 055 | 3 660 |

* Weir measurement.

### Frenchman River at Huff's Ranche.

This station was established on May 23, 1910, by F. H. Peters. It is located in Sec. 5, Tp. 5, Rge. 14, W. 3rd Mer., at Huff's Ranche. It is forty miles by trail from Notre Dame d'Auvergne post office, and seventy-five miles from Swift Current.

During low stages of the stream, discharge measurements are made by wading. The initial point for soundings is the face of post on the left bank, marked "O. + OO." When the stream becomes too deep for wading, the discharge is determined by the slope method.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to the top of the post at the initial point for soundings (elevation, 9.75 feet above the datum of the gauge). It was read, during 1911, by Roy Huff.

The gauge was carried out by ice early in the spring, but was replaced by N. M. Sutherland on June 15. Beaver dams below, which caused back-water on the gauge, and shifting conditions made it impossible to compute daily discharges for 1911. As the gauge-heights are of no value and are misleading, discharges measurements only are given.
565-566-567.

DISCHARGE MEASUREMENTS of Frenchman River at Huff's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| June 15 | N. M. Sutherland. | 4 3 | 40 84 | 0 599 | 2 16 | 24 46 |
| July 11 | do | | | | 2 20 | 25 94* |
| July 28 | do | | | | 1 81 | 7 09* |
| Aug 13 | do | | | | 2 05 | 5 06* |

* Measurements made upstream from regular section.

MISCELLANEOUS DISCHARGE MEASUREMENTS in Frenchman River Drainage Basin, in 1911.

| DATE. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | Feet. | Sq. Feet. | Feet per Sec. | Sec.-Ft. |
| July 27. | N.M.Sutherland. | Breed Creek.. | N.W. 12-4-12-3. | | | | Nil. |
| May 16. | G. H. Whyte ... | Calf Creek. | Sec. 5-8-22-3 | 7 5 | 3 22 | 1 112 | 3 590 |
| June 13 | do | do | do | 5 7 | 2 06 | 0 660 | 1 360 |
| Aug. 11 | do | do | do | 7 5 | 2 75 | 0 527 | 1 448 * |
| Oct. 16 | do | do | do | 5 5 | 2 17 | 0 696 | 1 510 |
| May 17.... | do | Concrete Coulee. | Sec. 11-7-23-3 | 8 1 | 4 76 | 0 666 | 3 170 |
| June 14. | do | do | do | 6 7 | 3 72 | 0 319 | 1 190 |
| July 12. | do | do | do | 4 4 | 2 35 | 0 476 | 1 120 |
| Aug. 12. | do | do | do | 4 6 | 1 86 | 0 535 | 1 001 * |
| July 12... | N.M.Sutherland. | Creek | Sec. 35-3-12-3. | | | | Nil. |
| July 13.... | do | do | Sec. 14-2-12-3. | | | | Nil. |
| July 26.... | do | do | Sec. 25-4-12-3. | | | | Nil. |
| Aug. 15.... | do | do | Sec.35-3-12-3. | | | | Nil. |
| Aug. 15.. | do | do | Sec. 35-2-12-3. | | | | Nil. |
| Aug 15... | do | do | Sec. 3-2-11-3. | | | | Nil. |
| July 11. | G. H. Whyte | A. M. Cross Ditch | Sec. 5-8-22-3. | 4 3 | 1 16 | 1 050 | 1 220 |
| May 17. | do | Doyle Coulee. | Sec. 17-7-22-3 | 2 0 | 1 01 | 0 587 | 0 590 * |
| June 14. | do | do | do | 1 7 | 0 68 | 0 559 | 0 380 * |
| Sept. 13 | G. R. Elliott ... | do | do | | | | 0 371 * |
| June 16. | G. H. Whyte | Dip Creek | Sec. 7-8-25-3. | | | | 0 182 * |
| June 17. | N.M.Sutherland. | Frenchman Riv.. | S.W. 4-1-10-3. | 20 6 | 11 53 | 2 080 | 23 940 |
| July 14 | do | do | do | 21 0 | 12 56 | 2 080 | 26 140 |
| Aug. 16 | do | do | do | 9 4 | 2 93 | 0 560 | 1 650 |
| Aug 2 | G. H. Whyte.... | do | N.E. 28-5-17-3. | 13 6 | 10 59 | 0 422 | 4 470 |
| Sept 14 | H. T. Thomas | do | do | 46 7 | 50 44 | 0 743 | 37 510 |
| Aug. 3. | G. H. Whyte.... | do | Sec. 26-6-21-3 | 21 5 | 13 35 | 0 431 | 5 760 |
| Aug 3. | do | do | Sec. 5-6-20-3 | 23 8 | 14 50 | 0 554 | 8 040 |
| Aug. 27. | G. R. Elliott.... | North Br. of do. | N.W. 16-8-22-3 | 4 5 | 1 86 | 1 190 | 2 180 |
| Sept. 6 | R. J. Burley & F. T. Fletcher.. | do | N.W. 15-7-22-3. | 25 8 | 30 00 | 1 800 | 54 100 |
| Aug. 14 | G. H. Whyte.... | Spring Creek.... | Sec. 28-7-24-3.... | | | | 0 706 * |
| Sept. 13 | G. R. Elliott.... | do | Sec. 18-7-22-3. | | | | 0 314 * |
| Sept. 14 | R. J. Burley & G. H. Whyte.... | do | S.W. 7-6-16-3. | | | | 0 389 * |
| Sept. 25 | F. T. Fletcher. | do | N.E. 23-6-24-3. | | | | 0 064 * |
| July 12. | N.M.Sutherland. | Snake Creek.. | S.E. 33-3-13-3. | | | | Nil. |
| July 27. | do | do | do | | | | Nil. |
| Aug. 13. | do | do | do | | | | Nil. |

* Weir measurement.

## SWIFTCURRENT CREEK DRAINAGE BASIN.

*General Description.*

Swiftcurrent Creek rises in the eastern slope of the Cypress Hills and follows a northeasterly course for 75 miles and then northward for about 25 miles and finally empties into the South Saskatchewan River in Tp. 20, Rge. 13, W. 3rd Mer.

The only important tributary is Bone Creek, which rises in the Cypress Hills and joins the Swiftcurrent in Tp. 10, Rge. 19, W. 3rd Mer.

The main stream flows through a valley two to three hundred feet deep and a mile wide to within a few miles of its mouth, where it enters a sandstone gorge, about five hundred feet deep.

The bench-land above the creek is of rolling prairie broken by innumerable coulees The soil is a sandy loam. There is very little tree growth along the stream.

The mean annual rainfall at the town of Swift Current is about fifteen inches. This increases slightly at the stream's head-waters. The greatest precipitation occurs during the months of May, June, and July. From November to April the stream is frozen over.

There are a number of small irrigation ditches in this drainage basin, and the town of Swift Current and the Canadian Pacific Railway Company take water for domestic and industrial purposes from the creek.

### Pollock East Ditch at South Fork, Sask.

This station was established August 10, 1911, by G. R. Elliott, on the irrigation ditch of Mr. D. Pollock, which diverts water from Swiftcurrent Creek on the N.E. ¼ Sec. 22, Tp. 22, Rge. 7, W. 3rd Mer.

The gauge is located on the N.E. ¼ Sec. 22, about twenty feet from the intake. The gauge, which is a plain staff graduated to feet and inches, is situated at the left side of the ditch. The zero (elev., 91.96) is referred to a permanent iron bench-mark (assumed elev., 100.00), located at the gauging station on Swiftcurrent Creek, which is three-quarters of a mile below.

The station is at a uniform cross-section of the ditch, which is one and a half feet wide at the bottom with side slopes of one to one and two to one.

No gauge-height observations were made during 1911.

Discharge Measurements of Pollock East Ditch at South Fork, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 7 | G. H. Whyte | | | | | 0 240* |
| July 28 | do | | | | | 0 268* |
| Aug. 29 | do | | | | | Nil. |

* Weir measurement.

### Pollock West Ditch at South Fork, Sask.

This station was established August 10, 1911, by G. R. Elliott, on the irrigation ditch of Mr. D. Pollock, which diverts water from Swiftcurrent Creek on the S.W. ¼ Sec. 27, Tp. 22, Rge. 7, W. 3rd Mer.

The gauge is located on the N.W. ¼ Sec. 22, about half a mile from the intake. The gauge, which is a plain staff graduated to feet and inches, is situated at the right side of a flume. The zero (elev., 82.09) is referred to a permanent iron bench-mark (assumed elev., 100.00) located at the gauging station on Swiftcurrent Creek.

The flume spans a coulee, is constructed of timber, and has a bottom width of two feet, and sides one foot in height.

No gauge-height readings were taken or gaugings made during 1911.

### Swiftcurrent Creek at Pollock's Ranche, Sask.

This station was established May 18, 1909, by H. R. Carscallen. It is located on the N.E. ¼ Sec. 22, Tp. 7, Rge. 21, W. 3rd Mer., about four miles southwest of Southfork post office.

The channel is straight for 50 feet above and 15 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of sand and gravel. The current is moderate at ordinary stages but sluggish at very low stages of the stream.

Discharge measurements are made at or near the gauge by wading at ordinary stages and at very low stages a weir is used. Mr. Pollock diverts water from the creek into an irrigation ditch about half a mile above the gauge, and when he is using water in his ditch the gauge does not record the total flow of the creek.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post sunk in the bed of the stream at the right bank and firmly stayed. The zero of the gauge (elev., 89.25) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated 138 feet N 30° E of the gauge.

During 1911, the gauge was read by D. Pollock.

Discharge Measurements of Swiftcurrent Creek at Pollock's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 14 | G. H. Whyte. | 9.0 | 7.23 | 1.116 | 1.37 | 8.070 |
| May 4 | do | 4.6 | 2.13 | 0.953 | 1.22 | 2.030 |
| June 6 | do | 4.0 | 1.80 | 0.701 | 0.68 | 1.300 |
| July 7 | do | 4.8 | 2.01 | 0.607 | 0.74 | 1.220 |
| July 28 | do | | | | 0.68 | 0.499* |
| Aug. 12 | G. R. Elliott | | | | 0.94 | 1.073* |
| Aug. 29 | G. H. Whyte. | | | | 0.88 | 0.924* |
| Oct. 5 | do | | | | 0.94 | 1.602* |

* Weir measurement.

Daily Gauge Height and Discharge of Swiftcurrent Creek at Pollock's Ranche, Sask., for 1911.

| Day. | May. | | June. | | July. | |
|---|---|---|---|---|---|---|
| | Gauge Height | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.80 | 1.8 | 0.75 | 1.3 |
| 2 | | | * 0.65 | 1.3 | 0.76 | 1.3 |
| 3 | | | 0.80 | 1.8 | 0.75 | 1.3 |
| 4 | 0.72 | 2.0 | 0.80 | 1.8 | 0.72 | 1.2 |
| 5 | 0.72 | 2.0 | 0.68 | 1.2 | 0.70 | 1.1 |
| 6 | 0.72 | 2.0 | 0.68 | 1.3 | 0.70 | 1.1 |
| 7 | 0.67 | 1.8 | 0.68 | 1.3 | 0.72 | 1.1 |
| 8 | 0.67 | 1.8 | 0.68 | 1.3 | 0.72 | 1.1 |
| 9 | 0.67 | 1.7 | 0.67 | 1.2 | 0.72 | 1.1 |
| 10 | 0.67 | 1.7 | 0.67 | 1.2 | 0.71 | 1.1 |
| 11 | 0.67 | 1.7 | 0.66 | 1.2 | 0.72 | 1.0 |
| 12 | 0.67 | 1.7 | 0.65 | 1.2 | 0.73 | 1.0 |
| 13 | 0.80 | 2.3 | 0.65 | 1.2 | 0.73 | 1.0 |
| 14 | 0.80 | 2.3 | 0.65 | 1.2 | 0.73 | 1.0 |
| 15 | 0.85 | 2.5 | 0.65 | 1.2 | 0.73 | 1.0 |
| 16 | 0.90 | 2.8 | 0.65 | 1.1 | 0.73 | 0.9 |
| 17 | 0.85 | 2.5 | 0.62 | 1.1 | 0.73 | 0.9 |
| 18 | 0.85 | 2.4 | 0.60 | 1.0 | 0.74 | 0.9 |
| 19 | 0.76 | 2.0 | 0.60 | 1.0 | 0.73 | 0.8 |
| 20 | 0.76 | 1.9 | 0.65 | 1.1 | 0.72 | 0.8 |
| 21 | 0.76 | 1.9 | 0.85 | 1.7 | 0.73 | 0.8 |
| 22 | 0.76 | 1.9 | 0.80 | 1.5 | 0.74 | 0.8 |
| 23 | 0.76 | 1.9 | 0.75 | 1.3 | 0.74 | 0.7 |
| 24 | 0.80 | 2.0 | 0.80 | 1.7 | 0.74 | 0.7 |
| 25 | 0.80 | 2.0 | 0.75 | 1.3 | 0.75 | 0.7 |
| 26 | 0.80 | 2.0 | 0.75 | 1.3 | 0.75 | 0.7 |
| 27 | 0.76 | 1.8 | 0.75 | 1.3 | 0.75 | 0.7 |
| 28 | 0.76 | 1.8 | 0.75 | 1.3 | * 0.68 | 0.5 |
| 29 | 0.75 | 1.7 | 0.75 | 1.3 | * 0.68 | 0.5 |
| 30 | 0.70 | 1.5 | 0.78 | 1.4 | * 0.68 | 0.5 |
| 31 | 0.80 | 1.9 | | | * 0.68 | 0.5 |

**SESSIONAL PAPER No. 25d**

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Pollock's Ranche, Sask,. for 1911. *Continued.*

| Day. | August. | | September. | | October. | | November | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | *0.68 | 0.5 | 0.88 | 1.0 | 0.98 | 1.7 | 0.98 | 1.8 |
| 2 | *0.68 | 0.5 | 0.88 | 1.0 | 1.20 | 2.9 | 0.98 | 1.8 |
| 3 | *0.66 | 0.5 | 0.90 | 1.0 | 1.25 | 3.2 | 0.98 | 1.8 |
| 4 | *0.67 | 0.5 | 0.95 | 1.2 | 1.15 | 2.7 | 0.98 | 1.8 |
| 5 | 0.70 | 0.5 | 0.98 | 1.3 | 1.00 | 1.9 | 0.98 | 1.8 |
| 6 | 0.95 | 1.2 | 0.98 | 1.3 | 0.94 | 1.6 | 0.98 | 1.8 |
| 7 | 1.50 | 3.9 | 0.96 | 1.2 | 0.94 | 1.6 | ... | .... |
| 8 | 0.95 | 1.2 | 0.96 | 1.3 | 0.94 | 1.6 | .. | .. |
| 9 | 0.90 | 1.0 | 0.96 | 1.3 | 0.94 | 1.6 | . | .. |
| 10 | 0.88 | 0.9 | 0.96 | 1.3 | 0.94 | 1.6 | | ... |
| 11 | 0.88 | 0.9 | 0.98 | 1.4 | 0.94 | 1.6 | | .. |
| 12 | 0.86 | 0.9 | 0.98 | 1.4 | 0.94 | 1.6 | | ... |
| 13 | 0.80 | 0.7 | 0.98 | 1.4 | 0.94 | 1.6 | | ... |
| 14 | 0.76 | 0.6 | 0.98 | 1.4 | 0.94 | 1.6 | | .... |
| 15 | 0.70 | 0.5 | *0.94 | 1.3 | 0.94 | 1.6 | | ... |
| 16 | 0.70 | 0.5 | *0.94 | 1.3 | 0.94 | 1.6 | | ... |
| 17 | 0.75 | 0.6 | *0.94 | 1.4 | 0.98 | 1.8 | | ... |
| 18 | 0.78 | 0.7 | *0.94 | 1.4 | 0.98 | 1.8 | | ... |
| 19 | 0.80 | 0.7 | *0.94 | 1.4 | 0.98 | 1.8 | | ... |
| 20 | 0.85 | 0.8 | *0.94 | 1.4 | 0.98 | 1.8 | | ... |
| 21 | 0.90 | 1.0 | *0.94 | 1.4 | 0.96 | 1.7 | | .. |
| 22 | 0.90 | 1.0 | 0.98 | 1.6 | 0.96 | 1.7 | | .. |
| 23 | 0.88 | 0.9 | 0.98 | 1.6 | 0.98 | 1.8 | | ... |
| 24 | 0.88 | 0.9 | 0.98 | 1.6 | 0.98 | 1.8 | | .. |
| 25 | 0.90 | 1.0 | 0.96 | 1.6 | 0.98 | 1.8 | | .. |
| 26 | 0.90 | 1.0 | 0.96 | 1.6 | 0.98 | 1.8 | | ... |
| 27 | 0.88 | 0.9 | 0.98 | 1.7 | 0.98 | 1.8 | | ... |
| 28 | 0.88 | 0.9 | 0.98 | 1.7 | 0.98 | 1.8 | | .. |
| 29 | 0.88 | 0.9 | 0.98 | 1.7 | 0.98 | 1.8 | | .. |
| 30 | 0.88 | 0,9 | 0.98 | 1.7 | 0.98 | 1.8 | | .. |
| 31 | 0.88 | 1.0 | . | | 0.98 | 1.8 | | .. |

* Water diverted above.

MONTHLY DISCHARGE of Swiftcurrent Creek at Pollock's Ranche, Sask., for 1911.

(Drainage area, 16 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| May (4-31) | 2.8 | 1.7 | 1.980 | 0.124 | 0.129 | 110 |
| June | 1.8 | 1.0 | 1.320 | 0.082 | 0.092 | 79 |
| July | 1.3 | 0.5 | 0.907 | 0.057 | 0.066 | 56 |
| August | 3.9 | 0.5 | 0.903 | 0.056 | 0.065 | 56 |
| September | 1.7 | 1.0 | 1.400 | 0.088 | 0.098 | 83 |
| October | 3.2 | 1.6 | 1.510 | 0.094 | 0.108 | 93 |
| November (1-6) | 1.8 | 1.8 | 1.800 | 0.112 | 0.025 | 21 |
| The period | | | | | 583 | 498 |

## Axton East Ditch near South Fork, Sask.

This station was established August 12, 1911, by G. R. Elliott, on the irrigation ditch of J. W. E. Axton, which diverts water from Swiftcurrent Creek on the N.E. ¼ Sec. 23, Tp. 7, Rge. 21, W. 3rd Mer.

The gauge is located on the N.E. ¼ Sec. 23, about 40 feet below the intake. The gauge, which is a plain staff, graduated to feet and inches, is on the left side of the ditch. The zero (elev., 97.92) is referred to the top of a plug on the right bank (assumed elev., 100.00).

The station is on a uniform cross-section of the ditch which is two feet wide at the bottom with perpendicular sides.

No records were obtained at this station during 1911, as the gauge was established after the irrigation season.

## Axton West Ditch near South Fork, Sask.

This station was established August 12, 1911, by G. R. Elliott, on the irrigation ditch of J. W. E. Axton, which diverts water from Swiftcurrent Creek on the N.E. ¼ Sec. 23, Tp. 7, Rge. 21, W. 3rd Mer.

The gauge is located on the N.E. ¼ Sec. 23, about 33 feet below the intake. The gauge, which is a plain staff graduated to feet and inches, is on the left side of the ditch. The zero (elev., 98.46) is referred to the top of a plug on the left bank (assumed elev., 100.00).

The station is on a uniform cross-section of the ditch, which is three feet wide at the bottom with side slopes of one to one.

No records were obtained at this station during 1911, as the gauge was established after the irrigation season.

## Jones Coulee at Read's Ranche, Sask.

This station was established on September 23, 1909, by H. R. Carscallen. It is located on N.E. ¼ Sec. 5, Tp. 8, Rge. 20, W. 3rd Mer., about 300 yards from the surveyed trail from East End to Gull Lake, and about 42 miles south of Gull Lake. It is about two and a half miles northeast of South Fork post office, and near the mouth of the stream.

The channel is straight for 75 feet above and 50 feet below the station. Both banks are high and not liable to overflow. The banks are free from brush except for a little undergrowth on the left bank. The bed of the stream is composed of soft clay with sand underneath. The current is very sluggish and the water comparatively deep at the station, giving rise to a small amount of vegetation.

Discharge measurements are made a short distance upstream from the gauge by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post sunk in the bed of the creek at the left bank and securely stayed. It is referred to bench-marks as follows:—(1) a spike-head in the top of the final stake driven close to the ground on the right bank and marked "B.M." (elevation, 8.25 feet above gauge zero); (2) the top of two spikes driven horizontally into the end of a log at the northwest corner of Mr. Read's stable, the log marked "B.M." (elevation 11.46 feet above gauge zero).

During 1911, the gauge was read by W. F. Read.

### Discharge Measurements of Jones Coulee at Read's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 14 | G. H. Whyte | 18.0 | 21.72 | 0.755 | 4.32 | 16.390 |
| May 4 | do | 5.5 | 5.15 | 0.658 | 2.14 | 3.39 |
| June 6 | do | 5.0 | 5.00 | 0.490 | 1.84 | 2.450 |
| July 7 | do | 5.3 | 4.96 | 0.257 | 1.84 | 1.260 |
| July 28 | do | | | | 1.54 | 0.101* |
| Aug. 11 | G. R. Elliott | | | | | 0.575* |
| Aug. 29 | G. H. Whyte | | | | 1.66 | 0.311* |
| Oct. 5 | do | 4.6 | 3.75 | 0.496 | 2.05 | 1.860 |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Jones Coulee at Read's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | | July. | | August. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 5.35 | 26.0 | 2.20 | 2.8 | 1.99 | 3.1 | 2.02 | 2.5 | 0.96 | 0.00 |
| 2 | ..... | ..... | 5.35 | 26.0 | 2.03 | 1.8 | 1.90 | 2.6 | 2.01 | 2.4 | 0.98 | 0.00 |
| 3 | ..... | ..... | 5.35 | 26.0 | 2.01* | 1.7 | 1.97 | 3.1 | 2.00 | 2.3 | 0.99 | 0.00 |
| 4 | ..... | ..... | 5.35 | 26.0 | 2.00 | 1.6 | 1.70 | 1.6 | 2.20 | 3.6 | 1.02 | 0.00 |
| 5 | ..... | ..... | 5.35 | 26.0 | 2.00 | 1.7 | 1.76 | 1.9 | 2.20 | 3.5 | 1.10 | 0.00 |
| 6 | ..... | ..... | 5.30 | 25.0 | 1.98 | 1.7 | 1.76 | 2.0 | 2.02 | 2.3 | 1.20 | 0.00 |
| 7 | ..... | ..... | 5.30 | 25.0 | 1.99 | 1.8 | 1.70 | 1.6 | 2.00 | 2.1 | 1.60 | 0.20 |
| 8 | ..... | ..... | 5.30 | 25.0 | 1.99 | 1.8 | 1.80* | 2.1 | 1.98 | 2.0 | 2.00 | 1.60 |
| 9 | ..... | ..... | 6.40 | 35.0 | 2.00 | 1.9 | 1.90* | 2.7 | 1.95 | 1.8 | 2.00 | 1.60 |
| 10 | ..... | ..... | 8.60 | 55.0 | 2.20 | 3.2 | 1.99 | 3.2 | 1.93 | 1.7 | 1.98 | 1.50 |
| 11 | ..... | ..... | 5.30 | 25.0 | 2.00 | 2.0 | 1.78 | 1.9 | 1.91 | 1.6 | 1.97 | 1.50 |
| 12 | ..... | ..... | 4.00 | 13.0 | 1.99 | 2.0 | 1.71 | 1.5 | 1.89 | 1.5 | 1.98 | 1.50 |
| 13 | ..... | ..... | 3.98 | 13.0 | 1.99 | 2.1 | 1.76 | 1.7 | 1.87 | 1.4 | 1.89 | 1.20 |
| 14 | ..... | ..... | 3.99 | 13.0 | 2.00 | 2.2 | 1.70 | 1.4 | 1.83 | 1.2 | 1.78 | 0.70 |
| 15 | ..... | ..... | 3.98 | 14.0 | 2.30 | 4.3 | 1.70 | 1.1 | 1.80 | 1.2 | 1.75 | 0.60 |
| 16 | ..... | ..... | 3.00 | 6.6 | 2.31 | 4.4 | 1.67 | 1.3 | 1.78 | 1.0 | 1.74 | 0.60 |
| 17 | ..... | ..... | 3.33 | 10.0 | 2.00 | 2.4 | 1.87 | 2.2 | 1.79 | 1.1 | 1.73 | 0.60 |
| 18 | ..... | ..... | 3.33 | 11.0 | 2.30 | 4.5 | 1.89 | 2.3 | 1.79 | 1.1 | 1.72 | 0.60 |
| 19 | ..... | ..... | 3.00 | 9.3 | 2.00 | 2.4 | 1.97 | 2.7 | 1.97 | 1.9 | 1.60 | 0.20 |
| 20 | ..... | ..... | 2.90 | 8.3 | 2.00 | 2.5 | 2.30 | 5.1 | 1.87 | 1.1 | 1.55 | 0.18 |
| 21 | ..... | ..... | 2.90 | 8.3 | 2.30 | 4.7 | 2.34 | 5.4 | 1.89 | 1.5 | 1.50 | 0.15 |
| 22 | ..... | ..... | 2.70 | 6.6 | 2.20 | 4.0 | 2.33 | 5.2 | 1.40 | 0.1 | 1.60 | 0.20 |
| 23 | ..... | ..... | 2.80 | 7.4 | 2.30 | 4.8 | 2.34 | 5.2 | 1.37 | 0.1 | 1.65 | 0.40 |
| 24 | ..... | ..... | 2.80 | 7.4 | 2.30 | 4.9 | 2.35 | 5.3 | 1.37 | 0.1 | 1.65 | 0.40 |
| 25 | ..... | ..... | 2.90 | 8.3 | 2.20 | 4.2 | 2.37 | 5.4 | 1.30 | 0.0 | 1.68 | 0.40 |
| 26 | ..... | ..... | 3.00 | 9.2 | 2.10 | 3.5 | 2.35 | 5.2 | 1.25 | 0 | 1.70 | 0.50 |
| 27 | ..... | ..... | 3.20 | 11.0 | 2.05 | 3.2 | 2.20 | 4.0 | 1.20 | 0 | 1.69 | 0.50 |
| 28 | 4.5 | 18 | 2.95 | 8.8 | 2.03 | 3.2 | 2.18 | 3.8 | 1.10 | 0 | 1.70 | 0.50 |
| 29 | 4.5 | 18 | 2.92 | 8.5 | 2.02 | 3.1 | 2.10 | 3.1 | 0.90 | 0 | 1.69 | 0.50 |
| 30 | 4.5 | 18 | 2.30 | 2.5 | 2.00 | 3.0 | 2.20 | 3.8 | 0.90 | 0 | 1.68 | 0.40 |
| 31 | 4.6 | 19 | ... | ..... | 1.99 | 3.0 | ... | ..... | 0.95 | 0 | ... | .... |

* Gauge height interpolated.
NOTE.—No observations of gauge height after September 1st.

MONTHLY DISCHARGE of Jones Coulee at Read's Ranche, Sask., for 1911.

(Drainage area, 45 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (28-31) | 19.0 | 18.0 | 18.20 | 0.404 | 0.601 | 145 |
| April | 55.0 | 2.5 | 16.50 | 0.367 | 0.401 | 982 |
| May | 4.9 | 1.6 | 2.91 | 0.065 | 0.075 | 179 |
| June | 5.4 | 1.3 | 3.06 | 0.068 | 0.076 | 182 |
| July | 3.6 | 0.0 | 1.27 | 0.028 | 0.032 | 78 |
| August | 2.0 | 0.0 | 0.55 | 0.012 | 0.013 | 33 |
| The period | ........ | ........ | ........ | ........ | 1.198 | 1599 |

SWIFTCURRENT CREEK AT SINCLAIR'S RANCHE, SASK. (Upper Station)

This station was established June 15, 1910, by R. G. Swan. It is located on the S.E. ¼ Sec. 18, Tp. 10, Rge. 19, W. 3rd Mer., about 150 feet upstream from the mouth of Bone Creek, and about 1200 feet above the lower station, The channel is straight for about 250 feet above and 150 feet blow the station. Both banks are fairly high, and covered with a growth of brush. Neither bank will overflow. The bed of the stream is composed of sand, which will shift.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 87.91) is referred to a permanent iron bench-mark (assumed elev., 100.00) located 300 feet S 64.5° W of the gauge.

Discharge measurements are made at the station by wading. The initial point for soundings is a plug on the left bank about four inches above ground and 45 feet from the gauge. During high stages the gauge-heights at this station are affected by back-water from Bone Creek.

During 1911, the gauge was read by Geo. A. Mackintosh.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 15 | G. H. Whyte | | | | 3 41 | |
| May 9 | do | 11 2 | 7 25 | 1 320 | 0.90 | 9 570 |
| June 7 | do | 8 8 | 4 58 | 0 926 | 0 64 | 4 165 |
| July 8 | do | 9 0 | 4 75 | 0 692 | 0 69 | 3 290 |
| July 29 | do | | | | 0.31 | 0 181* |
| Aug. 30 | do | 5 5 | 1 22 | 0 639 | 0 41 | 0.780 |
| Oct. 6 | do | 8.6 | 6.56 | 0 911 | 0.82 | 5.980 |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), Sask., for 1911.

| DAY. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | 1 41 | | 0 68 | 4 7 |
| 2 | | | 1 33 | | 0 65 | 4.3 |
| 3 | | | 1 26 | | 0 63 | 4 0 |
| 4 | | | 1 21 | | 0 65 | 4 3 |
| 5 | | | 1 10 | | 0 66 | 4 4 |
| 6 | | | 1 05 | | 0 64 | 4 2 |
| 7 | | | 1 03 | | 0 63 | 4 0 |
| 8 | | | 1 01 | | 0 63 | 4.0 |
| 9 | 3 26 | a | 0 97 | 11.6 | 0 61 | 3 6 |
| 10 | 3 25 | | 0 95 | 11 0 | 0.59 | 3 2 |
| 11 | 3 31 | | 0 92 | 10 1 | 0 53 | 2 5 |
| 12 | 3 40 | | 0 89 | 9 2 | 0 51 | 2 3 |
| 13 | 3 42 | | 0 88 | 9 0 | 0.49 | 2 0 |
| 14 | 3 39 | | 0 91 | 9.8 | 0 49 | 2 0 |
| 15 | 3 31 | | 1 10 | 16 0 | 0.47 | 1 8 |
| 16 | 3 26 | | 1 24 | 22 0 | 0 46 | 1 6 |
| 17 | 3.39 | | 1.35 | 26 0 | 0.43 | 1 1 |
| 18 | 3 51 | | 1 21 | 20.0 | 0 42 | 1 3 |
| 19 | 3.45 | | 1 21 | 20 0 | 0 40 | 1 1 |
| 20 | 3 10 | | 1 14 | 18 0 | 0 43 | 1 3 |
| 21 | 2 87 | | 0 97 | 11 6 | 0 99 | 11 0 |
| 22 | 2 54 | | 0 97 | 11.6 | 1 02 | 12 0 |
| 23 | 2 30 | | 0 96 | 11.3 | 0 89 | 8 3 |
| 24 | 2 11 | | 0 98 | 11 9 | 0 89 | 8 2 |
| 25 | 1.93 | | 1 02 | 13 2 | 0.94 | 9 5 |
| 26 | 1 74 | | 1 05 | 14 2 | 1 10 | 15 0 |
| 27 | 1 64 | | 1 01 | 12 8 | 1 09 | 14 0 |
| 28 | 1 63 | | 1 06 | 14 6 | 0 98 | 10 4 |
| 29 | 1.61 | | 1 05 | 14 2 | 0 93 | 8 8 |
| 30 | 1.56 | | 0 94 | 10 7 | 0 93 | 8.7 |
| 31 | | | 0 82 | 7 5 | | |

Daily Gauge Height and Discharge of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.08 | 14 | 0.34 | 0.4 | 0.38 | 0.6 | 0.68 | 3.2 |
| 2 | 1.11 | 14 | 0.33 | 0.3 | 0.35 | 0.4 | 0.69 | 3.3 |
| 3 | 1.08 | 13 | 0.31 | 0.2 | 0.34 | 0.4 | 0.78 | 4.7 |
| 4 | 1.08 | 13 | 0.32 | 0.3 | 0.68 | 3.2 | 0.84 | 5.9 |
| 5 | 0.93 | 8.2 | 0.45 | 1.0 | 1.10 | 13.0 | 0.83 | 5.7 |
| 6 | 0.84 | 6.0 | 0.57 | 2.0 | 1.98 | 48.0 | 0.82 | 5.5 |
| 7 | 0.83 | 5.7 | 0.59 | 2.1 | 2.11 | 53.0 | 0.82 | 5.5 |
| 8 | 0.80 | 5.1 | 0.65 | 2.8 | 2.36 | 63.0 | 0.80 | 5.1 |
| 9 | 0.85 | 6.1 | 0.65 | 2.8 | 2.10 | 53.0 | 0.78 | 4.7 |
| 10 | 0.70 | 3.4 | 0.61 | 2.3 | 1.97 | 48.0 | 0.75 | 4.2 |
| 11 | 0.67 | 3.0 | 0.80 | 5.1 | 1.65 | 35.0 | 0.74 | 4.0 |
| 12 | 0.61 | 2.3 | 0.74 | 4.0 | 1.01 | 10.0 | 0.71 | 3.6 |
| 13 | 0.60 | 2.2 | 0.63 | 2.6 | 0.73 | 3.9 | 0.67 | 3.0 |
| 14 | 0.58 | 2.0 | 0.56 | 1.9 | 0.70 | 3.4 | 0.64 | 2.7 |
| 15 | 0.51 | 1.5 | 0.56 | 1.9 | 0.69 | 3.3 | 0.62 | 2.4 |
| 16 | 0.49 | 1.3 | 0.53 | 1.6 | 0.67 | 3.0 | 0.62 | 2.4 |
| 17 | 0.48 | 1.2 | 0.51 | 1.5 | 0.65 | 2.8 | 0.62 | 2.4 |
| 18 | 0.45 | 1.0 | 0.46 | 1.1 | 0.65 | 2.8 | 0.64 | 2.7 |
| 19 | 0.46 | 1.1 | 0.43 | 0.9 | 0.64 | 2.7 | 0.69 | 3.3 |
| 20 | 0.46 | 1.1 | 0.41 | 0.8 | 0.64 | 2.7 | 0.73 | 3.9 |
| 21 | 0.45 | 1.0 | 0.43 | 0.9 | 0.64 | 2.7 | 0.73 | 3.9 |
| 22 | 0.44 | 0.9 | 0.45 | 1.0 | 0.66 | 2.9 | 0.71 | 3.6 |
| 23 | 0.46 | 1.1 | 0.44 | 0.9 | 0.70 | 3.4 | 0.73 | 3.9 |
| 24 | 0.45 | 1.0 | 0.43 | 0.9 | 0.72 | 3.7 | 0.79 | 4.9 |
| 25 | 0.44 | 0.9 | 0.44 | 0.9 | 0.71 | 3.6 | 0.81 | 5.3 |
| 26 | 0.44 | 0.9 | 0.46 | 1.1 | 0.70 | 3.4 | 0.89 | 7.1 |
| 27 | 0.40 | 0.7 | 0.45 | 1.0 | 0.70 | 3.4 | 0.95 | 8.6 |
| 28 | 0.35 | 0.4 | 0.44 | 0.9 | 0.69 | 3.3 | 1.01 | 10.0 |
| 29 | 0.31 | 0.2 | 0.43 | 0.9 | 0.69 | 3.3 | 1.05 | 12.0 |
| 30 | 0.32 | 0.3 | 0.42 | 0.8 | 0.68 | 3.2 | 1.07 | 12.0 |
| 31 | 0.35 | 0.4 | 0.40 | 0.7 | | | 1.09 | 13.0 |

*a* Backwater, making it impossible to obtain discharges from gauge heights from April 9 to May 8.

Monthly Discharge of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), Sask., for 1911.

(Drainage area, 171 square miles.)

| Month. | Discharge in Second-Feet | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| May (9-31) | 26.0 | 7.5 | 13.80 | 0.081 | 0.069 | 630 |
| June | 15.0 | 1.1 | 5.46 | 0.032 | 0.036 | 325 |
| July | 14.0 | 0.2 | 3.64 | 0.021 | 0.024 | 224 |
| August | 5.1 | 0.2 | 1.47 | 0.009 | 0.010 | 90 |
| September | 63.0 | 0.4 | 12.80 | 0.075 | 0.084 | 762 |
| October | 13.0 | 2.4 | 5.24 | 0.031 | 0.036 | 322 |
| The period | | | | | .259 | 2353 |

## Bone Creek at Lewis' Ranche, Sask.

This station was established July 2, 1908, by F. T. Fletcher. It is located at the bridge on the N.W. ¼ Sec. 34, Tp. 8, Rge. 22, W. 3rd Mer. It is on the surveyed trail from Skull Creek post office to East End post office, and is about fifteen miles south of Skull Creek post office by trail. The bridge is a small wooden structure, built in the form of a culvert, with a rectangular cross-section.

The channel is straight for 50 feet above the station, and below the station it curves gradually to the left after emerging from the downstream side of the bridge. The right bank is high and will not overflow; the left bank is comparatively low, but no indication of the water overflowing the bank can be found. Both banks are free from brush at the station. The bed of the stream is sandy, with some large stones scattered along the cross-section. The current is moderate, becoming very swift below the station.

Discharge measurements are made from the upstream side of the bridge during high water. The initial point for soundings is the inner face of the left abutment. Low-water measurements are made near the station by wading.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to the left abutment on the upstream side of the bridge. It is referred to bench marks as follows:—(1) the head of a spike surrounded by a circle of nail-heads in the top of the stringer on the left abutment at the upstream side of the bridge, marked "B.M." with white paint (elevation, 4.17 feet above the zero of the gauge); (2) the top of the iron pin in the road mound 754 feet north of the bridge on the left bank of the creek (elevation, 5.92 feet above the zero of the gauge).

During 1911, the gauge was read by C. L. Lewis.

DISCHARGE MEASUREMENTS of Bone Creek at Lewis' Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 10 | G. H. Whyte | 12.3 | 25.32 | 5.103 | 2.45 | 129.220 |
| May 1 | do | 12.3 | 3.70 | 0.643 | 0.40 | 2.380 |
| June 3 | do | 12.3 | 2.70 | 0.529 | 0.32 | 1.430 |
| July 4 | do | 12.3 | 2.00 | 0.484 | 0.26 | 1.560 |
| July 26 | do | 9.0 | 0.80 | 0.783 | 0.14 | 0.642* |
| Aug. 25 | do | 12.3 | 1.75 | 0.494 | 0.24 | 0.987* |
| Oct. 4 | do | 12.3 | 3.00 | 0.748 | 0.34 | 2.230 |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Bone Creek at Lewis' Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge. Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | .... | 0.86 | 18.0 | 0.39 | 2.5 | 0.30 | 1.6 |
| 2 | .... | .... | 1.00 | 26.0 | 0.38 | 2.4 | 0.30 | 1.6 |
| 3 | .... | .... | 1.09 | 31.0 | 0.37 | 2.3 | 0.32 | 1.8 |
| 4 | .... | .... | 1.09 | 31.0 | 0.37 | 2.3 | 0.31 | 1.7 |
| 5 | .... | .... | 1.09 | 31.0 | 0.37 | 2.3 | 0.48 | 4.1 |
| 6 | .... | .... | 1.09 | 31.0 | 0.37 | 2.3 | 0.31 | 1.7 |
| 7 | .... | .... | 0.70 | 10.4 | 0.38 | 2.4 | 0.31 | 1.7 |
| 8 | .... | .... | 0.36 | 2.2 | 0.32 | 1.8 | 0.32 | 1.8 |
| 9 | .... | .... | 2.18† | 108.0 | 0.32 | 1.8 | 0.30 | 1.6 |
| 10 | .... | .... | 2.45 | 126.0 | 0.33 | 1.9 | 0.30 | 1.6 |
| 11 | .... | .... | *1.15 | 36.0 | 0.33 | 1.9 | 0.30 | 1.6 |
| 12 | .... | .... | 1.09 | 31.0 | 0.33 | 1.9 | 0.29 | 1.5 |
| 13 | .... | .... | 1.09 | 31.0 | 0.32 | 1.8 | 0.28 | 1.5 |
| 14 | .... | .... | 1.09 | 31.0 | 0.51 | 4.7 | 0.27 | 1.4 |
| 15 | .... | .... | 0.50 | 4.4 | 0.52 | 4.9 | 0.26 | 1.3 |
| 16 | .... | .... | 1.25 | 42.0 | 0.60 | 7.0 | 0.25 | 1.3 |
| 17 | .... | .... | 0.95 | 23.0 | 0.45 | 3.6 | 0.23 | 1.1 |
| 18 | .... | .... | 0.59 | 6.7 | 0.44 | 3.4 | 0.22 | 1.0 |
| 19 | .... | .... | 0.70 | 10.4 | 0.44 | 3.4 | 0.50 | 4.4 |
| 20 | .... | .... | 0.75 | 13.0 | 0.40 | 2.7 | 0.45 | 3.5 |
| 21 | .... | .... | 0.50 | 4.4 | 0.34 | 2.0 | 0.40 | 2.7 |
| 22 | .... | .... | 0.49 | 4.2 | 0.34 | 2.0 | 0.35 | 2.1 |
| 23 | .... | .... | 0.48 | 4.1 | 0.32 | 1.8 | 0.30 | 1.6 |
| 24 | .... | .... | 0.45 | 3.6 | 0.32 | 1.8 | 0.30 | 1.6 |
| 25 | 1.10 | 32.0 | 0.47 | 3.9 | 0.32 | 1.8 | 0.40 | 2.7 |
| 26 | 0.70 | 10.4 | 0.41 | 2.9 | 0.32 | 1.8 | 0.38 | 2.4 |
| 27 | 0.80 | 15.0 | 0.41 | 2.9 | 0.32 | 1.8 | 0.34 | 2.0 |
| 28 | 0.60 | 7.0 | 0.42 | 3.0 | 0.33 | 1.9 | 0.32 | 1.8 |
| 29 | 1.15 | 36.0 | 0.42 | 3.0 | 0.34 | 2.0 | 0.33 | 1.9 |
| 30 | 0.69 | 10.1 | 0.51 | 4.7 | 0.34 | 2.0 | 0.34 | 2.0 |
| 31 | 0.59 | 6.7 | ... | ... | 0.33 | 1.9 | .... | ....... |

Daily Gauge Height and Discharge of Bone Creek at Lewis' Ranche, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.40 | 2.7 | 0.25 | 1.2 | 0.24 | 1.2 | 0.30 | 1.6 | 0.25 | 1.2 |
| 2 | 0.40 | 2.7 | 0.25 | 1.2 | 0.24 | 1.2 | 0.31 | 1.7 | 0.25 | 1.2 |
| 3 | 0.35 | 2.1 | 0.28 | 1.5 | 0.25 | 1.2 | 0.40 | 2.7 | 0.25 | 1.2 |
| 4 | 0.30 | 1.6 | 0.28 | 1.5 | 0.30 | 1.6 | 0.31 | 1.7 | 0.25 | 1.2 |
| 5 | 0.27 | 1.4 | 0.29 | 1.5 | 0.50 | 4.4 | 0.31 | 1.7 | 0.25 | 1.2 |
| 6 | 0.25 | 1.2 | 0.30 | 1.6 | 0.70 | 10.4 | 0.30 | 1.6 | 0.26 | 1.3 |
| 7 | 0.24 | 1.2 | 0.30 | 1.6 | 0.60 | 7.0 | 0.29 | 1.5 | 0.26 | 1.3 |
| 8 | 0.24 | 1.2 | 0.30 | 1.6 | 0.55 | 5.7 | 0.31 | 1.7 | 0.26 | 1.3 |
| 9 | 0.27 | 1.4 | 0.27 | 1.4 | 0.30 | 1.6 | 0.30 | 1.6 | 0.25 | 1.2 |
| 10 | 0.25 | 1.2 | 0.29 | 1.5 | 0.31 | 1.7 | 0.30 | 1.6 | 0.25 | 1.2 |
| 11 | 0.25 | 1.2 | 0.27 | 1.4 | 0.30 | 1.6 | 0.30 | 1.6 | 0.25 | 1.2 |
| 12 | 0.27 | 1.4 | 0.28 | 1.5 | 0.40 | 2.7 | 0.30 | 1.6 | 0,50 | *a* |
| 13 | 0.26 | 1.3 | 0.26 | 1.3 | 0.55 | 5.7 | 0.30 | 1.6 | 0.55 | ...... |
| 14 | 0.25 | 1.2 | 0.22 | 1.0 | 0.26 | 1.3 | 0.30 | 1.6 | 0.65 | ...... |
| 15 | 0.24 | 1.2 | 0.25 | 1.2 | 0.25 | 1.2 | 0.29 | 1.5 | 0.68 | ...... |
| 16 | 0.25 | 1.2 | 0.26 | 1.3 | 0.25 | 1.2 | 0.30 | 1.6 | ...... | ...... |
| 17 | 0.25 | 1.2 | 0.25 | 1.2 | 0.33 | 1.9 | 0.31 | 1.7 | ...... | ...... |
| 18 | 0.25 | 1.2 | 0.19 | 0.8 | 0.30 | 1.6 | 0.32 | 1.8 | ...... | ...... |
| 19 | 0.25 | 1.2 | 0.19 | 0.8 | 0.30 | 1.6 | 0.30 | 1.6 | ...... | ...... |
| 20 | 0.26 | 1.3 | 0.20 | 0.9 | 0.30 | 1.6 | 0.30 | 1.6 | ...... | ...... |
| 21 | 0.25 | 1.2 | 0.21 | 1.0 | 0.32 | 1.8 | 0.30 | 1.6 | ...... | ...... |
| 22 | 0.24 | 1.2 | 0.22 | 1.0 | 0.35 | 2.1 | 0.30 | 1.6 | ...... | ...... |
| 23 | 0.25 | 1.2 | 0.22 | 1.0 | 0.36 | 2.2 | 0.27 | 1.4 | ...... | ...... |
| 24 | 0.25 | 1.2 | 0.26 | 1.3 | 0.35 | 2.1 | 0.25 | 1.2 | ...... | ...... |
| 25 | 0.24 | 1.2 | 0.25 | 1.2 | 0.33 | 1.9 | 0.25 | 1.2 | ...... | ...... |
| 26 | 0.20 | 0.9 | 0.27 | 1.4 | 0.33 | 1.9 | 0.27 | 1.4 | ...... | ...... |
| 27 | 0.20 | 0.9 | 0.25 | 1.2 | 0.31 | 1.7 | 0.30 | 1.6 | ...... | ...... |
| 28 | 0.20 | 0.9 | 0.26 | 1.3 | 0.32 | 1.8 | 0.27 | 1.4 | ...... | ...... |
| 29 | 0.20 | 0.9 | 0.26 | 1.3 | 0.31 | 1.7 | 0.25 | 1.2 | ...... | ...... |
| 30 | 0.25 | 1.2 | 0.25 | 1.2 | 0.31 | 1.7 | 0.25 | 1.2 | ...... | ...... |
| 31 | 0.24 | 1.2 | 0.24 | 1.2 | ...... | ...... | 0.25 | 1.2 | ...... | ...... |

*a* Stream frozen after this date.
† Water rose and ice went out.
* Ice all out.

Monthly Discharge of Bone Creek at Lewis' Ranche, Sask., for 1911.

(Drainage area, 17 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (25-31) | 36.0 | 6.7 | 16.70 | 0.982 | 0.256 | 232 |
| April | 126.0 | 2.2 | 22.70 | 1.34 | 1.500 | 1351 |
| May | 7.0 | 1.8 | 2.54 | 0.149 | 0.172 | 156 |
| June | 4.4 | 1.0 | 1.95 | 0.115 | 0.128 | 116 |
| July | 2.7 | 0.9 | 1.29 | 0.076 | 0.088 | 79 |
| August | 1.6 | 0.8 | 1.26 | 0.074 | 0.085 | 77 |
| September | 10.4 | 1.2 | 2.51 | 0.148 | 0.165 | 149 |
| October | 2.7 | 1.2 | 1.57 | 0.092 | 0.106 | 96 |
| November | 1.3 | 1.2 | 1.23 | 0.072 | 0.029 | 27 |
| The period | ........ | ........ | ........ | ........ | 2.529 | 2283 |

Swiftcurrent Creek at Sinclair's Ranche (Lower Station) Sask.

This station was established on May 27, 1910, by H. R. Carscallen. It is located in the S.W. 1/4 Sec. 17, Tp. 10, Rge. 19, W. 3rd Mer., at the highway bridge on the surveyed trail from East End to Gull Lake, and just below the mouth of Bone Creek.

The channel is straight for 75 feet above and 20 feet below the station. The left bank has a gradual slope, is high and well wooded. The right bank rises abruptly. It is also high and well wooded. The stream-bed is sandy in character, free from vegetation and liable to shift at high water. The current at this point is sluggish.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left abutment. Low-water measurements are made by wading, 100 feet upstream.

The gauge is of the standard chain type. The box is nailed securely to the downstream side of the floor of the bridge. The length of chain from bottom of weight to marker is 21.2 feet The zero (elev., 84.83) is referred to a permanent iron bench-mark (assumed elev., 100.00) located on the right bank 600 feet upstream from the bridge.

During 1911, the gauge was read by George A. Mackintosh.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 15 | G. H. Whyte | 22.0 | 70.90 | 1.690 | 5.43 | 120.05 |
| May 9 | do | 28.0 | 28.84 | 1.179 | 3.53 | 33.95 |
| June 7 | do | 17.0 | 28.15 | 0.827 | 3.32 | 23.28 |
| July 8 | do | 16.0 | 24.30 | 0.630 | 3.22 | 15.37 |
| July 29 | do | 17.1 | 6.57 | 0.685 | 2.57 | 4.50 |
| Aug. 30 | do | | 8.04 | 0.859 | 2.78 | 6.88 |
| Oct. 6 | do | 17.0 | 25.39 | 1.114 | 3.47 | 28.33 |

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), Sask., for 1911.

| DAY. | May. | | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | ...... | 3.28 | 22.0 | 3.69 | 38.0 | 2.64 | 5.3 | 2.70 | 6.1 | 3.28 | 22.0 |
| 2 | | ...... | 3.24 | 20.0 | 3.78 | 42.0 | 2.61 | 4.8 | 2.64 | 5.3 | 3.29 | 22.0 |
| 3 | | ...... | 3.24 | 20.0 | 3.74 | 40.0 | 2.59 | 4.6 | 2.64 | 5.3 | 3.38 | 25.0 |
| 4 | | ...... | 3.25 | 20.0 | 3.73 | 40.0 | 2.60 | 4.7 | 2.90 | 10.0 | 3.44 | 28.0 |
| 5 | | ...... | 3.26 | 21.0 | 3.58 | 33.0 | 2.73 | 6.5 | 3.50 | 30.0 | 3.43 | 27.0 |
| 6 | ...... | ...... | 3.25 | 20.0 | 3.44 | 28.0 | 2.81 | 8.1 | 4.50 | 76.0 | 3.43 | 27.0 |
| 7 | ...... | ...... | 3.23 | 20.0 | 3.41 | 26.0 | 2.93 | 11.0 | 4.34 | 93.0 | 3.41 | 26.0 |
| 8 | ...... | ...... | 3.22 | 19.0 | 3.31 | 25.0 | 3.13 | 17.0 | 5.01 | 101.0 | 3.38 | 25.0 |
| 9 | ...... | ...... | 3.19 | 18.0 | 3.31 | 23.0 | 3.08 | 15.0 | 4.70 | 86.0 | 3.35 | 24.0 |
| 10 | ...... | ...... | 3.08 | 15.0 | 3.22 | 19.0 | 3.06 | 14.0 | 4.05 | 55.0 | 3.30 | 22.0 |
| 11 | ...... | ...... | 3.01 | 13.0 | 3.19 | 18.0 | 3.03 | 14.0 | 3.60 | 34.0 | 3.28 | 22.0 |
| 12 | 3.54 | 32.0 | 2.94 | 11.0 | 3.14 | 17.0 | 3.35 | 24.0 | 3.41 | 26.0 | 3.26 | 21.0 |
| 13 | 3.54 | 32.0 | 2.15 | 9.0 | 3.08 | 15.0 | 3.54 | 32.0 | 3.28 | 22.0 | 3.21 | 19.0 |
| 14 | 3.58 | 33.0 | 2.84 | 8.8 | 3.02 | 13.0 | 3.69 | 38.0 | 3.24 | 20.0 | 3.19 | 18.0 |
| 15 | 3.61 | 35.0 | 2.83 | 8.6 | 2.94 | 11.0 | 3.70 | 39.0 | 3.20 | 19.0 | 3.17 | 18.0 |
| 16 | 3.89 | 47.0 | 2.80 | 7.9 | 2.86 | 9.2 | 3.59 | 34.0 | 3.19 | 18.0 | 3.16 | 17.0 |
| 17 | 4.04 | 54.0 | 2.76 | 7.2 | 2.90 | 10.0 | 2.97 | 12.0 | 3.19 | 18.0 | 3.16 | 17.0 |
| 18 | 3.98 | 51.0 | 2.74 | 6.8 | 2.95 | 11.0 | 2.68 | 5.8 | 3.21 | 19.0 | 3.19 | 18.0 |
| 19 | 3.94 | 50.0 | 2.73 | 6.6 | 2.98 | 12.0 | 2.61 | 4.8 | 3.21 | 19.0 | 3.26 | 21.0 |
| 20 | 3.75 | 41.0 | 2.84 | 8.8 | 2.96 | 12.0 | 2.54 | 4.0 | 3.20 | 19.0 | 3.34 | 24.0 |
| 21 | 3.60 | 34.0 | 3.84 | 45.0 | 2.95 | 11.0 | 2.65 | 5.4 | 3.21 | 19.0 | 3.33 | 23.0 |
| 22 | 3.59 | 34.0 | 3.74 | 40.0 | 2.95 | 11.0 | 2.76 | 7.2 | 3.25 | 20.0 | 3.33 | 23.0 |
| 23 | 3.58 | 33.0 | 3.72 | 40.0 | 2.98 | 12.0 | 2.75 | 7.0 | 3.33 | 23.0 | 3.33 | 23.0 |
| 24 | 3.63 | 36.0 | 3.68 | 38.0 | 2.97 | 12.0 | 2.75 | 7.0 | 3.33 | 23.0 | 3.34 | 24.0 |
| 25 | 3.68 | 38.0 | 3.70 | 39.0 | 2.72 | 6.5 | 2.79 | 7.7 | 3.32 | 23.0 | 3.40 | 26.0 |
| 26 | 3.71 | 39.0 | 3.76 | 41.0 | 2.71 | 6.3 | 2.84 | 8.8 | 3.31 | 23.0 | 3.51 | 31.0 |
| 27 | 3.69 | 38.0 | 3.74 | 40.0 | 2.68 | 5.8 | 2.80 | 7.9 | 3.30 | 22.0 | 3.60 | 34.0 |
| 28 | 3.70 | 39.0 | 3.54 | 32.0 | 2.63 | 5.1 | 2.79 | 7.7 | 3.29 | 22.0 | 3.71 | 39.0 |
| 29 | 3.68 | 38.0 | 3.48 | 29.0 | 2.57 | 4.3 | 2.77 | 7.3 | 3.29 | 22.0 | 3.77 | 42.0 |
| 30 | 3.50 | 30.0 | 3.47 | 29.0 | 2.58 | 4.5 | 2.77 | 7.3 | 3.28 | 22.0 | 3.79 | 43.0 |
| 31 | 3.35 | 24.0 | ...... | ...... | 2.64 | 5.3 | 2.75 | 7.0 | ...... | ...... | 3.82 | 44.0 |

MONTHLY DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), Sask., for 1911.

(Drainage area, 365 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| May (12-31) | 54.0 | 24.0 | 37.9 | 0.104 | 0.077 | 1503 |
| June | 45.0 | 6.6 | 21.9 | 0.060 | 0.067 | 1303 |
| July | 42.0 | 4.3 | 17.0 | 0.047 | 0.054 | 1045 |
| August | 39.0 | 4.0 | 12.2 | 0.033 | 0.038 | 750 |
| September | 101.0 | 5.3 | 30.0 | 0.082 | 0.091 | 1785 |
| October | 44.0 | 17.0 | 25.6 | 0.07 | 0.081 | 1574 |
| The period | | | | | 408 | 7960 |

## SWIFTCURRENT CREEK AT SWIFT CURRENT, SASK.

This station was established April 30, 1910, by H. R. Carscallen. It is located at the traffic bridge on the north side of the C.P.R. tracks in the town of Swift Current on S.W. 1/4 Sec. 30, Tp. 15, Rge. 13, W. 3rd Mer.

The channel curves slightly, but is almost straight for about 300 feet above the station and is straight for about 300 feet below. The right bank is rather low with a gradual slope; the left bank is high. Both banks are clear of brush and undergrowth, and are not liable to overflow. The bed of the stream is sandy, with a few large stones, and is liable to shift at high stages. Weeds in the cross-section make it difficult to make discharge measurements during low stages of the stream, when the current is sluggish.

During ordinary stages, discharge measurements are made from the downstream side of the bridge, but at low stages they are made by wading near the bridge. The initial point for soundings is the inner face of the row of piles at end of the south approach.

The gauge is a plain staff graduated to feet and hundredths, spiked vertically to the inside face of the left abutment of the bridge. The zero of the gauge (elev., 85.71) is referred to a permanent iron bench-mark (assumed elev., 100.00) situated eight feet east of the south approach of the bridge.

The survey did not obtain sufficient data during 1910, to plot a gauge-height discharge curve, and the records for 1910 are therefore published in this report.

During 1910 and 1911, the gauge was read by C. E. Wesley, who lives within 200 yards of the bridge.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Swift Current, Sask., in 1910-11.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| 1910 | | | | | | |
| April 30 | H. R. Carscallen | 67.8 | 73.84 | 0.581 | 1.600 | 42.92 |
| May 25 | P. M. Sauder | 43.5 | 34.29 | 0.962 | 1.600 | 32.99* |
| June 6 | G. H. Whyte | 42.0 | 30.91 | 0.774 | 1.500 | 23.93* |
| June 23 | R. G. Swan | 42.0 | 29.88 | 0.726 | 1.600 | 21.69* |
| July 21 | do | 38.0 | 23.43 | 0.260 | 1.390 | 6.10* |
| Aug. 11 | do | 39.0 | 23.02 | 0.318 | 1.460 | 7.32* |
| Sept. 1 | do | 39.0 | 24.37 | 0.400 | 1.400 | 9.74* |
| Oct. 1 | do | 41.0 | 29.65 | 0.548 | 1.380 | 16.27* |
| Oct. 29 | do | 42.0 | 32.16 | 0.731 | 1.470 | 23.51* |
| 1911. | | | | | | |
| Mar. 27 | G. H. Whyte | 85.0 | 263.50 | 2.115 | 6.420 | 557.36† |
| April 25 | W. H. Greene | 74.1 | 123.18 | 1.520 | 2.340 | 187.18 |
| May 4 | J. C. Keith | 71.5 | 89.92 | 1.090 | 1.870 | 97.48 |
| May 22 | do | 70.5 | 74.93 | 0.840 | 1.700 | 63.33 |
| June 6 | do | 70.0 | 76.98 | 0.700 | 1.740 | 53.80 |
| July 4 | do | 71.0 | 81.47 | 0.610 | 1.825 | 50.09 |
| Sept. 5 | do | 29.0 | 17.12 | 1.060 | 1.430 | 18.23* |
| Oct. 25 | do | 70.0 | 40.0 | 0.400 | 1.290 | 15.99 |

* Measurement made upstream from regular station.
† Ice in stream.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Swift Current, Sask., for 1910.

| Day. | May. | | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.60 | 44 | 1.50 | 23 | 1.50 | 14 | 1.25 | 0 | 1.40 | 10 | 1.35 | 14 |
| 2 | 1.57 | 40 | 1.50 | 23 | 1.45 | 9 | 1.25 | 0 | 1.50 | 20 | 1.35 | 14 |
| 3 | 1.57 | 40 | 1.55 | 28 | 1.60 | 24 | 1.25 | 0 | 1.45 | 15 | 1.40 | 19 |
| 4 | 1.55 | 36 | 1.55 | 28 | 1.50 | 14 | 1.20 | 0 | 1.50 | 20 | 1.35 | 14 |
| 5 | 1.55 | 36 | 1.60 | 34 | 1.55 | 19 | 1.20 | 0 | 1.50 | 20 | 1.35 | 14 |
| 6 | 1.55 | 36 | 1.50 | 24 | 1.50 | 14 | 1.30 | 0 | 1.55 | 28 | 1.35 | 14 |
| 7 | 1.55 | 35 | 1.50 | 23 | 1.70 | 36 | 1.40 | 4 | 1.60 | 33 | 1.35 | 14 |
| 8 | 1.55 | 35 | 1.50 | 22 | 1.60 | 25 | 1.40 | 4 | 1.60 | 33 | 1.35 | 14 |
| 9 | 1.55 | 34 | 1.50 | 22 | 1.55 | 20 | 1.50 | 13 | 1.55 | 28 | 1.35 | 14 |
| 10 | 1.55 | 34 | 1.55 | 26 | 1.59 | 24 | 1.50 | 13 | 1.55 | 28 | 1.35 | 14 |
| 11 | 1.55 | 34 | 1.50 | 20 | 1.65 | 32 | 1.50 | 13 | 1.55 | 28 | 1.35 | 14 |
| 12 | 1.55 | 33 | 1.50 | 19 | 1.55 | 21 | 1.50 | 13 | 1.55 | 29 | 1.35 | 14 |
| 13 | 1.55 | 32 | 1.45 | 13 | 1.65 | 32 | 1.40 | 3 | 1.55 | 29 | 1.35 | 14 |
| 14 | 1.55 | 32 | 1.45 | 12 | 1.60 | 18 | 1.35 | 1 | 1.55 | 30 | 1.35 | 14 |
| 15 | 1.60 | 38 | 1.55 | 22 | 1.55 | 22 | 1.40 | 4 | 1.50 | 24 | 1.35 | 14 |
| 16 | 1.60 | 37 | 1.50 | 17 | 1.55 | 22 | 1.40 | 4 | 1.45 | 20 | 1.35 | 13 |
| 17 | 1.70 | 48 | 1.60 | 26 | 1.50 | 18 | 1.55 | 20 | 1.42 | 17 | 1.35 | 13 |
| 18 | 1.60 | 36 | 1.70 | 36 | 1.50 | 18 | 1.50 | 16 | 1.40 | 15 | 1.35 | 13 |
| 19 | 1.65 | 42 | 1.60 | 24 | 1.45 | 12 | 1.45 | 11 | 1.40 | 16 | 1.35 | 13 |
| 20 | 1.75 | 54 | 1.65 | 29 | 1.45 | 12 | 1.40 | 7 | 1.35 | 11 | 1.35 | 13 |
| 21 | 1.90 | 76 | 1.60 | 23 | 1.40 | 8 | 1.40 | 8 | 1.35 | 11 | 1.35 | 12 |
| 22 | 1.70 | 46 | 1.60 | 23 | 1.35 | 4 | 1.40 | 8 | 1.30 | 8 | 1.35 | 12 |
| 23 | 1.70 | 46 | 1.55 | 17 | 1.40 | 8 | 1.35 | 3 | 1.30 | 8 | 1.35 | 12 |
| 24 | 1.65 | 40 | 1.60 | 22 | 1.40 | 7 | 1.50 | 18 | 1.30 | 8 | 1.35 | 12 |
| 25 | 1.60 | 32 | 1.55 | 17 | 1.40 | 7 | 1.55 | 23 | 1.35 | 12 | 1.35 | 12 |
| 26 | 1.55 | 28 | 1.55 | 17 | 1.45 | 11 | 1.50 | 19 | 1.30 | 8 | 1.35 | 12 |
| 27 | 1.55 | 28 | 1.50 | 13 | 1.40 | 7 | 1.50 | 19 | 1.30 | 8 | 1.35 | 11 |
| 28 | 1.55 | 28 | 1.50 | 13 | 1.35 | 2 | 1.45 | 14 | 1.30 | 8 | 1.55 | 34 |
| 29 | 1.55 | 28 | 1.50 | 13 | 1.35 | 2 | 1.40 | 9 | 1.30 | 8 | 1.40 | 18 |
| 30 | 1.55 | 28 | 1.50 | 14 | 1.35 | 2 | 1.40 | 9 | 1.35 | 14 | 1.40 | 18 |
| 31 | 1.55 | 28 | ..... | ..... | 1.30 | 0.0 | 1.40 | 9 | ..... | ..... | 1.40 | 17 |

**SESSIONAL PAPER No. 25d**

Daily Gauge Height and Discharge of Swiftcurrent Creek at Swift Current, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge charge | Dis-Height | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | .. | 4.8 | 360 | 2.0 | 117 | 1.7 | 53 |
| 2 | | | 5.0 | 460 | 2.0 | 117 | 1.7 | 52 |
| 3 | | | 5.0 | 505 | 1.9 | 99 | 1.7 | 52 |
| 4 | | | 5.1 | 580 | 1.9 | 99 | 1.6 | 38 |
| 5 | | ... | 5.1 | 625 | 1.9 | 99 | 1.7 | 50 |
| 6 | | | 5.1 | 675 | 1.9 | 99 | 1.7 | 49 |
| 7 | | | 5.1 | 725 | 1.8 | 82 | 1.7 | 48 |
| 8 | | | 4.5 | 608 | 1.8 | 82 | 1.7 | 47 |
| 9 | | | 4.1 | 548 | 1.7 | 66 | 1.7 | 46 |
| 10 | | | 3.9 | 538 | 1.7 | 66 | 1.7 | 46 |
| 11 | | | 4.2 | 672 | 1.7 | 66 | 1.7 | 45 |
| 12 | | | 4.4 | 728 | 1.7 | 66 | 1.6 | 32 |
| 13 | | | 5.0 | 896 | 1.7 | 66 | 1.6 | 31 |
| 14 | | | 4.8 | 840 | 1.7 | 66 | 1.6 | 30 |
| 15 | | | 3.8 | 562 | 1.7 | 66 | 1.6 | 30 |
| 16 | | | 3.1 | 376 | 1.7 | 66 | 1.6 | 29 |
| 17 | | | 3.0 | 350 | 1.7 | 66 | 1.5 | 18 |
| 18 | | | 3.0 | 350 | 1.7 | 66 | 1.5 | 18 |
| 19 | | | 2.8 | 298 | 1.7 | 66 | 1.4 | 7 |
| 20 | | | 2.7 | 272 | 1.8 | 82 | 1.4 | 7 |
| 21 | | | 2.7 | 272 | 1.8 | 82 | 1.5 | 16 |
| 22 | | | 2.6 | 248 | 1.8 | 82 | 1.5 | 16 |
| 23 | | | 2.5 | 224 | 1.8 | 78 | 1.6 | 26 |
| 24 | | | 2.4 | 200 | 1.7 | 61 | 1.6 | 25 |
| 25 | | | 2.3 | 178 | 1.7 | 60 | 1.9 | 64 |
| 26 | | | 2.1 | 136 | 1.7 | 59 | 2.0 | 79 |
| 27 | 6.42 | 558 | 2.2 | 157 | 1.7 | 58 | 1.9 | 62 |
| 28 | 6.40 | 600 | 2.2 | 157 | 1.8 | 71 | 1.9 | 62 |
| 29 | 6.10 | 568 | 2.1 | 136 | 1.8 | 70 | 1.9 | 61 |
| 30 | 5.30 | 400 | 2.1 | 136 | 1.8 | 69 | 1.9 | 61 |
| 31 | 5.00 | 365 | ... | .. | 1.8 | 68 | .. | ... |

Daily Gauge Height and Discharge of Swiftcurrent Creek at Swift Current, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.9 | 61 | 1.3 | 3 | 1.4 | 14 | 1.6 | 44 |
| 2 | 1.9 | 60 | 1.3 | 4 | 1.4 | 14 | 1.5 | 32 |
| 3 | 1.9 | 60 | 1.3 | 4 | 1.4 | 14 | 1.6 | 45 |
| 4 | 1.8 | 47 | 1.3 | 4 | 1.4 | 14 | 1.6 | 45 |
| 5 | 1.9 | 60 | 1.3 | 4 | 1.4 | 15 | 1.6 | 46 |
| 6 | 1.8 | 48 | 1.3 | 4 | 1.4 | 15 | 1.5 | 34 |
| 7 | 1.9 | 62 | 1.4 | 11 | 1.6 | 38 | 1.5 | 34 |
| 8 | 1.8 | 48 | 1.6 | 32 | 1.6 | 38 | 1.5 | 34 |
| 9 | 1.8 | 49 | 1.6 | 32 | 1.7 | 52 | 1.5 | 35 |
| 10 | 1.8 | 50 | 1.6 | 32 | 2.1 | 116 | 1.5 | 35 |
| 11 | 1.7 | 38 | 1.5 | 22 | 2.2 | 136 | 1.5 | 36 |
| 12 | 1.7 | 38 | 1.5 | 22 | 2.2 | 137 | 1.5 | 36 |
| 13 | 1.6 | 26 | 1.5 | 22 | 2.1 | 118 | 1.5 | 36 |
| 14 | 1.5 | 16 | 1.5 | 22 | 1.9 | 82 | 1.4 | 25 |
| 15 | 1.5 | 16 | 1.6 | 34 | 1.8 | 68 | 1.4 | 25 |
| 16 | 1.4 | 7 | 1.5 | 23 | 1.7 | 54 | 1.4 | 25 |
| 17 | 1.5 | 17 | 1.5 | 23 | 1.7 | 54 | 1.4 | 26 |
| 18 | 1.5 | 17 | 1.5 | 23 | 1.6 | 40 | 1.4 | 26 |
| 19 | 1.5 | 18 | 1.5 | 23 | 1.6 | 40 | 1.5 | 38 |
| 20 | 1.5 | 18 | 1.4 | 13 | 1.5 | 29 | 1.5 | 38 |
| 21 | 1.5 | 18 | 1.4 | 13 | 1.5 | 29 | 1.5 | 39 |
| 22 | 1.4 | 8 | 1.4 | 13 | 1.6 | 42 | 1.4 | 27 |
| 23 | 1.5 | 18 | 1.4 | 13 | 1.6 | 42 | 1.4 | 27 |
| 24 | 1.5 | 18 | 1.4 | 13 | 1.6 | 42 | 1.5 | 39 |
| 25 | 1.4 | 9 | 1.4 | 14 | 1.6 | 43 | 1.4 | 28 |
| 26 | 1.4 | 9 | 1.5 | 24 | 1.5 | 31 | 1.3 | 17 |
| 27 | 1.4 | 9 | 1.4 | 14 | 1.5 | 31 | 1.3 | 17 |
| 28 | 1.4 | 9 | 1.4 | 14 | 1.5 | 31 | 1.3 | 17 |
| 29 | 1.3 | 3 | 1.4 | 14 | 1.6 | 44 | 1.4 | 28 |
| 30 | 1.3 | 3 | 1.4 | 14 | 1.6 | 44 | 1.4 | 28 |
| 31 | 1.3 | 3 | 1.4 | 14 | ...... | ....... | 1.4 | 28 |

Monthly Discharge of Swiftcurrent Creek at Swift Current, Sask., for 1910-11.

(Drainage area, 1015 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| **1910** | | | | | | |
| May | 76 | 28.0 | 37.50 | 0.037 | 0.043 | 2306 |
| June | 36 | 12.0 | 21.40 | 0.021 | 0.023 | 1273 |
| July | 36 | 0.0 | 15.00 | 0.015 | 0.017 | 922 |
| August | 23 | 0.0 | 8.55 | 0.008 | 0.009 | 526 |
| September | 33 | 8.0 | 18.20 | 0.018 | 0.020 | 1083 |
| October | 34 | 11.0 | 14.50 | 0.014 | 0.016 | 892 |
| The period | ....... | ......... | ......... | ......... | .128 | 7002 |
| **1911** | | | | | | |
| March (27-31) | 600 | 365 | 498.0 | 0.491 | 0.091 | 4939 |
| April | 896 | 136 | 427.0 | 0.421 | 0.470 | 25408 |
| May | 117 | 58 | 76.1 | 0.075 | 0.086 | 4679 |
| June | 79 | 7 | 40.0 | 0.039 | 0.044 | 2380 |
| July | 62 | 3 | 27.8 | 0.027 | 0.031 | 1709 |
| August | 34 | 3 | 16.7 | 0.016 | 0.018 | 1027 |
| September | 137 | 14 | 48.9 | 0.048 | 0.054 | 2910 |
| October | 46 | 17 | 31.9 | 0.031 | 0.036 | 1962 |
| The period | ....... | ......... | ......... | ....... | .830 | 45014 |

MISCELLANEOUS DISCHARGE MEASUREMENTS of Swiftcurrent Creek Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| Aug. 7....... | G. R. Elliott | A Coulee..... | Sec. 21-7-21-3. | | | ...... | 1 153 * |
| Aug. 12 ..... | do | do | do | ... | | | Nil |
| Aug. 12..... | do | do | Sec. 8-7-21-3 | | | | Nil. |
| Aug. 1....... | F. T. Fletcher. | Spring Creek | N.W. 34-8-22-3. | | | | 0 411 * |
| Aug. 1....... | do | do | N.E. 33-8-22-3. | | | | 0 575 * |

* Weir measurement.

## ANTELOPE LAKE DRAINAGE BASIN.

### *General Description.*

Antelope Lake is a small body of saline water, six miles long, and from one to one and a half miles wide, at an elevation of 2300 feet above sea-level. It lies in a deep depression north of the main line of the Canadian Pacific Railway, in Tp. 15, Rge. 18, W. 3rd Mer., and drains an area of about 350 square miles.

The lake receives its supply from Bridge Creek, which rises in the Cypress Hills. The altitude of the source of this creek is 2800 feet and it has an average fall of 15 feet per mile.

The valley traversed by Bridge Creek is narrow and quite shallow, rarely exceeding 100 feet in depth. The land lying along the creek bottom is very flat and liable to become inundated during periods of flood. The bench-land is rolling prairie, cut up by innumerable coulees which drain the surrounding country into the main valley.

The mean annual rainfall amounts to about 14 inches, most of which occurs during May, June and July. The creek has only a small flow, and is dry along most of its course for several months during the year.

A number of irrigation schemes receive their supply from this basin. The largest of these are Moorhead and Fearon's works, which divert water from Bridge Creek in Sec. 33, Tp. 10, Rge. 22, W. 3rd Mer.

### BRIDGE CREEK NEAR DOYLE'S RANCHE, SASK.

This station was established April 8, 1911, by G. H. Whyte, to obtain the discharge of Bridge Creek above Fearon and Moorhead's irrigation ditch. It is located on S.E. ¼ Sec. 33, Tp. 10, Rge. 22, W. 3rd Mer., and about 400 yards up-stream from the head-gate of the ditch and some two miles from Skull Creek post office.

The channel is straight for about 30 feet above and below the station. The right bank is low and covered with small shrubs, while the left is high and clear of tree growth. The bed of the stream is sandy and shifts. The current is moderate at all stages.

The gauge, which is read by Thos. Doyle, is a plain staff graduated to feet and hundredths, placed at the left side of the channel and referred to bench marks as follows:—(1) a spike in the top of the initial-point stake driven close to the ground on the left bank (elevation 8.26 above zero of the gauge); (2) a spike on the top of a plug driven close to the ground, 56 feet N 62° W of the rod (elevation 7.94 above the zero of the gauge).

Discharge measurements are made at the gauge by wading or during high stages at the government bridge three miles below. During most of the season, however, measurements are made with a weir at or near the gauge. The initial point for sounding is a plug driven close to the ground on the left bank, and a tagged wire is strung across the stream to mark the regular section.

DISCHARGE MEASUREMENTS of Bridge Creek near Doyle's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 8 | G. H. Whyte | 3 2 | 2 27 | 1 471 | 1 89 | 3 3400† |
| April 29 | do | 6 9 | 4 33 | 0 323 | 0 94 | 1.4000* |
| June 2 | do | | | | 0 74 | 0 3120* |
| June 29 | do | | | | 0 70 | 0 2385* |
| July 6 | G. R. Elliott | | | | | 0 3280* |
| July 21 | G. H. Whyte | | | | 0 67 | 0 2350* |
| Aug. 24 | do | | | | 0 66 | 0 1750* |
| Sept. 30 | do | | | | 0 74 | 0 3440* |

† Ice in stream.
* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek near Doyle's Ranche, Sask., for 1911.

| DAY. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.00 | 1.80 | 0 75 | 0.41 |
| 2 | | | 0 95 | 1 40 | 0 75 | 0.41 |
| 3 | | | 0.85 | 0 84 | 0 75 | 0.41 |
| 4 | | | 0.80 | 0.58 | 0.75 | 0.41 |
| 5 | | | 0.75 | 0.41 | 0 78 | 0.51 |
| 6 | | | 0.75 | 0 41 | 0 75 | 0.41 |
| 7 | | | 0.80 | 0.58 | 0 75 | 0.41 |
| 8 | | | 0 75 | 0 41 | 0 74 | 0.38 |
| 9 | | | 0 75 | 0 41 | 0 73 | 0.34 |
| 10 | | | 0.75 | 0 41 | 0 70 | 0 24 |
| 11 | | | 0 80 | 0.58 | 0 70 | 0 24 |
| 12 | | | 0 75 | 0 41 | 0 70 | 0.24 |
| 13 | | | 0.75 | 0 41 | 0 67 | 0.19 |
| 14 | | | 0 80 | 0 58 | 0 67 | 0.19 |
| 15 | | | 0 75 | 0.41 | 0 64 | 0.14 |
| 16 | | | 0 80 | 0 58 | 0 64 | 0 14 |
| 17 | | | 0.80 | 0 58 | 0 62 | 0 11 |
| 18 | | | 0 78 | 0.51 | 0 62 | 0.11 |
| 19 | | | 0 75 | 0 41 | 0 62 | 0.11 |
| 20 | | | 0.75 | 0.41 | 0.75 | 0.41 |
| 21 | | | 0 75 | 0 41 | 0 80 | 0.58 |
| 22 | | | 0 75 | 0.41 | 0 78 | 0.51 |
| 23 | | | 0 94 | 1.40 | 0 76 | 0.44 |
| 24 | | | 0.90 | 1 10 | 0 75 | 0.41 |
| 25 | | | 0.85 | 0.84 | 0.80 | 0.58 |
| 26 | | | 0.85 | 0.84 | 0.80 | 0.58 |
| 27 | | | 0.85 | 0 84 | 0.72 | 0.31 |
| 28 | | | 0.84 | 0 79 | 0 70 | 0 24 |
| 29 | 0 95 | 1 4 | 0 80 | 0 58 | 0.70 | 0.24 |
| 30 | 0 90 | 1.1 | 0 80 | 0.58 | 0.95 | 1.40 |
| 31 | | | 0.75 | 0 41 | | |

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek near Doyle's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.80 | 0.58 | 0.59 | 0.07 | 0.65 | 0.16 | 0.75 | 0.41 |
| 2 | 0.95 | 1.4 | 0.58 | 0.07 | 0.65 | 0.16 | 0.75 | 0.41 |
| 3 | 0.85 | 0.84 | 0.58 | 0.07 | 0.65 | 0.16 | 0.78 | 0.51 |
| 4 | 0.85 | 0.84 | 0.60 | 0.08 | 0.75 | 0.41 | 0.75 | 0.41 |
| 5 | 0.85 | 0.84 | 0.65 | 0.16 | 0.75 | 0.41 | 0.75 | 0.41 |
| 6 | 0.80 | 0.58 | 0.65 | 0.16 | 0.95 | 1.4 | 0.75 | 0.41 |
| 7 | 0.78 | 0.51 | 0.80 | 0.58 | 0.95 | 1.4 | 0.75 | 0.41 |
| 8 | 0.75 | 0.41 | 0.80 | 0.58 | 0.85 | 0.84 | 0.75 | 0.41 |
| 9 | 0.75 | 0.41 | 0.85 | 0.84 | 0.80 | 0.58 | 0.75 | 0.41 |
| 10 | 0.75 | 0.41 | 0.82 | 0.68 | 0.75 | 0.41 | 0.75 | 0.41 |
| 11 | 0.72 | 0.31 | 0.80 | 0.58 | 0.75 | 0.41 | 0.75 | 0.41 |
| 12 | 0.72 | 0.31 | 0.75 | 0.41 | 0.75 | 0.41 | 0.75 | 0.41 |
| 13 | 0.72 | 0.31 | 0.75 | 0.41 | 0.75 | 0.41 | 0.75 | 0.41 |
| 14 | 0.70 | 0.24 | 0.70 | 0.24 | 0.75 | 0.41 | 0.75 | 0.41 |
| 15 | 0.67 | 0.19 | 0.70 | 0.24 | 0.75 | 0.41 | 0.75 | 0.41 |
| 16 | 0.65 | 0.16 | 0.65 | 0.16 | 0.75 | 0.41 | 0.75 | 0.41 |
| 17 | 0.70 | 0.24 | 0.65 | 0.16 | 0.75 | 0.41 | 0.75 | 0.41 |
| 18 | 0.70 | 0.24 | 0.65 | 0.16 | 0.75 | 0.41 | 0.75 | 0.41 |
| 19 | 0.67 | 0.19 | 0.60 | 0.08 | 0.73 | 0.34 | 0.76 | 0.44 |
| 20 | 0.65 | 0.16 | 0.62 | 0.11 | 0.73 | 0.34 | 0.76 | 0.44 |
| 21 | 0.64 | 0.14 | 0.63 | 0.13 | 0.75 | 0.41 | 0.75 | 0.41 |
| 22 | 0.62 | 0.11 | 0.65 | 0.16 | 0.75 | 0.41 | 0.76 | 0.44 |
| 23 | 0.62 | 0.11 | 0.65 | 0.16 | 0.75 | 0.41 | 0.76 | 0.44 |
| 24 | 0.62 | 0.11 | 0.66 | 0.18 | 0.75 | 0.41 | 0.76 | 0.44 |
| 25 | 0.62 | 0.11 | 0.66 | 0.18 | 0.75 | 0.41 | .... | ...... |
| 26 | 0.60 | 0.08 | 0.66 | 0.18 | 0.75 | 0.41 | | ...... |
| 27 | 0.60 | 0.08 | 0.67 | 0.19 | 0.75 | 0.41 | | ...... |
| 28 | 0.60 | 0.08 | 0.67 | 0.19 | 0.70 | 0.24 | | ..... |
| 29 | 0.60 | 0.08 | 0.66 | 0.18 | 0.70 | 0.24 | | .... |
| 30 | 0.60 | 0.08 | 0.67 | 0.19 | 0.75 | 0.41 | | .. |
| 31 | 0.60 | 0.08 | 0.66 | 0.18 | ......... | | | .... |

MONTHLY DISCHARGE of Bridge Creek near Doyle's Ranche, Sask., for 1911.

(Drainage area, 6 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (29-30) | 1.40 | 1.10 | 1.250 | 0.208 | 0.016 | 5 |
| May | 1.80 | 0.41 | 0.658 | 0.109 | 0.126 | 40 |
| June | 1.40 | 0.11 | 0.370 | 0.062 | 0.069 | 22 |
| July | 1.40 | 0.08 | 0.330 | 0.055 | 0.063 | 20 |
| August | 0.84 | 0.07 | 0.250 | 0.042 | 0.048 | 15 |
| September | 1.40 | 0.16 | 0.455 | 0.076 | 0.085 | 27 |
| October (1-24) | 0.51 | 0.41 | 0.420 | 0.070 | 0.062 | 20 |
| The period | ...... | ..... | ...... | ......... | .469 | 149 |

## Fearon and Moorhead Bridge Creek Ditch near Skull Creek, Sask.

This station was established July 6, 1911, by G. R. Elliott, on Messrs. Fearon and Moorhead's irrigation ditch, which diverts water from Bridge Creek on the S.E. ¼ Sec. 33, Tp. 10, Rge. 22, W. 3rd Mer.

The gauge is located on S.E. ¼ Sec. 33, and is about 25 feet from the intake. It is a plain staff graduated into feet and inches, and is on the left bank of the ditch. The zero (elev., 95.37) is referred to a small nail on the left side of the head-gate marked "B.M." (assumed elev., 100.00).

The station is at a uniform cross-section of the ditch, which is three feet wide at the bottom with side slopes of two to one.

As the rod was established late in the season, no records of the flow were obtained. Considerable water was diverted through this ditch earlier in the season.

## Bridge Creek near Skull Creek, Sask.

This station was established July 29, 1909, by H. R. Carscallen. It is located at the highway bridge on the surveyed trail running eastward from Maple Creek on the N.E. ¼ Sec. 11, Tp. 11, Rge. 22, W. 3rd Mer. It is about four miles from Skull Creek Post Office and 27 miles from Maple Creek.

The channel is straight for 100 feet above and 30 feet below the station. Both banks are high and not liable to overflow. The stream is entirely devoid of tree growth. The bed of the creek is composed of clay, and may shift somewhat at high stages. There is a small amount of vegetation at the station. The current is sluggish.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to the centre pile on the downstream side of the bridge. It is referred to bench marks as follows:—(1) the head of a spike surrounded by a circle of nail-heads in the top of the stringer at the right or east abutment on the downstream side of the bridge (elevation, 9.83 feet above gauge zero); (2) the head of a spike in the top of a pointed six-inch wooden post firmly sunk into the ground on the left bank about 60 feet northwest of the gauge, the post blazed and marked "B.M." (elevation, 6.26 feet above gauge zero).

During high water, discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left, or west abutment. Low-water measurements are made near the bridge by wading, and at very low stages a weir is used.

During 1911, the gauge was read by James Mann.

### Discharge Measurements of Bridge Creek near Skull Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 8 | G. H. Whyte | | | | | Nil. † |
| June 2 | do | | | | 0.99 | 0.022‡ |
| Sept. 30 | do | | | | 1.08 | 0.145‡ |

† Creek was full of snow.
‡ Weir measurements.

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek near Skull Creek, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height | Discharge | Gauge Height | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | *a* | | 1.68 | 1.30 | 1.12 | 0.13 |
| 2 | *a* | | 1.59 | 1.00 | 0.97 | 0.03 |
| 3 | *a* | | 1.57 | 0.95 | 0.97 | 0.03 |
| 4 | *a* | | 1.39 | 0.52 | *1.00 | 0.04 |
| 5 | *a* | | 1.43 | 0.61 | 1.01 | 0.05 |
| 6 | *a* | | 1.21 | 0.22 | 1.04 | 0.07 |
| 7 | *a* | | *1.14 | 0.15 | 1.08 | 0.10 |
| 8 | *a* | | 1.04 | 0.07 | 1.09 | 0.10 |
| 9 | *a* | | 1.04 | 0.05 | 1.11 | 0.12 |
| 10 | *a* | | 1.00 | 0.04 | 0.87 | Nil |
| 11 | *a* | | 1.01 | 0.05 | *0.80 | " |
| 12 | *a* | | 1.15 | 0.16 | 0.78 | " |
| 13 | 1.86 | 1.90 | 1.17 | 0.18 | 0.77 | " |
| 14 | 1.90 | 2.10 | 1.23 | 0.26 | 0.75 | " |
| 15 | 2.15 | 3.20 | 1.36 | 0.47 | Dry | " |
| 16 | 2.12 | 3.00 | 1.25 | 0.28 | " | " |
| 17 | 2.05 | 2.70 | 1.35 | 0.45 | " | " |
| 18 | 1.96 | 2.30 | 1.25 | 0.28 | " | " |
| 19 | 1.94 | 2.30 | 1.16 | 0.17 | " | " |
| 20 | 1.90 | 2.10 | 1.16 | 0.17 | " | " |
| 21 | 1.63 | 1.10 | 1.16 | 0.17 | " | " |
| 22 | 1.62 | 1.10 | 1.20 | 0.21 | " | " |
| 23 | 1.58 | 0.98 | 1.24 | 0.27 | 1.00 | 0.04 |
| 24 | 1.61 | 1.10 | *1.27 | 0.32 | 1.10 | 0.11 |
| 25 | 1.63 | 1.10 | 1.30 | 0.36 | 1.12 | 0.13 |
| 26 | 1.69 | 1.30 | 1.38 | 0.50 | 1.13 | 0.14 |
| 27 | *1.54 | 1.87 | 1.48 | 0.72 | 1.10 | 0.11 |
| 28 | 1.37 | 1.49 | *1.44 | 0.63 | 1.06 | 0.08 |
| 29 | 1.11 | 1.12 | 1.39 | 0.52 | 1.11 | 0.12 |
| 30 | 1.40 | 1.54 | 1.35 | 0.45 | 1.17 | 0.18 |
| 31 | .... | .... | 1.24 | 0.27 | .... | .... |

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek near Skull Creek, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.12 | 0.13 | Dry. | Nil. | Dry. | Nil. | * 1.15 | 0.16 |
| 2 | 0.97 | 0.03 | " | " | " | " | 1.21 | 0.22 |
| 3 | 1.66 | 1.20 | " | " | " | " | 1.26 | 0.30 |
| 4 | 1.54 | 0.87 | " | " | " | " | 1.32 | 0.40 |
| 5 | 1.48 | 0.72 | " | " | " | " | 1.33 | 0.41 |
| 6 | 1.41 | 0.56 | " | " | " | " | 1.33 | 0.41 |
| 7 | 1.18 | 0.19 | " | " | 1.30 | 0.36 | 1.35 | 0.45 |
| 8 | 1.21 | 0.22 | " | " | 1.90 | 2.10 | * 1.30 | 0.36 |
| 9 | * 1.23 | 0.26 | " | " | 1.89 | 2.10 | 1.25 | 0.28 |
| 10 | 1.26 | 0.30 | " | " | * 1.82 | 1.80 | 1.21 | 0.22 |
| 11 | 1.14 | 0.15 | " | " | 1.76 | 1.60 | 1.17 | 0.18 |
| 12 | 1.00 | 0.04 | " | " | 1.78 | 1.60 | 1.14 | 0.15 |
| 13 | 0.98 | 0.03 | " | " | 1.09 | 0.10 | 1.14 | 0.15 |
| 14 | 0.96 | 0.02 | " | " | 1.52 | 0.81 | 1.15 | 0.16 |
| 15 | 0.94 | 0.02 | " | " | 1.47 | 0.69 | 1.18 | 0.19 |
| 16 | 0.82 | Nil. | " | " | 1.40 | 0.54 | 1.21 | 0.22 |
| 17 | 0.78 | " | " | " | * 1.50 | 0.76 | 1.22 | 0.24 |
| 18 | Dry. | " | " | " | 1.58 | 0.98 | 1.24 | 0.27 |
| 19 | " | " | " | " | 1.55 | 0.90 | 1.25 | 0.28 |
| 20 | " | " | " | " | 1.53 | 0.84 | 1.26 | 0.30 |
| 21 | " | " | " | " | 1.58 | 0.98 | 1.27 | 0.32 |
| 22 | " | " | " | " | 1.87 | 2.00 | 1.28 | 0.33 |
| 23 | " | " | " | " | 1.49 | 0.74 | 1.30 | 0.36 |
| 24 | " | " | " | " | 1.35 | 0.45 | 1.30 | 0.36 |
| 25 | " | " | " | " | 1.31 | 0.38 | 1.32 | 0.40 |
| 26 | " | " | " | " | 1.28 | 0.33 | 1.34 | 0.43 |
| 27 | " | " | " | " | 1.26 | 0.30 | 1.36 | 0.47 |
| 28 | " | " | " | " | 1.26 | 0.30 | 1.37 | 0.49 |
| 29 | " | " | " | " | 1.29 | 0.34 | 1.38 | 0.50 |
| 30 | " | " | " | " | 1.08 | 0.10 | ...... | *a* |
| 31 | " | " | " | " | ...... | ...... | ...... | *a* |

*a* Stream frozen.
* Gauge height interpolated.

MONTHLY DISCHARGE of Bridge Creek near Skull Creek, Sask., for 1911.

(Drainage area, 15 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (13-30) | 3.20 | 0.12 | 1.57 | 0.105 | 0.070 | 56 |
| May | 1.30 | 0.04 | 0.381 | 0.025 | 0.029 | 23 |
| June | 0.18 | 0.00 | 0.053 | 0.004 | 0.004 | 3 |
| July | 1.20 | 0.00 | 0.153 | 0.010 | 0.012 | 9 |
| August | 0.00 | 0.00 | 0.00 | | | 0 |
| September | 2.10 | 0.00 | 0.703 | 0.047 | 0.052 | 42 |
| October (1-29) | 0.50 | 0.15 | 0.311 | 0.021 | 0.023 | 18 |
| The period | ........ | ........ | ..... | ....... | .190 | 151 |

## BRIDGE CREEK AT GULL LAKE, SASK.

This station was established March 29, 1911, by G. H. Whyte, on the highway bridge near the Canadian Pacific Railway station on S. E. ¼ Sec. 23, Tp. 13, Rge. 19, W. 3rd Mer.

The channel is slightly curved for 160 feet above, but is straight for 80 feet below. Both banks are low and liable to overflow. The bed of the stream is sandy and liable to shift.

Discharge measurements are made from the bridge at high stages or by wading near the section. At low stages a weir may be used. The initial point for sounding is on the left-hand down-stream side of the bridge and is marked with a broad arrow.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the down-stream side of the right abutment. The zero (elev., 95.775) is referred to a permanent iron bench-mark (assumed elev., 100.00), located on the right bank 182 feet from the gauge and 158 feet from the northwest corner of the Canadian Pacific Railway station.

The gauge was read by J. D. Lloyd and J. B. Scott.

DISCHARGE MEASUREMENTS of Bridge Creek at Gull Lake, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Mar. 29 | G. H. Whyte | 22.0 | 5.54 | 0.713 | 0.895 | 3.950 |
| May 5 | J. C. Keith | 4.0 | 1.10 | 0.735 | 0.525 | 0.801 |
| May 8 | G. H. Whyte | 5.1 | 2.74 | 0.722 | 0.670 | 1.978 |
| May 23 | J. C. Keith | | | | | Nil. |
| June 9 | do | | | | | Nil. |
| July 5 | do | | | | | Nil. |
| Sept. 5 | do | | | | | Nil. |
| Oct. 26 | do | | | | | Nil. |

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek at Gull Lake, Sask., for 1911.

| DAY. | March. | | April. | | May. | |
|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.90 | 4.0 | 0.59 | 1.30 |
| 2 | | | 0.91 | 4.0 | 0.59 | 1.30 |
| 3 | | | 0.90 | 4.0 | 0.59 | 1.30 |
| 4 | | | 0.93 | 4.0 | 0.58 | 1.20 |
| 5 | | | 0.90 | 4.0 | 0.56 | 1.10 |
| 6 | | | 0.90 | 4.0 | 0.56 | 1.10 |
| 7 | | | 0.99 | 4.0 | 0.55 | 1.00 |
| 8 | | | 0.90 | 4.0 | 0.52 | 0.77 |
| 9 | | | 1.10 | 6.0 | 0.48 | 0.48 |
| 10 | | | 1.90 | 14.0 | 0.42 | 0.10 |
| 11 | | | 1.70 | 12.0 | 0.38 | 0.0 |
| 12 | | | 1.30 | 8.0 | 0.38 | 0.0 |
| 13 | | | 0.80 | 3.1 | 0.39 | 0.0 |
| 14 | | | 0.70 | 2.2 | 0.39 | 0.0 |
| 15 | | | 0.90 | 4.0 | 0.39 | 0.0 |
| 16 | | | | a | | |
| 17 | | | | | 0.38 | 0.0 |
| 18 | | | | | 0.38 | 0.0 |
| 19 | | | | | 0.36 | 0.0 |
| 20 | | | | | | b |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | 0.63 | 1.6 | | |
| 24 | | | 0.59 | 1.3 | | |
| 25 | | | 0.59 | 1.3 | | |
| 26 | | | 0.59 | 1.3 | | |
| 27 | | | 0.58 | 1.2 | | |
| 28 | | | 0.62 | 1.6 | | |
| 29 | 0.9 | 4.0 | 0.69 | 2.1 | | |
| 30 | 0.9 | 4.0 | | a | | |
| 31 | 0.9 | 4.0 | | | | |

*a* No observations April 16 to 22 and 30.
*b* Dry to end of season.

MONTHLY DISCHARGE of Bridge Creek at Gull Lake, Sask., for 1911.

(Drainage area, 213 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (29-31) | 4.0 | 4.0 | 4.000 | 0.019 | 0.002 | 24 |
| April (1-15, 23-29) | 14.0 | 1.3 | 4.170 | 0.020 | 0.016 | 18 |
| May (1-18) | 1.3 | 0.0 | 0.311 | 0.001 | 0.001 | 19 |
| The period | | | | | 019 | 61 |

## LAKE OF THE NARROWS DRAINAGE BASIN.

### *General Description.*

Lake of the Narrows is a small lake, three miles long and one and a half miles wide, in Township 3, Range 23, west of the 3rd Meridian. It has a drainage area of about 200 square miles.

The principal stream in the basin is Skull Creek, which rises in the eastern slope of Cypress Hills. It flows through a narrow valley for the greater part of its course, but as it nears the lake, the valley widens out into large meadows. The surrounding country is rolling prairie.

In very dry years such as 1910, Skull Creek goes dry for a short time. The mean annual precipitation in the drainage basin is about 13 inches.

There are several small irrigation ditches in this drainage basin, the largest of which is Moorhead and Fearon's ditch, which diverts water from Skull Creek on the N.E. ¼ Sec. 29, Tp. 10, Rge. 22, W. 3rd Mer.

### SKULL CREEK AT DOYLE'S RANCHE.

This station was established April 8, 1911, by G. H. Whyte, to obtain the discharge of the stream above all ditches. It is located on the N.E. ¼ Sec. 29, Tp. 10, Rge. 22, W. 3rd Mer., about one-quarter of a mile above the head-gate of Fearon and Moorhead's irrigation ditch, one and a half miles above Skull Creek post office, and half a mile upstream from Thos. Doyle's house.

The channel is straight for about twenty feet above and below the station. The right bank is high, while the left is low and liable to overflow during high-water stages. Both banks are well wooded. The bed is composed of sand and gravel, which may shift during high water. The current is fairly swift.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank. The zero (elev., 87.20) is referred to a permanent iron bench-mark (assumed elev., 100.00), located 350 feet N 32° E of the gauge.

Discharge measurements are made at low and ordinary stages by wading or with a weir. At high stages, measurements are made from the traffic bridge at the lower station, which is three miles downstream.

The gauge was read by Mr. Thomas Doyle.

DISCHARGE MEASUREMENTS of Skull Creek at Doyle's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft per sec.* | *Feet.* | *Sec.-ft.* |
| April 9 | G. H. Whyte | 15.4 | 18.18 | 2.788 | 1.965 | 50.700 |
| April 29 | do | 15.4 | 10.31 | 0.869 | 0.980 | 8.960 |
| June 2 | do | 8.9 | 5.08 | 0.594 | 0.740 | 3.020 |
| June 29 | do | 11.0 | 3.47 | 0.562 | 0.750 | 1.95 |
| July 21 | do | | | | 0.700 | 0.985 |
| July 25 | do | | | | 0.650 | 0.736 |
| Aug. 24 | do | | | | 0.730 | 0.837 |
| Oct. 1 | do | 10.0 | 3.27 | 0.633 | 0.780 | 2.070 |

DAILY GAUGE HEIGHT AND DISCHARGE of Skull Creek at Doyle's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | .... | 0.95 | 8.0 | 0.75 | 3.3 |
| 2 | | .... | 0.90 | 6.3 | 0.75 | 3.3 |
| 3 | | | 0.85 | 4.8 | 0.75 | 3.3 |
| 4 | | | 0.85 | 4.9 | 0.75 | 3.2 |
| 5 | | | 0.85 | 5.0 | 0.80 | 4.5 |
| 6 | | ..... | 0.80 | 3.6 | 0.75 | 3.1 |
| 7 | | .... | 0.85 | 5.1 | 0.75 | 3.1 |
| 8 | a1.10 | 14.0 | 0.80 | 3.6 | 0.75 | 3.0 |
| 9 | 1.25 | 20.0 | 0.85 | 5.2 | 0.75 | 3.0 |
| 10 | 2.25 | 62.0 | 0.80 | 3.8 | 0.73 | 2.4 |
| 11 | 1.20 | 18.0 | 0.75 | 2.6 | 0.73 | 2.4 |
| 12 | 1.05 | 12.0 | 0.80 | 3.9 | 0.70 | 1.7 |
| 13 | 0.95 | 7.8 | 0.75 | 2.7 | 0.70 | 1.7 |
| 14 | 1.15 | 16.0 | 0.90 | 7.3 | 0.70 | 1.6 |
| 15 | 1.00 | 9.7 | 0.85 | 5.6 | 0.67 | 1.0 |
| 16 | 1.75 | 41.0 | 0.90 | 7.4 | 0.66 | 0.8 |
| 17 | 1.65 | 37.0 | 0.80 | 4.2 | 0.66 | 0.8 |
| 18 | 1.70 | 39.0 | 0.80 | 4.2 | 0.65 | 0.7 |
| 19 | 1.25 | 20.0 | 0.85 | 5.8 | 0.65 | 0.7 |
| 20 | 1.10 | 14.0 | 0.80 | 4.3 | 0.75 | 2.4 |
| 21 | 1.15 | 16.0 | 0.78 | 3.9 | 0.80 | 3.6 |
| 22 | 1.25 | 20.0 | 0.76 | 3.3 | 0.75 | 2.3 |
| 23 | 1.00 | 9.7 | 0.94 | 9.3 | 0.67 | 0.8 |
| 24 | 0.95 | 7.8 | 0.90 | 7.9 | 0.67 | 0.8 |
| 25 | 1.00 | 9.7 | 0.87 | 7.8 | 0.75 | 2.2 |
| 26 | 0.95 | 7.8 | 0.85 | 7.2 | 0.80 | 3.3 |
| 27 | 0.95 | 7.8 | 0.85 | 7.2 | 0.72 | 1.4 |
| 28 | 0.90 | 6.0 | 0.85 | 7.2 | 0.70 | 1.0 |
| 29 | 0.95 | 7.8 | 0.80 | 4.6 | 0.70 | 1.0 |
| 30 | 0.95 | 8.0 | 0.80 | 4.6 | 0.90 | 6.0 |
| 31 | ...... | ...... | 0.78 | 4.1 | ...... | ...... |

DAILY GAUGE HEIGHT AND DISCHARGE of Skull Creek at Doyle's Ranche, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0 85 | 4 6 | 0 65 | 0 4 | 0 74 | 1 1 | 0 78 | 1 9 |
| 2 | 0 95 | 7 8 | 0 65 | 0 4 | 0 75 | 1 3 | 0 78 | 1 9 |
| 3 | 0 85 | 4 6 | 0 65 | 0 4 | 0 75 | 1 3 | 0 78 | 1 9 |
| 4 | 0 85 | 4 6 | 0 65 | 0 4 | 0 85 | 3 6 | 0 78 | 1 9 |
| 5 | 0 85 | 4 6 | 0 70 | 0 9 | 0 87 | 4 1 | 0 78 | 1.9 |
| 6 | 0 80 | 3 1 | 0 75 | 1 8 | 1 00 | 8 5 | 0 78 | 1 9 |
| 7 | 0 76 | 2 3 | 0 75 | 1 7 | 1 00 | 8 5 | 0 80 | 2.3 |
| 8 | 0 73 | 1 6 | 0 82 | 3 3 | 0 90 | 5 0 | 0 80 | 2 3 |
| 9 | 0 75 | 2 0 | 0 80 | 2 6 | 0 90 | 5 0 | 0 80 | 2.3 |
| 10 | 0 75 | 2 0 | 0 80 | 2 6 | 0 85 | 3 6 | 0.78 | 1.9 |
| 11 | 0 72 | 1 4 | 0 75 | 1 6 | 0 80 | 2 3 | 0 80 | 2 3 |
| 12 | 0 72 | 1 4 | 0 75 | 1 6 | 0 80 | 2 3 | 0 80 | 2 3 |
| 13 | 0 70 | 1 0 | 0 75 | 1 6 | 0 80 | 2 3 | 0 80 | 2.3 |
| 14 | 0 70 | 1 0 | 0 73 | 1 2 | 0 80 | 2 3 | 0 80 | 2.3 |
| 15 | 0 73 | 1 6 | 0 70 | 0 7 | 0 80 | 2 3 | 0 80 | 2 3 |
| 16 | 0 75 | 2 0 | 0 70 | 0 7 | 0 80 | 2 3 | 0 80 | 2.3 |
| 17 | 0 75 | 2 0 | 0 70 | 0 7 | 0 82 | 2 8 | 0 85 | 3 6 |
| 18 | 0 72 | 1 4 | 0 70 | 0 6 | 0 82 | 2 8 | 0 85 | 3 6 |
| 19 | 0 72 | 1 4 | 0 72 | 0 9 | 0 82 | 2 8 | 0 86 | 3 8 |
| 20 | 0 72 | 1 4 | 0 72 | 0 8 | 0 82 | 2 8 | 0 86 | 3.8 |
| 21 | 0 70 | 1 0 | 0 72 | 0 8 | 0 83 | 3 0 | 0.88 | 4.4 |
| 21 | 0 70 | 1 0 | 0 72 | 0 8 | 0 85 | 3 6 | 0.88 | 4 4 |
| 23 | 0 68 | 0 8 | 0 73 | 0 9 | 0 85 | 3 6 | 0 88 | 4 4 |
| 24 | 0 68 | 0 8 | 0 73 | 0 9 | 0 85 | 3 6 | 0 88 | 4.4 |
| 25 | 0 66 | 0.6 | 0 73 | 1 0 | 0 85 | 3 6 | ........ | ..*b*.... |
| 26 | 0 65 | 0 5 | 0 75 | 1 3 | 0 83 | 3 0 | ........ | ........ |
| 27 | 0 65 | 0 5 | 0 76 | 1 5 | 0 80 | 2 3 | ........ | ........ |
| 28 | 0 63 | 0 4 | 0 75 | 1 3 | 0 80 | 2 3 | ........ | ........ |
| 29 | 0 63 | 0 4 | 0 75 | 1 3 | 0 80 | 2 3 | ........ | ........ |
| 30 | 0 64 | 0 4 | 0 75 | 1 3 | 0 80 | 2.3 | ........ | ........ |
| 31 | 0 65 | 0 4 | 0 76 | 1 5 | ........ | ........ | ........ | ........ |

*a* Sta. established.
*b* Stream frozen over.

MONTHLY DISCHARGE of Skull Creek at Doyle's Ranche, Sask., for 1911.

(Drainage area, 20 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (8-30) | 6 2 | 6 0 | 17 90 | 0 895 | 0 766 | 815 |
| May | 9 3 | 2 6 | 5 33 | 0 266 | 0 307 | 328 |
| June | 6 0 | 0 7 | 2 28 | 0 114 | 0.127 | 136 |
| July | 7 8 | 0 4 | 1 89 | 0 094 | 0 108 | 116 |
| August | 3 3 | 0 4 | 1 21 | 0 065 | 0 075 | 74 |
| September | 8 5 | 1 1 | 3 22 | 0 161 | 0 180 | 192 |
| October (1-24) | 4 4 | 1 9 | 2 77 | 0.138 | 0 123 | 132 |
| The period | ... | ... | ...... | ........ | 1 686 | 1793 |

FEARON AND MOORHEAD SKULL CREEK DITCH, NEAR SKULL CREEK, SASK.

This station was established July 6, 1911, by G. R. Elliott, on Messrs. Fearon and Moorhead's ditch, which diverts water from Skull Creek on the N.E. ¼ Sec. 29, Tp. 10, Rge. 22, W. 3rd Mer.

The gauge is located on the N.E. ¼ Sec. 29, and is about ninety feet from the intake. It is a plain staff graduated into feet and inches, and is on the right bank of the ditch. The zero (elev., 90.86) is referred to a permanent iron bench-mark (assumed elev., 100.00), located 180 feet S 25′ E.

The station is at a uniform cross-section of the ditch, which is five feet wide at the bottom with side slopes of one to one.

As the gauge was not established until late in the season, no gauge-height observations were obtained. Considerable water was diverted through this ditch earlier in the season.

Discharge Measurements of Fearon and Moorhead Skull Creek Ditch near Skull Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| July 6 | G. R. Elliott | | | | 5 | 0 239* |
| Aug. 22 | G. H. Whyte | | | | | Nil. |

* Weir measurement.

Fearon and Moorhead Main Ditch near Skull Creek, Sask.

This station was established July 4, 1911, by G. R. Elliott, on Messrs. Fearon and Moorhead's main irrigation ditch, which diverts water from Skull and Bridge Creeks. The two branches join on the N.E. ¼ Sec. 33, Tp. 10, Rge. 22, W. 3rd Mer.

The gauge is located on the flume on the N.E. ¼ Sec. 33 and about 75 feet from the junction of the two branches of the ditch. It is a plain staff graduated to feet and inches, and is nailed at the centre of the right side of the flume. The zero (elev., 89.19) is referred to the top of a rock (assumed elev., 100.00), situated 140 feet northeast of the flume and on the right side of the ditch.

The flume is constructed of timber and has a bottom width of eight feet, with sides two feet in height.

As the gauge was established late in the irrigation season, no observations of gauge-height were obtained.

Discharge Measurements of Fearon and Moorhead Main Ditch near Skull Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| June 2 | G. H. Whyte | 5 4 | 2 55 | 0 557 | | 1 420 |
| June 2 | do | | | | | 0 165*a.b. |
| July 3 | F. T. Fletcher & G. H. Whyte | | | | | 1 133*a.c. |
| July 3 | do | | | | | 1 251* |
| July 4 | G. R. Elliott | | | | 3 | 0 937* |
| Aug. 22 | G. H. Whyte | | | | | Nil. |

* Weir measurement.

a. Measurement made above reservoir at 14-11-22-3.

b. In 8 miles of ditch there was seepage loss of 1 255 sec.-ft. or 0.157 sec.-ft. per mile. Warm wind and very dry.

c. In 8 miles of ditch there was seepage loss of 0 118 sec.-ft. or 0.015 sec.-ft. per mile. Cool and had been raining.

Skull Creek near Skull Creek, Sask.

This station was established June 29, 1908, by F. T. Fletcher. It is located on the N.W. ¼ Sec. 10, Tp. 11, Rge. 22, W. 3rd Mer., at the highway bridge on the surveyed trail running east from Maple Creek. It is about two miles north of Skull Creek post office, and about twenty-five miles east of Maple Creek, by trail.

The channel is straight for 100 feet above and 150 feet below the station. Both banks are high and not liable to overflow. The banks are clear of brush for about fifty feet above and below the station, and then become densely wooded. The bed of the stream is composed of sand, and may shift somewhat at high stages. The current is moderate.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to the centre pile on the upstream, or south side of the bridge. It is referred to bench-marks as follows:—(1) a bolt-head surrounded by a circle of nails in the top of the stringer at the right, or east, abutment on the upstream side of the bridge (elevation, 11.96 feet above the zero of the gauge); (2) the top of the iron pin in the road mound about fifty feet southeast of the bridge on the right, or east bank (elevation, 14.19 feet above the zero of the gauge).

Discharge measurements are made from the upstream side of the bridge. The initial point for soundings is the inner face of the right abutment of the bridge. There is only one channel at low stages, but owing to the centre row of piles supporting the bridge there are two channels at high stages of the stream. Low-water measurements are made at or near the gauge by wading, and at very low stages a weir is used.

During 1911, the gauge was read by James Mann.

### Discharge Measurements of Skull Creek near Skull Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| April 7 | G. H. Whyte | 6.7 | 5.98 | 0.624 | 1.350 | 3.730 |
| April 9 | do | 21.0 | 36.90 | 1.147 | 3.350 | 42.570 |
| June 2 | do | 5.8 | 1.48 | 0.824 | 0.520 | 1.220 |
| July 12 | G. R. Elliott | 5.0 | 3.34 | 0.161 | 0.535 | 1.540 |
| July 25 | G. H. Whyte | ..... | ..... | ..... | 0.430 | 0.605† |
| Aug. 24 | do | ..... | ..... | ..... | 0.420 | 0.598† |
| Sept. 30 | do | ..... | ..... | ..... | 0.630 | 1.551† |

† Weir measurement.

### Daily Gauge Height and Discharge of Skull Creek near Skull Creek, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | | | ..... | ..... | 1.34 | 6.9 | 0.60 | 1.5 |
| 2 | | | b | | 1.22 | 5.8 | 0.52 | 1.1 |
| 3 | | | 1.46 | 8.1 | 1.21 | 5.7 | 0.50 | 1.1 |
| 4 | | | b | | 0.88 | 3.2 | 0.53* | 1.2 |
| 5 | | | b | | 0.84 | 2.9 | 0.56 | 1.4 |
| 6 | | | b | | 0.94 | 3.6 | 0.56 | 1.4 |
| 7 | | | 1.35 | 7.0 | 0.83 | 2.8 | 0.57 | 1.5 |
| 8 | | | 1.35 | 7.0 | 0.69 | 2.0 | 0.59 | 1.6 |
| 9 | | | 2.65 | 26.0 | 0.69 | 2.0 | 0.59* | 1.6 |
| 10 | | | 4.39 | 74.0 | 0.68 | 1.9 | 0.59 | 1.6 |
| 11 | | | 3.42 | 45.0 | 0.70 | 2.0 | 0.57* | 1.5 |
| 12 | | | 2.99 | 33.0 | 0.70 | 2.0 | 0.55 | 1.4 |
| 13 | | | 2.44 | 22.0 | 0.69 | 2.0 | 0.54 | 1.4 |
| 14 | | | 1.31 | 6.6 | 0.69 | 2.0 | 0.50 | 1.1 |
| 15 | | | 2.15 | 17.0 | 0.70 | 2.0 | 0.42 | 0.8 |
| 16 | | | 2.20 | 18.0 | 0.71 | 2.1 | 0.34 | 0.5 |
| 17 | | | 3.08 | 35.0 | 0.71 | 2.1 | 0.29 | 0.4 |
| 18 | | | 2.06 | 16.0 | 0.70 | 2.0 | 0.29 | 0.4 |
| 19 | | | 2.11 | 16.0 | 0.88 | 3.2 | 0.25 | 0.3 |
| 20 | | | 1.92 | 11.0 | 0.69 | 2.0 | 0.39 | 0.7 |
| 21 | | | 1.58 | 9.3 | 0.69 | 2.0 | 0.68 | 2.2 |
| 22 | | | 1.52 | 8.7 | 0.69 | 2.0 | 0.58 | 1.7 |
| 23 | | | 1.45 | 8.0 | 0.68 | 1.9 | 0.56 | 1.6 |
| 24 | | | 1.46 | 8.1 | 0.69* | 2.0 | 0.56 | 1.6 |
| 25 | 4.86 | a | 1.46 | 8.1 | 0.72 | 2.1 | 0.56 | 1.6 |
| 26 | 4.00 | a | 1.46 | 8.1 | 0.84 | 2.9 | 0.57 | 1.6 |
| 27 | 4.25 | a | 1.16 | 5.3 | 0.86 | 3.0 | 0.56 | 1.6 |
| 28 | 4.86 | a | 1.41 | 7.6 | 0.83* | 2.8 | 0.54 | 1.5 |
| 29 | 4.12 | a | 1.65 | 10.0 | 0.82 | 2.7 | 0.65 | 2.1 |
| 30 | 4.12 | a | 1.40 | 7.5 | 0.70 | 2.0 | 0.74 | 2.6 |
| 31 | 3.34 | a | ..... | ..... | 0.73 | 2.2 | ..... | ..... |

Daily Gauge Height and Discharge of Skull Creek near Skull Creek, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.85 | 3.1 | 0.41 | 0.6 | 0.26 | 0.2 | 0.60* | 1.5 | 0.76 | *a* |
| 2 | 0.69* | 2.3 | 0.44 | 0.8 | 0.29 | 0.3 | 0.56 | 1.3 | 0.80 | *a* |
| 3 | 0.54 | 1.5 | 0.45 | 0.8 | 0.32 | 0.4 | 0.64 | 1.7 | 0.84 | *a* |
| 4 | 0.54 | 1.5 | 0.46 | 0.8 | 0.38 | 0.5 | 0.75 | 2.3 | 0.84 | *a* |
| 5 | 0.54 | 1.5 | 0.48 | 0.9 | 1.01 | 4.1 | 0.74 | 2.2 | 0.84 | *a* |
| 6 | 0.54 | 1.5 | 0.72 | 2.1 | 1.95 | 14.0 | 0.74 | 2.2 | 0.86 | *a* |
| 7 | 0.51 | 1.4 | 0.74 | 2.2 | 1.68 | 10.0 | 0.73 | 2.2 | ... | ... |
| 8 | 0.52 | 1.4 | 0.64 | 1.7 | 0.70 | 2.0 | 0.71* | 2.1 | ... | ... |
| 9 | 0.52* | 1.4 | 0.58 | 1.4 | 0.70 | 2.0 | 0.69 | 2.0 | ... | ... |
| 10 | 0.52 | 1.4 | 0.56 | 1.3 | 0.67 | * 1.8 | 0.68 | 1.9 | ... | ... |
| 11 | 0.52 | 1.4 | 0.56 | 1.3 | 0.62 | 1.6 | 0.67 | 1.8 | ... | ... |
| 12 | 0.50 | 1.3 | 0.40 | 0.6 | 0.58 | 1.4 | 0.66 | 1.8 | ... | ... |
| 13 | 0.57 | 1.7 | 0.40 | 0.6 | 0.54 | 1.2 | 0.65 | 1.8 | ... | ... |
| 14 | 0.51 | 1.3 | 0.44 | 0.8 | 0.54 | 1.2 | 0.65 | 1.8 | ... | ... |
| 15 | 0.53 | 1.4 | 0.41 | 0.6 | 0.56 | 1.3 | 0.65 | 1.8 | ... | ... |
| 16 | 0.56 | 1.6 | 0.39 | 0.6 | 0.58 | 1.4 | 0.65 | 1.8 | ... | ... |
| 17 | 0.58 | 1.7 | 0.38 | 0.5* | 0.67 | 1.8 | 0.65 | 1.8 | ... | ... |
| 18 | 0.59* | 1.7 | 0.36 | 0.5 | 0.72 | 2.1 | 0.66 | 1.8 | ... | ... |
| 19 | 0.56 | 1.5 | 0.36 | 0.5 | 0.68 | 1.9 | 0.68 | 1.9 | ... | ... |
| 20 | 0.54 | 1.3 | 0.36 | 0.5 | 0.51 | 1.0 | 0.69 | 2.0 | ... | ... |
| 21 | 0.53 | 1.3 | 0.42 | 0.7 | 0.54 | 1.2 | 0.70 | 2.0 | ... | ... |
| 22 | 0.43 | 0.8 | 0.42 | 0.7 | 0.69 | 2.0 | 0.71 | 2.1 | ... | ... |
| 23 | 0.45 | 0.9 | 0.42 | 0.7 | 0.72 | 2.1 | 0.71 | 2.1 | ... | ... |
| 24 | 0.42 | 0.7 | 0.42 | 0.7 | 0.74 | 2.2 | 0.71 | 2.1 | ... | ... |
| 25 | 0.43 | 0.7 | 0.46 | 0.8 | 0.74 | 2.2 | 0.72 | 2.1 | ... | ... |
| 26 | 0.39 | 0.6 | 0.39 | 0.6 | 0.70 | 2.0 | 0.72 | 2.1 | ... | ... |
| 27 | 0.36 | 0.5 | 0.36 | 0.5 | 0.67 | 1.8 | 0.72 | 2.1 | ... | ... |
| 28 | 0.34 | 0.4 | 0.34 | 0.4 | 0.64 | 1.7 | 0.72 | 2.1 | ... | ... |
| 29 | 0.36 | 0.5 | 0.36 | 0.5 | 0.63 | 1.7 | 0.72 | 2.1 | ... | ... |
| 30 | 0.37 | 0.5 | 0.37 | 0.5 | 0.63 | 1.7 | 0.73 | 2.2 | ... | ... |
| 31 | 0.39 | 0.6 | 0.29 | 0.3 | ..... | ..... | 0.74 | 2.2 | ... | ... |

* Gauge height interpolated.
*a* Ice in stream.
*d* No gauge height observed.

Monthly Discharge of Skull Creek near Skull Creek, Sask., for 1911.

(Drainage area, 33 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (3, 7-30) | 74.0 | 5.3 | 17.000 | 0.515 | 0.479 | 843 |
| May | 6.9 | 1.9 | 2.700 | 0.082 | 0.094 | 166 |
| June | 2.6 | 0.3 | 1.350 | 0.041 | 0.046 | 80 |
| July | 3.4 | 0.4 | 1.280 | 0.039 | 0.045 | 79 |
| August | 2.2 | 0.3 | 0.823 | 0.025 | 0.029 | 51 |
| September | 14.0 | 0.2 | 2.290 | 0.069 | 0.077 | 136 |
| October | 2.3 | 1.3 | 1.96 | 0.059 | 0.068 | 121 |
| The period | ......... | ......... | ......... | ......... | .838 | 1476 |

## CRANE LAKE DRAINAGE BASIN.

### *General Description.*

Crane Lake is one of the largest of the lakes which receive their supply from the drainage of the northern slope of the Cypress Hills. It is situated in Tp. 13, Rge. 23, W. 3rd Mer., and covers an area of 25 square miles.

The lake, which has no outlet, is shallow, and the water is saline in character. It is fed by Piapot Creek, which rises in the Cypress Hills and flows northeastward, being joined by Bear Creek in Sec. 7, Tp. 12, Rge. 22, W. 3rd Mer., before it reaches the lake.

The country to the north of the lake is rolling and of little use, being the eastern end of a range of sand hills which extend northwestward some forty miles. South of the lake the country is rolling prairie which is devoid of tree growth except along the creeks, where there is small growths of willow and shrubs. As one gets closer to the hills the country becomes more broken and the tree growth increases, making the ravines and coulees at the head of the creeks, natural reservoirs which regulate the spring run-off considerably.

There are a number of irrigation schemes, in operation and proposed, in this basin, also one or two industrial schemes along the main line of the Canadian Pacific Railway.

The mean annual precipitation of the northern part of the basin is about twelve inches, but in the hills this is exceeded. During 1911, the rainfall was much greater. During the winter season, from November to April, the streams are frozen over.

### East Branch of Bear Creek at Johnson's Ranche, Sask.

This station was established August 18, 1909, by H. R. Carscallen. It is located on the S.E. ¼ Sec. 21, Tp. 10, Rge. 23, W. 3rd Mer., about a mile and a half southeast of Skibereen post office.

The channel is straight for 50 feet above and 40 feet below the station. Both banks are high and not liable to overflow, except during extreme floods. The banks are free from brush at the station, but are wooded above and below. The bed of the stream is composed of coarse gravel and stones. Large stones in the bed of the stream make accurate soundings at the station rather difficult to obtain. The current is moderate.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a vertical post sunk in the bed of the stream at the right bank and securely stayed. The zero (elev., 92.63) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated on the right bank in the line of the gauging section and 53 feet from the gauge.

Discharge measurements are made at or near the gauge by wading, or by means of a weir. A measuring wire is stretched across the stream at the section. The initial point for soundings is a square stake driven close to the ground on the left bank and marked "I.P."

During 1911, the gauge was read by Ralph Johnson.

Discharge Measurements of East Branch of Bear Creek at Johnson's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 6 | G. H. Whyte | 11 0 | 4.56 | 1.469 | 1.04 | 6.70 |
| April 27 | do | 10 4 | 6.85 | 1 230 | 0.66 | 8.39 |
| June 1 | do | 10 0 | 5.42 | 0.755 | 0.54 | 4.09 |
| June 26 | G. R. Elliott | 13 0 | 12 50 | 0.320 | 0.53 | 4.45 |
| June 28 | G. H. Whyte | 7 0 | 2.85 | 1.007 | 0.46 | 2.87 |
| July 20 | do | 6 6 | 2 29 | 0 573 | 0.35 | 1 28* |
| July 20 | do | 6.6 | 2 74 | 0 474 | 0 35 | 1.30 |
| Aug. 23 | do | ........ | 1.95 | 0.533 | 0 34 | 1.04* |
| Sept. 29 | do | 6 0 | 2 70 | 1 077 | 0 45 | 2.92 |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of East Branch of Bear Creek at Johnson's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | .. | .... | 1 29 | 16 0 | 0 7 | 10 0 | 0 60 | 6 1 |
| 2 | .. | .... | *1 28 | 16 0 | 0.7 | 10 0 | 0 60 | 6 1 |
| 3 | | | 1 28 | 16 0 | 0 7 | 10 0 | 0 60 | 6 1 |
| 4 | | | 1 28 | 16 0 | 0 7 | 10 0 | 0 60 | 6 1 |
| 5 | | | 1 28 | 16 0 | 0 7 | 10 0 | 0 50 | 3 6 |
| 6 | | | 1 04 | 6 7 | 0 7 | 10 0 | 0 50 | 3 6 |
| 7 | | | 1 80 | 32 0 | *0.6 | 6 1 | 0 50 | 3 6 |
| 8 | | | 1 80 | 34 0 | 0 6 | 6 1 | 0 50 | 3 6 |
| 9 | .. | | 1 70 | 35 0 | 0.6 | 6 1 | 0 50 | 3 6 |
| 10 | | | 1 20 | 16 0 | 0 6 | 6 1 | 0 50 | 3 6 |
| 11 | | | 1 20 | 17 0 | 0 6 | 6 1 | 0 50 | 3 6 |
| 12 | | | 0 70 | 1 9 | 0 6 | 6 1 | 0 40 | 1 9 |
| 13 | | | 0 80 | 4 0 | 0 6 | 6 1 | 0 40 | 1 9 |
| 14 | | | 0 80 | 4 6 | *0 6 | 6 1 | 0 40 | 1 9 |
| 15 | .. | | 0 80 | 5 0 | 0 7 | 10 0 | 0 40 | 1 9 |
| 16 | .. | | 0 90 | 9 1 | 0 7 | 10 0 | 0 40 | 1 9 |
| 17 | .. | | 0 95 | 12 0 | 0 7 | 10 0 | 0 40 | 1 9 |
| 18 | .. | .. | 0 98 | 14 0 | 0 7 | 10 0 | 0 40 | 1 9 |
| 19 | .. | | 0 84 | 9 1 | 0.6 | 6 1 | *0 40 | 1 9 |
| 20 | .. | | 0 80 | 8 3 | 0 6 | 6 1 | *0 40 | 1 9 |
| 21 | .. | ... | 0 80 | 9 0 | *0 6 | 6 1 | *0 40 | 1 9 |
| 22 | | | 0 80 | 9 8 | 0 7 | 10 0 | 0 40 | 1 9 |
| 23 | .. | | *0 77 | 9 6 | 0 7 | 10 0 | 0 40 | 1 9 |
| 24 | .. | | 0 75 | 9 5 | 0 7 | 10 0 | 0 40 | 1 9 |
| 25 | .. | | 0 75 | 10 0 | 0 7 | 10 0 | *0 40 | 1 9 |
| 26 | | | 0 70 | 9 3 | 0 7 | 10 0 | 0 40 | 1 9 |
| 27 | 1 31 | 17 0 | 0 65 | 7 8 | 0 7 | 10 0 | 0 40 | 1 9 |
| 28 | 1 31 | 17 0 | 0.70 | 10 0 | *0 6 | 6 1 | 0 40 | 1 9 |
| 29 | 1 30 | 17 0 | 0.70 | 10 0 | 0 6 | 6 1 | 0 42 | 2 2 |
| 30 | 1 30 | 17 0 | 0 70 | 10 0 | 0 6 | 6 1 | 0 43 | 2 4 |
| 31 | 1 19 | 12 0 | ...... | ....... | *0 6 | 6 1 | .. . | .. .. |

DAILY GAUGE HEIGHT AND DISCHARGE of East Branch of Bear Creek at Johnson's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.42 | 2.2 | 0.29 | 0.8 | 0.35 | 1.4 | 0.45 | 2.8 |
| 2 | * 0.43 | 2.4 | 0.30 | 0.9 | 0.33 | 1.2 | 0.46 | 3.0 |
| 3 | 0.45 | 2.8 | 0.30 | 0.9 | * 0.34 | 1.3 | 0.45 | 2.8 |
| 4 | 0.46 | 3.0 | 0.31 | 1.0 | 0.35 | 1.4 | 0.44 | 2.6 |
| 5 | 0.46 | 2.8 | 0.35 | 1.4 | 0.36 | 1.5 | 0.41 | 2.6 |
| 6 | 0.46 | 3.0 | 0.36 | 1.5 | 0.37 | 1.6 | 0.45 | 2.8 |
| 7 | 0.46 | 3.0 | 0.45 | 2.8 | 0.40 | 1.9 | * 0.45 | 2.8 |
| 8 | 0.46 | 3.0 | 0.51 | 3.8 | 0.37 | 1.6 | 0.46 | 3.0 |
| 9 | * 0.45 | 2.8 | 0.46 | 3.0 | 0.36 | 1.5 | 0.40 | 1.9 |
| 10 | 0.45 | 2.8 | 0.40 | 1.9 | * 0.34 | 1.3 | 0.45 | 2.8 |
| 11 | 0.45 | 2.8 | 0.40 | 1.9 | 0.33 | 1.2 | 0.44 | 2.6 |
| 12 | 0.45 | 2.8 | 0.39 | 1.8 | 0.36 | 1.5 | 0.45 | 2.8 |
| 12 | 0.42 | 2.2 | 0.37* | 1.6 | 0.33 | 1.2 | 0.45 | 2.8 |
| 14 | 0.42 | 2.2 | 0.36 | 1.5 | 0.32 | 1.1 | * 0.45 | 2.8 |
| 15 | 0.42 | 2.2 | 0.32 | 1.1 | 0.33 | 1.2 | 0.45 | 2.8 |
| 16 | * 0.42 | 2.2 | 0.31 | 1.0 | 0.32 | 1.1 | 0.44 | 2.6 |
| 17 | 0.43 | 2.4 | 0.30 | 0.9 | * 0.34 | 1.3 | 0.46 | 3.0 |
| 18 | 0.40 | 1.9 | 0.31 | 1.0 | 0.36 | 1.5 | 0.45 | 2.8 |
| 19 | 0.35 | 1.4 | 0.29 | 0.8 | 0.34 | 1.3 | 0.46 | 3.0 |
| 20 | 0.30 | 0.9 | * 0.32 | 1.1 | 0.38 | 1.7 | 0.46 | 3.0 |
| 21 | 0.30 | 0.9 | 0.35 | 1.4 | 0.45 | 2.8 | * 0.46 | 3.0 |
| 22 | 0.30 | 0.9 | 0.37 | 1.6 | 0.50 | 3.6 | 0.47 | 3.1 |
| 23 | 0.30 | 0.9 | 0.35 | 1.4 | 0.32 | 1.1 | 0.48 | 3.3 |
| 24 | 0.30 | 0.9 | 0.30 | 0.9 | * 0.38 | 1.7 | † | ...... |
| 25 | 0.30 | 0.9 | 0.32 | 1.1 | 0.45 | 2.8 | ...... | ...... |
| 26 | 0.30 | 0.9 | 0.36 | 1.5 | 0.45 | 2.8 | ...... | ...... |
| 27 | 0.35 | 1.4 | * 0.35 | 1.4 | 0.44 | 2.6 | ...... | ...... |
| 28 | 0.36 | 1.5 | 0.35 | 1.4 | 0.45 | 2.8 | ...... | ...... |
| 29 | 0.35 | 1.4 | 0.33 | 1.2 | 0.45 | 2.8 | ...... | ...... |
| 30 | * 0.30 | 0.9 | 0.33 | 1.2 | 0.43 | 2.4 | ...... | ...... |
| 31 | 0.30 | 0.9 | 0.34 | 1.3 | ...... | ...... | ...... | ...... |

* No observation. Gauge-height interpolated.
† Creek frozen over.

MONTHLY DISCHARGE of East Branch of Bear Creek at Johnson's Ranche, Sask., for 1911.

(Drainage area, 22 square miles.)

| Month. | Discharge in Second-Feet | | | | Run-Off | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (27-31) | 17.0 | 12.0 | 16.00 | 0.728 | 0.135 | 159 |
| April | 35.0 | 1.9 | 12.80 | 0.582 | 0.649 | 762 |
| May | 10.0 | 6.1 | 8.10 | 0.368 | 0.424 | 498 |
| June | 6.1 | 1.9 | 2.90 | 0.132 | 0.147 | 173 |
| July | 3.0 | 0.9 | 1.95 | 0.089 | 0.103 | 120 |
| August | 3.8 | 0.8 | 1.50 | 0.068 | 0.078 | 92 |
| September | 3.6 | 1.1 | 1.80 | 0.082 | 0,092 | 107 |
| October (1-23) | 3.3 | 1.9 | 2.80 | 0.127 | 0.108 | 128 |
| The period | ...... | ...... | ...... | ...... | 1.736 | 2039 |

WEST BRANCH OF BEAR CREEK AT BERTRAM'S RANCHE, SASK.

This station was established September 16, 1909, by H. R. Carscallen. It is located on the S.W. 1/4 Sec. 32, Tp. 10, Rge. 23, W. 3rd Mer., about a mile and a half north of Skibereen post office. It is about three hundred yards above the junction of this branch with the east branch of Bear Creek.

The channel is straight for 25 feet above and 15 feet below the station. Both banks are comparatively high and will overflow only in extreme flood. The banks are free from brush at the station, but are heavily wooded immediately above and twenty feet below. The bed of the creek is composed of sand and coarse gravel. The current is moderate at the station, but becomes very swift twenty feet downstream.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post sunk in the bed of the stream at the left bank and firmly stayed to the bank. It is referred to bench-marks as follows:—(1) a spike-head in the top of the initial-point stake on the left bank, marked "B.M." (elevation, 8.00 above the zero of the gauge); (2) a spike-head in the top of a pointed poplar stump just below the bank on the left side of the stream, and about 50 feet downstream from the gauge, the stump blazed and marked "B.M." (elevation, 8.41 feet above the zero of the gauge).

During ordinary stages discharge measurements are made at, or a short distance below, the gauge by wading. High-water measurements are made at the government bridge, situated about three-quarters of a mile upstream. The initial point for soundings at the station is a square stake driven close to the ground on the left bank and marked "I.P."

During 1911, the gauge was read by Charles Bertram.

Discharge Measurements of West Branch of Bear Creek at Bertram's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 7 | G. H. Whyte | 12.0 | 9.40 | 0.970 | 1.34 | 9.120 |
| April 27 | do | 18.0 | 11.60 | 1.280 | 1.46 | 14.780 |
| June 1 | do | 20.0 | 10.72 | 0.911 | 1.34 | 9.760 |
| June 26 | G. R. Elliott | 17.3 | 7.97 | 0.849 | 1.34 | 6.780 |
| June 28 | G. H. Whyte | 7.40 | 3.44 | 1.064 | 1.22 | 3.660 |
| July 20 | do | 7.70 | 2.66 | 0.808 | 1.16 | 2.150 |
| July 20 | do | ........ | ........ | ........ | 1.16 | 2.073* |
| Aug. 23 | do | ........ | ........ | ........ | 1.16 | 1.565* |
| Sept. 29 | do | 7.0 | 3.22 | 1.460 | 1.26 | 4.560 |

* Weir measurement.

Daily Gauge Height and Discharge of West Branch of Bear Creek at Bertram's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.60 | 23.0 | 1.55 | 20.0 | 1.34 | 8.5 |
| 2 | 1.60 | 23.0 | 1.55 | 20.0 | 1.34 | 8.5 |
| 3 | 1.50 | 17.0 | 1.55 | 20.0 | 1.34 | 8.5 |
| 4 | 1.50 | 17.0 | 1.45 | 14.0 | 1.30 | 6.6 |
| 5 | 1.75 | 32.0 | 1.40 | 11.4 | 1.30 | 6.6 |
| 6 | 1.40 | 11.4 | 1.40 | 11.4 | 1.35 | 9.0 |
| 7 | 1.35 | 9.0 | 1.40 | 11.4 | 1.35 | 9.0 |
| 8 | 1.35 | 9.0 | 1.40 | 11.4 | 1.35 | 9.0 |
| 9 | 2.00 | 47.0 | 1.35 | 9.0 | 1.35 | 9.0 |
| 10 | 2.50 | 77.0 | 1.35 | 9.0 | 1.35 | 9.0 |
| 11 | 2.30 | 65.0 | 1.33 | 8.0 | 1.30 | 6.6 |
| 12 | 2.00 | 47.0 | 1.33 | 8.0 | 1.30 | 6.6 |
| 13 | 2.00 | 47.0 | 1.33 | 8.0 | 1.30 | 6.6 |
| 14 | 1.80 | 35.0 | 1.33 | 8.0 | 1.30 | 6.6 |
| 25 | 1.80 | 35.0 | 1.33 | 8.0 | 1.30 | 6.6 |
| 16 | 1.60 | 23.0 | 1.50 | 17.0 | 1.25 | 4.8 |
| 17 | 2.50 | 77.0 | 1.40 | 11.4 | 1.25 | 4.8 |
| 18 | 2.00 | 47.0 | 1.38 | 10.4 | 1.25 | 4.8 |
| 19 | 1.70 | 29.0 | 1.38 | 10.4 | 1.25 | 4.8 |
| 20 | 1.70 | 29.0 | 1.38 | 10.4 | 1.25 | 4.8 |
| 21 | 1.75 | 32.0 | 1.35 | 9.0 | 1.25 | 4.8 |
| 22 | 1.75 | 32.0 | 1.35 | 9.0 | 1.22 | 3.8 |
| 23 | 1.55 | 20.0 | 1.65 | 26.0 | 1.22 | 3.8 |
| 24 | 1.55 | 20.0 | 1.70 | 29.0 | 1.25 | 4.8 |
| 25 | 1.50 | 17.0 | 1.50 | 17.0 | 1.50 | 17.0 |
| 26 | 1.45 | 14.0 | 1.50 | 17.0 | 1.27 | 5.5 |
| 27 | 1.40 | 11.4 | 1.45 | 14.0 | 1.20 | 3.2 |
| 28 | 1.45 | 14.0 | 1.45 | 14.0 | 1.25 | 4.8 |
| 29 | 1.45 | 14.0 | 1.45 | 14.0 | 1.30 | 6.6 |
| 30 | 1.50 | 17.0 | 1.40 | 11.4 | 1.30 | 6.6 |
| 31 | ........ | ........ | 1.40 | 11.4 | ........ | ........ |

DAILY GAUGE HEIGHT AND DISCHARGE of West Branch of Bear Creek at Bertram's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.40 | 11.4 | 1.00 | 0.2 | 1.10 | 1.0 | 1.30 | 6.6 |
| 2 | 1.40 | 11.4 | 1.00 | 0.2 | 1.00 | 0.2 | 1.30 | 6.6 |
| 3 | 1.35 | 9.0 | 1.10 | 1.0 | 1.00 | 0.2 | 1.35 | 9.0 |
| 4 | 1.30 | 6.6 | 1.10 | 1.0 | 1.00 | 0.2 | 1.35 | 9.0 |
| 5 | 1.30 | 6.6 | 1.15 | 2.0 | 1.30 | 6.6 | 1.30 | 6.6 |
| 6 | 1.25 | 4.8 | 1.20 | 3.2 | 1.40 | 11.4 | 1.30 | 6.6 |
| 7 | 1.20 | 3.2 | 1.30 | 6.6 | 1.47 | 15.0 | 1.30 | 6.6 |
| 8 | 1.20 | 3.2 | 1.30 | 6.6 | 1.40 | 11.4 | 1.30 | 6.6 |
| 9 | 1.20 | 3.2 | 1.25 | 4.8 | 1.30 | 6.6 | 1.30 | 6.6 |
| 10 | 1.20 | 3.2 | 1.20 | 3.2 | 1.25 | 4.8 | 1.35 | 9.0 |
| 11 | 1.20 | 3.2 | 1.20 | 3.2 | 1.20 | 3.2 | 1.25 | 4.8 |
| 12 | 1.20 | 3.2 | 1.15 | 2.0 | 1.20 | 3.2 | 1.25 | 4.8 |
| 13 | 1.15 | 2.0 | 1.10 | 1.0 | 1.15 | 2.0 | 1.20 | 3.2 |
| 14 | 1.15 | 2.0 | 1.10 | 1.0 | 1.15 | 2.0 | 1.20 | 3.2 |
| 15 | 1.10 | 1.0 | 1.19 | 3.0 | 1.15 | 2.0 | 1.20 | 3.2 |
| 16 | 1.00 | 0.2 | 1.10 | 1.0 | 1.15 | 2.0 | 1.25 | 4.8 |
| 17 | 1.00 | 0.2 | 1.10 | 1.0 | 1.35 | 9.0 | 1.25 | 4.8 |
| 18 | 1.00 | 0.2 | 1.10 | 1.0 | 1.40 | 11.4 | 1.25 | 4.8 |
| 19 | 1.00 | 0.2 | 1.10 | 1.0 | 1.40 | 11.4 | 1.25 | 4.8 |
| 20 | 1.17 | 2.5 | 1.05 | 0.5 | 1.35 | 9.0 | 1.25 | 4.8 |
| 21 | 1.10 | 1.0 | 1.00 | 0.2 | 1.35 | 9.0 | 1.25 | 4.8 |
| 22 | 1.10 | 1.0 | 1.16 | 0.2 | 1.25 | 4.8 | 1.25 | 4.8 |
| 23 | 1.10 | 1.0 | 1.12 | 1.4 | 1.25 | 4.8 | 1.29 | 6.2 |
| 24 | 1.10 | 1.0 | 1.12 | 1.4 | 1.30 | 6.6 | 1.29 | 6.2 |
| 25 | 1.05 | 0.5 | 1.12 | 1.4 | 1.30 | 6.6 | 1.29 | 6.2 |
| 26 | 1.05 | 0.5 | 1.20 | 3.2 | 1.30 | 6.6 | 1.29 | 6.2 |
| 27 | 1.00 | 0.2 | 1.15 | 2.0 | 1.30 | 6.6 | 1.28 | 5.9 |
| 28 | 1.00 | 0.2 | 1.10 | 1.0 | 1.30 | 6.6 | 1.28 | 5.9 |
| 29 | 1.00 | 0.2 | 1.10 | 1.0 | 1.30 | 6.6 | 1.30 | 6.6 |
| 30 | 1.00 | 0.2 | 1.10 | 1.0 | 1.30 | 6.6 | 1.30 | 6.6 |
| 31 | 1.00 | 0.2 | 1.10 | 1.0 | .... | .... | 1.30 | 6.6 |

MONTHLY DISCHARGE of West Branch of Bear Creek at Bertram's Ranche, Sask., for 1911.

(Drainage area, 45 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April | 77.0 | 9.0 | 29.70 | 0.660 | 0.736 | 1767 |
| May | 29.0 | 8.0 | 13.20 | 0.294 | 0.339 | 812 |
| June | 17.0 | 3.2 | 6.72 | 0.149 | 0.166 | 400 |
| July | 11.4 | 0.2 | 2.69 | 0.060 | 0.069 | 165 |
| August | 6.6 | 0.2 | 1.91 | 0.042 | 0.048 | 117 |
| September | 15.0 | 0.2 | 5.91 | 0.131 | 0.141 | 352 |
| October | 9.0 | 3.2 | 5.88 | 0.131 | 0.151 | 362 |
| The period | ........ | ........ | ........ | ........ | 1.659 | 3975 |

BEAR CREEK NEAR UNSWORTH'S RANCHE, SASK.

This station was established June 22, 1908, by F. T. Fletcher. It is located on the S.E. ¼ Sec. 18, Tp. 11, Rge. 23, W. 3rd Mer., at the highway bridge on the surveyed trail running east from Maple Creek. It is about half a mile south of S. Unsworth's ranche, and fifteen miles east of Maple Creek.

The channel is straight for 100 feet above and below the station. Both banks are high and not liable to overflow. The station is kept clear of underbrush, but both banks are covered with small trees above and below the bridge. The bed of the stream is sandy and is liable to change at high stages of the creek. The current is moderate, becoming sluggish at very low stages.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to the centre pile of the downstream side of the bridge. It is referred to bench-marks as follows:—(1) a circle of nail-heads in the top of the stringer at the left abutment on the downstream side of the bridge (elevation, 14.05 feet above the zero of the gauge); (2) the top of the iron pin in the road-mound southeast of the bridge on the left bank (elevation, 18.97 feet above the zero of the gauge).

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left abutment of the bridge. Low-water measurements are made at a wading section about half a mile downstream from the gauge, or about 200 feet above. There is only one channel at low stages, but at high stages the centre row of piles supporting the bridge divides the stream into two channels.

During 1911, the gauge was read by S. Unsworth.

### Discharge Measurements of Bear Creek near Unsworth's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 6 | G. H. Whyte | 10.0 | 25.60 | 0.933 | 2.21 | 23.880 |
| April 27 | do | 10.5 | 24.61 | 1.340 | 2.43 | 32.890 |
| June 1 | do | 13.0 | 11.76 | 0.738 | 1.46 | 14.260 |
| June 22 | G. R. Elliott | 10.4 | 11.38 | 0.538 | 0.88 | 6.120 |
| June 26 | G. H. Whyte | 9.0 | 13.78 | 0.910 | 1.37 | 12.550 |
| July 20 | do | 7.5 | 9.87 | 0.302 | 0.70 | 2.980 |
| Aug. 22 | do | 7.0 | 6.92 | 0.156 | 0.38 | 1.078* |
| Sept. 29 | do | 9.3 | 12.10 | 0.662 | 1.11 | 8.010 |

* Weir measurement.

### Daily Gauge Height and Discharge of Bear Creek near Unsworth's Ranche, Sask., for 1911.

| Day. | April. | | May | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 3.90 | ...... | 3.00 | 44 | 1.75 | 19.0 | 1.35 | 12.0 |
| 2 | 3.55 | ...... | 3.05 | 45 | 1.50 | 15.0 | 2.00 | 24.0 |
| 3 | 3.05 | ...... | 3.00 | 44 | 1.45 | 14.0 | 2.05 | 25.0 |
| 4 | 2.75 | ...... | 2.95 | 43 | 1.45 | 14.0 | 1.80 | 20.0 |
| 5 | 2.20 | ...... | 2.90 | 42. | 1.60 | 16.0 | 1.65 | 17.0 |
| 6 | 2.10 | ...... | 2.80 | 40. | 2.10 | 26.0 | 1.55 | 16.0 |
| 7 | 2.05 | ...... | 2.80 | 40 | 1.90 | 22.0 | 1.40 | 13.0 |
| 8 | 2.05 | ...... | 2.75 | 39 | 1.75 | 19.0 | 1.35 | 12.0 |
| 9 | 4.10 | ...... | 2.70 | 38 | 1.70 | 18.0 | 1.30 | 11.0 |
| 10 | 8.20 | ...... | 2.68 | 38. | 1.60 | 16.0 | 1.30 | 11.0 |
| 11 | 12.00 | ...... | 2.70 | 38. | 1.50 | 15.0 | 1.25 | 10.0 |
| 12 | 9.80 | ...... | 2.75 | 39 | 1.45 | 14.0 | 1.20 | 9.5 |
| 13 | 7.90 | ...... | 2.75 | 39 | 1.40 | 13.0 | 1.15 | 8.7 |
| 14 | 3.40 | ...... | 2.72 | 38 | 1.30 | 11.0 | 1.05 | 7.2 |
| 15 | 3.75 | ...... | 2.70 | 38. | 1.25 | 10.0 | 1.05 | 7.2 |
| 16 | 4.50 | ...... | 2.70 | 38. | 1.10 | 7.9 | 0.95 | 5.8 |
| 17 | 7.05 | ...... | 2.75 | 39 | 1.05 | 7.2 | 0.90 | 5.1 |
| 18 | 11.00 | ...... | 2.70 | 38 | 0.90 | 5.1 | 0.90 | 5.1 |
| 19 | 8.10 | ...... | 2.50 | 34. | 0.80 | 4.0 | 0.85 | 4.6 |
| 20 | 5.40 | ...... | 2.50 | 34. | 0.80 | 4.0 | 0.80 | 4.0 |
| 21 | 4.10 | 66.0 | 2.45 | 33 | 0.85 | 4.6 | 0.75 | 3.6 |
| 22 | 3.75 | 59.0 | 2.42 | 32 | 0.90 | 5.1 | 0.70 | 3.1 |
| 23 | 3.40 | 52.0 | 2.50 | 34. | 0.95 | 5.8 | 0.70 | 3.1 |
| 24 | 3.05 | 45.0 | 3.10 | 46. | 0.95 | 5.8 | 0.70 | 3.1 |
| 25 | 2.85 | 41.0 | 2.85 | 41. | 1.00 | 6.4 | 0.65 | 2.8 |
| 26 | 2.80 | 40.0 | 2.80 | 40. | 1.05 | 7.2 | 0.65 | 2.8 |
| 27 | 2.95 | 43.0 | 2.75 | 39. | 1.05 | 7.2 | 0.65 | 2.8 |
| 28 | 3.00 | 44.0 | 2.60 | 36. | 1.05 | 7.2 | 0.62 | 2.5 |
| 29 | 3.10 | 46.0 | 2.50 | 34. | 1.10 | 7.9 | 0.62 | 2.5 |
| 30 | 3.10 | 46.0 | 2.10 | 26. | 1.25 | 8.4 | 0.60 | 2.4 |
| 31 | ...... | ...... | 2.00 | 24. | ...... | ...... | 0.60 | 2.4 |

DAILY GAUGE HEIGHT AND DISCHARGE of Bear Creek near Unsworth's Ranche, Sask., for 1911.—*Continued.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0 60 | 2 4 | 0 58 | 2 3 | 0 95 | 5 8 | 1 10 | 7 9 |
| 2 | 0 63 | 2 6 | 0 55 | 2 1 | 1 15 | 8 7 | 1 10 | 7 9 |
| 3 | 0 65 | 2 8 | 0 55 | 2 1 | 1 25 | 10 0 | 1 05 | 7 2 |
| 4 | 0 68 | 3 0 | 0 95 | 5 8 | 1 40 | 13 0 | 1 05 | 7 2 |
| 5 | 0 70 | 3 1 | 1 40 | 13 0 | 1 35 | 12 0 | 1 05 | 7 2 |
| 6 | 0 75 | 3 6 | 2 10 | 26 0 | 1 35 | 12 0 | 1 10 | 7 9 |
| 7 | 0 85 | 4 6 | 2 15 | 27 0 | 1 30 | 11 0 | 1 15 | 8 7 |
| 8 | 1 15 | 8 7 | 1 90 | 22 0 | 1 25 | 10 0 | 1 15 | 8 7 |
| 9 | 1 05 | 7 2 | 1 50 | 15 0 | 1 25 | 10 0 | 1 15 | 8 7 |
| 10 | 0 95 | 5 8 | 1 40 | 13 0 | 1 22 | 9 8 | 1 15 | 8.7 |
| 11 | 0 90 | 5 1 | 1 30 | 11 0 | 1 20 | 9 5 | 1 15 | 8.7 |
| 12 | 0 80 | 4 0 | 1 25 | 10 0 | 1 17 | 9 0 | 1 15 | 8 7 |
| 13 | 0 75 | 3 6 | 1 10 | 7 9 | 1 15 | 8 7 | 1 15 | 8 7 |
| 14 | 0 70 | 3 1 | 1 05 | 7 2 | 1 15 | 8 7 | 1 15 | 8 7 |
| 15 | 0 72 | 3 3 | 1 05 | 7 2 | 1 12 | 8 2 | 1 15 | 8.7 |
| 16 | 0 75 | 3 6 | 1 00 | 6 4 | 1 12 | 8 2 | ... | ..... |
| 17 | 0 70 | 3 1 | 1 00 | 6 4 | 1 10 | 7 9 | | ..... |
| 18 | 0 68 | 3 0 | 1 10 | 7 9 | 1 10 | 7 9 | ... | ..... |
| 19 | 0 65 | 2 8 | 1 10 | 7 9 | 1 10 | 7 9 | . | ..... |
| 20 | 0.60 | 2 4 | 1 15 | 8 7 | 1 00 | 6 4 | ... | ...... |
| 21 | 0.58 | 2 3 | 1 20 | 9 5 | 1 00 | 6 4 | ... | ...... |
| 22 | 0.55 | 2 1 | 1 25 | 10 0 | 1 05 | 7 2 | .. | ...... |
| 23 | 0 55 | 2 1 | 1 30 | 11 0 | 1 10 | 7 9 | .. | ...... |
| 24 | 0 50 | 1.8 | 1 30 | 11 0 | 1 15 | 8 7 | ..... | ...... |
| 25 | 0.50 | 1.8 | 1 25 | 10 0 | 1 17 | 9 0 | ..... | ...... |
| 26 | 0 55 | 2 1 | 1 20 | 9 5 | 1 20 | 9 5 | ...... | ...... |
| 27 | 0 65 | 2 8 | 1 18 | 9 2 | 1 25 | 10 0 | ..... | ...... |
| 28 | 0 65 | 2 8 | 1 15 | 8 7 | 1 25 | 10 0 | ..... | ...... |
| 29 | 0 62 | 2 5 | 1 10 | 7 9 | 1 20 | 9 5 | ..... | ...... |
| 29 | 0 60 | 2 4 | 0 95 | 5 7 | 1 20 | 9 5 | ..... | ...... |
| 31 | 0.60 | 2 4 | .. | .. | 1 15 | 8 7 | ..... | ...... |

As the stream was full of snow and ice April 1st to April 21st. the daily discharge was not taken as the curve will not apply.

MONTHLY DISCHARGE of Bear Creek near Unsworth's Ranche, Sask., for 1911.

(Drainage area, 100 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (21-30) | 69 0 | 40 0 | 48 20 | 0 482 | 0 179 | 954 |
| May | 46 0 | 24 0 | 37.80 | 0 378 | 0.436 | 2324 |
| June | 26 0 | 4 0 | 11.20 | 0 112 | 0 125 | 666 |
| July | 25 0 | 2.4 | 8 37 | 0 084 | 0.097 | 515 |
| August | 8.7 | 1.8 | 3.32 | 0 033 | 0 038 | 204 |
| September | 27 0 | 2 1 | 10 00 | 0 100 | 0 112 | 595 |
| October | 13 0 | 5 8 | 9 07 | 0 091 | 0 105 | 558 |
| November | 8 7 | 7.2 | 8 24 | 0 082 | 0 046 | 245 |
| The period | | | | | 1.138 | 6061 |

NEEDHAM BROTHERS' DITCH NEAR PIAPOT, SASK.

This station was established on June 22, 1911, by G. R. Elliott, on the irrigation ditch of Messrs. Needham Brothers, which diverts water from Bear Creek on the S.W. ¼ Sec. 30, Tp. 11, Rge. 23, W. 3rd Mer.

The gauge is located on the S.W. ¼ Sec. 30, at the outlet of the sluice-box. It is a plain staff graduated to feet and inches. The zero of the gauge (elev., 97.47) is referred to a plug on the right bank of ditch (assumed elev., 100.00).

The station is on a uniform cross-section of the ditch, which has a bottom width of seven feet with side slopes of one to one.

As this station was established after the irrigation season was over, no records were obtained during 1911.

## Braniff Ditch near Piapot, Sask.

This station was established June 22, 1911, by G. R. Elliott, on D. Braniff's irrigation ditch, which diverts water from Bear Creek on the S.E. ¼ Sec. 30, Tp. 11, Rge. 23, W. 3rd Mer.

The gauge is located on the S.E. ¼ Sec. 30, about twenty feet from the point of intake. The gauge, which is a plain staff graduated to feet and inches, is fixed to the upstream side of a log bridge across the ditch.

No records were obtained at this station during 1911.

## Beveridge East Ditch on Piapot Creek, Sask.

This station was established June 9, 1911, by G. R. Elliott, on the irrigation ditch of D. Beveridge, which diverts water from Piapot Creek on the N.E. ¼ Sec. 7, Tp. 10, Rge. 24, W. 3rd Mer., to irrigate land on the east side of the creek.

The gauge is located on N.E. ¼ Sec. 7, and is about half a mile from the intake. The gauge, which is a plain staff graduated to feet and inches, is located at the upstream side of the bridge over the ditch.

The station is at a uniform cross-section of the ditch, which is three feet wide at the bottom with side slopes of one to one.

As the ditch was used for only a few days after the gauge was established, discharge measurements only were made.

Discharge Measurements of Beveridge East Ditch on Piapot Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| June 9 | G. R. Elliott | | | | 14 5 | 1 414* |
| do | do | | | | 15 0 | 1 625* |
| do | do | | | | 14 0 | 1 153* |
| do | do | | | | 13.9 | 1 050* |
| do | do | | | | 13 5 | 0 868* |
| do | do | | | | 13 0 | 0 611* |
| Aug. 20 | G. H. Whyte | | | | | Nil. |

* Weir measurement.

## Beveridge West Ditch on Piapot Creek, Sask.

This station was established June 5, 1911, by F. T. Fletcher, on the irrigation ditch of D. Beveridge, which diverts water from Piapot Creek on the N.W. ¼ Sec. 18, Tp. 10, Rge. 24, W. 3rd Mer., to irrigate land on the west side of the creek.

The gauge is located on N.W. ¼ Sec. 18, and is about 240 feet from the intake. The gauge, which is a plain staff graduated to feet and inches, is located at the left side of the ditch.

The zero of the gauge (elev., 98.16) is referred to a peg in a cairn of stones (assumed elev., 100.00), located upstream from the gauge, and on the left bank.

The station is at a uniform cross-section of the ditch, which is two feet wide at the bottom with side slopes of one to one.

As the ditch was used for only a few days after the gauge was established, discharge measurements only were made.

Discharge Measurements of Beveridge West Ditch on Piapot Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge. Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Inches.* | *Sec.-ft.* |
| June 9 | G. R. Elliott | | | | 12 00 | 0 391* |
| do | do | | | | 11 50 | 0 150* |
| do | do | | | | 11 50 | 0 226* |
| do | do | | | | 12 50 | 0 456* |
| do | do | | | | 12 90 | 0 530* |
| do | do | | | | 12 75 | 0 499* |
| Aug. 29 | G. H. Whyte. | | | | | Nil. |

* Weir measurement.

## Moorhead Ditch on Piapot Creek, Sask.

This station was established June 10, 1911, by G. R. Elliott, on the irrigation ditch of Mr. H. Moorhead, which diverts water from Piapot Creek on the S.E. ¼ Sec. 25, Tp. 10, Rge. 22, W. 3rd Mer.

The gauge is located on the N.W. ¼ Sec. 25, about three-quarters of a mile from the point of intake. The gauge, which is a plain staff graduated into feet and inches, is at the right side of the ditch. The zero (elev., 98.23) is referred to a wooden stake (assumed elev., 100.00), situated on the left bank.

This station is at a regular cross-section of the ditch, which is three and a half feet wide at the bottom with side slopes of one to one.

No data was secured as to the quantity of water diverted before the gauge was established.

Monthly Discharge of Moorhead Ditch on Piapot Creek, Sask., for 1911.

| Month. | Discharge in Second-Feet. | | | Run-Off. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Total in Acre-Feet. |
| June (10-30) | 4 2 | 0 56 | 1 31 | 547 |
| July (1-15) | 6 9 | 0 56 | 3 27 | 97 |
| The periods | | | | 644 |

Note.—These results cover only period after gauge was established on June 10.

Daily Gauge Height and Discharge of Moorhead Ditch on Piapot Creek, Sask., for 1911.

| Day. | June. | | July | |
|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | .... | ..... | 20 | 6 90 |
| 2 | .... | ..... | 19 | 6.30 |
| 3 | .... | ..... | 18 | 5 70 |
| 4 | .... | ..... | 18 | 5 70 |
| 5 | .... | ..... | 20 | 6 90 |
| 6 | .... | ..... | 15 | 3 00 |
| 7 | .... | ..... | 12 | 2 15 |
| 8 | .... | ..... | 12 | 2 15 |
| 9 | .... | ..... | 12 | 2 15 |
| 10 | 9 5 | 1 22 | 11 | 1 73 |
| 11 | 12 0 | 2 15 | 11 | 1 73 |
| 12 | 10 0 | 1.38 | 10 | 1 38 |
| 13 | 10 0 | 1 38 | 9 | 1 07 |
| 14 | 10 0 | 1 38 | 8 | 0 80 |
| 15 | 10 0 | 1 38 | 7 | 0.56 |
| 16 | 8 0 | 0 80 | .... | .... |
| 17 | 9 0 | 1 07 | .... | .... |
| 18 | 7 5 | 0 68 | .... | .... |
| 19 | 7 0 | 0.56 | .... | .... |
| 20 | 8 0 | 0 80 | .... | .... |
| 21 | 7 0 | 0.56 | .... | .... |
| 22 | 10 0 | 1 38 | .... | .... |
| 23 | 7.5 | 0 68 | .... | .... |
| 24 | 7 0 | 0 56 | .... | .... |
| 25 | 15.5 | 4 20 | .... | .... |
| 26 | 12 5 | 2 42 | .... | .... |
| 27 | 10 0 | 1 38 | .... | .... |
| 28 | 9.0 | 1 07 | .... | .... |
| 29 | 8 0 | 0 80 | .... | .... |
| 30 | 11 0 | 1 73 | .... | .... |
| 31 | .... | ..... | .... | .... |

Discharge Measurements of Moorhead Ditch on Piapot Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Ft., Ins.* | *Sec.-ft.* |
| June 10 | G. R. Elliott | .... | .... | .... | 0-7½ | 0 672* |
| do | do | .... | .... | .... | 0-11 | 1 730* |
| do | do | .... | .... | .... | 0-9¼ | 1 153* |
| do | do | .... | .... | .... | 1-0 | 2 146* |
| do | do | .... | .... | .... | 1-1 | 2 422* |
| do | do | .... | .... | .... | 1-1½ | 3 005* |
| Aug. 20 | G. H. Whyte | .... | .... | .... | .... | Nil. |

* Weir measurement.

## Piapot Creek at Cumberland's Ranche, Sask.

This station was established June 17, 1908, by F. T. Fletcher. It was originally located on Sec. 17, Tp. 11, Rge. 24, W. 3rd Mer., at the highway bridge on the surveyed trail running east of Maple Creek and about nine miles from Maple Creek. On account of the difficulty of obtaining an observer, it was moved on May 13, 1909, by H. R. Carscallen to a wading section near A. Cumberland's house. It is now located in the N.E. ¼ Sec. 18, Tp. 11, Rge. 24, W. 3rd Mer., about one mile north of the bridge.

The channel is straight for 50 feet above and 100 feet below the station. The right bank is high and not liable to overflow; the left is comparatively low and will overflow at flood stages of the stream. The bed of the stream is composed of sand, and may shift during high stages. The current is sluggish. During the summer months vegetation in the stream-bed gives considerable trouble.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a post sunk in the bed of the stream at the left bank and securely stayed to the bank. The zero (elev., 89.75) is referred to a permanent iron bench-mark (assumed elev., 100.00), located on the right bank 17 feet N 40° E from the gauge, and sunk within five inches of the ground.

During ordinary stages, discharge measurements are made from the downstream side of the bridge at the old station.

During 1911, the gauge was read by A. Cumberland.

DISCHARGE MEASUREMENTS of Piapot Creek at Cumberland's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 5 | G. H. Whyte | 10 0 | 16 93 | 0 765 | 2 21 | 12 96 |
| April 26 | do | 8 8 | 6 49 | 0 980 | 1 40 | 6.41 |
| May 31 | do | 8 2 | 6 94 | 0 537 | 1.16 | 3 50 |
| June 27 | do | 8.5 | 10 42 | 0 355 | 1 41 | 3 70 |
| July 19 | do | 8 5 | 11 00 | 0 208 | 1 45 | 2 29 |
| Aug. 22 | do | 8 3 | 8 97 | 0 185 | 1 25 | 1 65 |
| Sept. 27 | do | 8.5 | 12 50 | 0 416 | 1.67 | 5.10 |

DAILY GAUGE HEIGHT AND DISCHARGE of Piapot Creek at Cumberland's Ranche, Sask., for 1911.

| Day. | April. | | May. | | June. | |
|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1 65 | 10 0 | 1 13 | 3 0 |
| 2 | | | 1 72 | 11 0 | 1 12 | 2 6 |
| 3 | | | 1 64 | 10 0 | 1.05 | 1 7 |
| 4 | | | 1 48 | 7 8 | 1.05 | 1.7 |
| 5 | 2 21 | 13 0 | 1 60 | 9 7 | 1 75 | 12.0 |
| 6 | 1 80 | 7 0 | 1 52 | 8 4 | 1 27 | 4.5 |
| 7 | 1 55 | 3 6 | 1 39 | 6 5 | 1 73 | 11.0 |
| 8 | 1 28 | 0.7 | 1 21 | 3 9 | 1 48 | 7 4 |
| 9 | 1 65 | 5 6 | 1 19 | 3 6 | 1 18 | 3 0 |
| 10 | 2 66 | 21 0 | *1 25 | 4 5 | 1 25 | 3 4 |
| 11 | 2 47 | 19.0 | 1 31 | 5.4 | *1 14 | 2 0 |
| 12 | | | 1 21 | 4 0 | 1.03 | 0.7 |
| 13 | 1 71 | 7 6 | 1 15 | 3.1 | 1 13 | 1 7 |
| 14 | 1 76 | 8 6 | 1 24 | 4 4 | 1 20 | 2 5 |
| 15 | 1 65 | 7 2 | 1 19 | 3.7 | 1 17 | 2 0 |
| 16 | 2 07 | 14 0 | 1.45 | 7 5 | 1 15 | 1.7 |
| 17 | 2 53 | 21 0 | 1 19 | 3 8 | 1 18 | 1 9 |
| 18 | 1 79 | 10 0 | 1 18 | 3 6 | 1 17 | 1 7 |
| 19 | 1.93 | 12 0 | 1 21 | 4 1 | 1 13 | 1 1 |
| 20 | 1 97 | 13 0 | 1 22 | 4 2 | 1 19 | 1 6 |
| 21 | 1 88 | 12 0 | 1 14 | 3.1 | 1 15 | 1.1 |
| 22 | 1 74 | 10 0 | 1 14 | 3 1 | 1 22 | 1 7 |
| 23 | 1 64 | 9 3 | 1 19 | 3.8 | 1 13 | 0 8 |
| 24 | 1 62 | 9 2 | 1 25 | 4 7 | 1 53 | 5 8 |
| 25 | 1 49 | 7 6 | 1 44 | 7 5 | 2.06 | 14 0 |
| 26 | 1 40 | 6 4 | 1.50 | 8 5 | 1 32 | 2.6 |
| 27 | 1.45 | 7 2 | 1 45 | 7 7 | 1.39 | 3 4 |
| 28 | 1 45 | 7 2 | 1 40 | 7.0 | 1 29 | 2 0 |
| 29 | 1 48 | 7 7 | 1 27 | 5 0 | 1 25 | 1.5 |
| 30 | 1 55 | 8 8 | 1 19 | 3 9 | 1 40 | 3 3 |
| 31 | | | 1 17 | 3 6 | | |

DAILY GAUGE HEIGHT AND DISCHARGE of Piapot Creek at Cumberland's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.45 | 19.0 | 1.40 | 2.3 | 1.21 | 1.0 | 1.45 | 2.1 |
| 2 | 2.39 | 23.0 | 1.38 | 2.1 | 1.20 | 0.8 | 1.50 | 2.8 |
| 3 | 1.59 | 5.7 | 1.35 | 1.8 | 1.35 | 2.3 | 1.78 | 6.8 |
| 4 | 1.45 | 3.6 | 1.30 | 1.4 | * 1.69 | 7.2 | 1.75 | 6.3 |
| 5 | 1.82 | 9.1 | 1.45 | 3.2 | 2.03 | 12.0 | 1.74 | 6.2 |
| 6 | 15.4 | 4.8 | 1.35 | 2.0 | 2.65 | 22.0 | 1.67 | 5.1 |
| 7 | 1.99 | 11.0 | 1.41 | 2.8 | 2.39 | 18.0 | 1.64 | 4.7 |
| 8 | 1.80 | 8.5 | 1.46 | 3.5 | 2.00 | 12.0 | 1.55 | 3.5 |
| 9 | 1.60 | 5.3 | 1.36 | 2.3 | 1.65 | 6.1 | 1.49 | 2.6 |
| 10 | 1.60 | 5.3 | 1.36 | 2.3 | * 1.55 | 4.6 | 1.49 | 2.6 |
| 11 | 1.50 | 3.8 | 1.35 | 2.2 | 1.45 | 3.1 | 1.47 | 2.4 |
| 12 | * 1.43 | 2.7 | 1.33 | 2.0 | 1.37 | 2.0 | 1.46 | 2.3 |
| 13 | 1.35 | 1.6 | 1.32 | 2.0 | 1.25 | 0.8 | 1.47 | 2.4 |
| 14 | 1.40 | 2.1* | 1.36 | 2.5 | 1.25 | 0.8 | 1.47 | 2.4 |
| 15 | * 1.36 | 1.6 | 1.35 | 2.4 | 1.22 | 0.5 | 1.43 | 1.9 |
| 16 | 1.32 | 1.1 | 1.32 | 2.1 | 1.20 | 0.3 | 1.45 | 2.1 |
| 17 | 1.38 | 1.6 | 1.35 | 2.5 | 1.45 | 2.7 | 1.48 | 2.5 |
| 18 | 1.41 | 1.9 | 1.32 | 2.1 | 1.85 | 8.5 | 1.45 | 2.2 |
| 19 | 1.45 | 2.3 | 1.30 | 2.0 | 1.65 | 5.4 | 1.55 | 3.5 |
| 20 | 1.45 | 2.4 | 1.27 | 1.7 | 1.55 | 3.9 | 1.55 | 3.5 |
| 21 | 1.41 | 1.9 | 1.25 | 1.6 | 1.53 | 3.5 | 1.55 | 3.5 |
| 22 | 1.39 | 1.7 | 1.25 | 1.7 | 1.55 | 3.8 | 1.65 | 5.0 |
| 23 | 1.55 | 3.8 | 1.22 | 1.3 | 1.85 | 8.1 | 1.72 | 6.0 |
| 24 | 1.41 | 2.0 | 1.25 | 1.6 | 1.75 | 6.5 | 1.91 | 8.9 |
| 25 | 1.38 | 1.7 | 1.24 | 1.4 | 1.70 | 5.7 | 1.55 | 3.5 |
| 26 | * 1.36 | 1.6 | 1.26 | 1.6 | 1.89 | 8.6 | 1.53 | 3.3 |
| 27 | 1.35 | 1.5 | 1.27 | 1.7 | 1.45 | 2.1 | 1.65 | 5.0 |
| 28 | 1.37 | 1.8 | 1.25 | 1.4 | 1.55 | 3.5 | 1.64 | 4.9 |
| 29 | 1.36 | 1.7 | 1.23 | 1.2 | 1.54 | 3.3 | 1.70 | 5.7 |
| 30 | 1.36 | 1.7 | 1.22 | 1.1 | 1.48 | 2.5 | 1.42 | 1.8 |
| 31 | 1.42 | 2.5 | 1.21 | 1.0 | | | 1.42 | 1.8 |

*Gauge height interpolated.

MONTHLY DISCHARGE of Piapot Creek at Cumberland's Ranche, Sask., for 1911.

(Drainage area, 50 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| April (5-30) | 21.0 | 0.7 | 9.95 | 0.199 | 0.185 | 493 |
| May | 11.0 | 3.1 | 5.71 | 0.114 | 0.131 | 351 |
| June | 14.0 | 0.7 | 3.45 | 0.069 | 0.077 | 205 |
| July | 23.0 | 1.1 | 4.46 | 0.089 | 0.103 | 274 |
| August | 3.5 | 1.0 | 1.96 | 0.039 | 0.045 | 121 |
| September | 22.0 | 0.8 | 5.39 | 0.107 | 0.119 | 321 |
| October | 8.9 | 1.8 | 3.78 | 0.076 | 0.088 | 232 |
| The period | | | | | .748 | 1997 |

MISCELLANEOUS DISCHARGE MEASUREMENTS in Crane Lake Drainage Basin, in 1911.

| DATE. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 21....... | G. R. Elliott.... | E. Branch of Bear Creek..... | N.E. 29-10-23-3.. | 7 0 | 4 16 | 0 423 | 2 140 |
| June 21....... | do | West do | N.W. 29-10-23-3. | 16 0 | 9 04 | 0 444 | 4.010 |
| June 20....... | do | Glennie Creek... | S.E. 25-10-24-3. | ........ | ........ | ........ | 0 213 * |
| June 26....... | G. H. Whyte.... | do | do | ........ | ........ | ........ | 0 408 * |
| June 9. ....... | G. R. Elliott.... | Piapot Creek.... | N.E. 7-10-24-3. | 11.5 | 11 60 | 0 763 | 8.850 |
| April 27....... | G. H. Whyte.... | Spring Creek.... | Sec. 26-10-23-3. | 4 9 | 2 29 | 0.420 | 0 960 |
| June 22....... | G. R. Elliott.... | do | N.W. 5-11-23-3. | ........ | ........ | ........ | 0.408 * |
| June 26....... | G. H. Whyte.... | do | Sec. 25-10-24-3. | ........ | ........ | ........ | 0.200 * |

* Weir Measurement

## HAY LAKE DRAINAGE BASIN.

*General Description.*

Hay Lake is in Township 11, Range 25, west of the 3rd Meridian, and is fed by Hay Creek which rises in the Cypress Hills. It is a comparatively small body of saline water of an approximate area of three square miles. Like all lakes in this locality it has no outlet.

The basin supplies water for a number of irrigation schemes and also to the town of Maple Creek for domestic and industrial purposes, the water being piped some nine miles, by means of a gravity system.

The annual precipitation is about twelve inches, but during 1911, it was at least four inches greater; most of the rainfall occurred during May, June, July and September.

### HAY CREEK AT HAY CREEK SCHOOL, SASK.

This station was established on July 4, 1910, by R. G. Swan. It is located on the S.W. ¼ Sec. 29, Tp. 10, Rge. 25, W. 3rd Mer., and is above Mr. Fauquier's ditch and below the overflow of the Maple Creek waterworks reservoir.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the right bank of the stream. It is referred to two bench-marks as follows:—(1) a spike driven in the southeast corner of a house 300 feet west of the gauge and marked "B.M." (elev., 8.32 above the datum of the gauge); (2) a spike in the base of a willow stump, about 75 feet south of the gauge and marked "B.M." (elev., 4.96 above the datum of the gauge).

The channel of the creek is slightly curved for about eight feet above and fifty feet below the gauge. The bed of the stream is sandy and covered with vegetation, which causes the point of zero flow to change slightly. The current is sluggish, and during high stages both banks, being low, are liable to overflow.

Discharge measurements are made with a meter at high stages and with a weir at ordinary and low stages. During 1911, the Maple Creek waterworks were so arranged that all the overflow occurred at the intake and there was very little, if any, at the reservoir near this station as in former years.

During 1911, the gauge was read by Miss A. Bornemann.

DISCHARGE MEASUREMENTS of Hay Creek at Hay Creek School, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 3 ......... | G. H. Whyte................ | 4 2 | 1 09 | 0 716 | 0 850 | 0 780 |
| June 24 ......... | do | ........ | ........ | ........ | 0 555 | 0.198* |
| Sept. 27.......... | do | ........ | ........ | ........ | 0 540 | 0.049* |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Hay Creek at Hay Creek School, Sask., in 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. | Feet. | Sec.-ft. |
| 1 | .... | .. | 1 20 | 1 9 | 1 28 | 2 60 | 1 04 | 0 31 |
| 2 | .... | .... | 1 30 | 2 8 | 1 30 | 2 80 | 1 04 | 0 31 |
| 3 | .. | .... | 1 70 | 6 6 | 1 30 | 2 80 | 1 04 | 0 31 |
| 4 | .. | .. | 1 70 | 6 8 | 1 21 | 2 10 | 1 04 | 0 31 |
| 5 | ... | .... | 1 70 | 6 9 | 1 13 | 1 60 | 1 01 | 0 19 |
| 6 | ... | .... | 1 70 | 7 0 | 1 50 | 4 40 | 1 05 | 0 35 |
| 7 | . | .. | 1 30 | 3 2 | 1 05 | 1 00 | 1 08 | 0 47 |
| 8 | ... | .. | 1 50 | 5 1 | 1 05 | 1 00 | 1 10 | 0 55 |
| 9 | . | . | 1 50 | 5 2 | 1 05 | 1 00 | 1 07 | 0 43 |
| 10 | | .... | 1 90 | 10 1 | 1 05 | 1 00 | 1 06 | 0 39 |
| 11 | ..... | .. | 1 70 | 7 6 | 1 05 | 1 00 | 1 05 | 0 35 |
| 12 | .. | .. | 2 20 | 14 9 | 1 05 | 0 95 | 1 05 | 0 35 |
| 13 | | ... | 1 90 | 10 4 | 1 05 | 0 95 | 1 05 | 0 35 |
| 14 | .. | ...... | 1 90 | 10 4 | 1 05 | 0 90 | 1 05 | 0 35 |
| 15 | .. | ...... | 1 90 | 10 5 | 1 05 | 0 90 | 1 05 | 0 35 |
| 16 | .... | ..... | 1 90 | 10 5 | 1 05 | 0 85 | 1 05 | 0 35 |
| 17 | .. | .... | 1 90 | 10 5 | 1 05 | 0 80 | 1 05 | 0 35 |
| 18 | ...... | .... | 1 30 | 3 8 | 1 05 | 0 80 | 1 05 | 0 35 |
| 19 | ..... | ... | 1 50 | 5 7 | 1 05 | 0.75 | 1 05 | 0 35 |
| 20 | .. | ..... | 1.50 | 5 7 | 1 05 | 0 70 | 1 05 | 0 35 |
| 21 | .... | .... | 1 50 | 5 5 | 1 05 | 0 65 | 1 05 | 0 35 |
| 22 | ..... | .. | 1 50 | 5 4 | 1 05 | 0 60 | 1 05 | 0 35 |
| 23 | | . | 1 50 | 5 3 | 1 05 | 0 60 | 1 05 | 0 35 |
| 24 | 2 65 | 18 6 | 1 50 | 5 2 | 1 05 | 0 55 | 1 05 | 0 35 |
| 25 | 1 70 | 5 1 | 1 50 | 5 0 | 1 05 | 0 50 | 1 05 | 0 35 |
| 26 | 1 50 | 3 5 | 1 18 | 2 1 | 1 05 | 0 50 | 1 05 | 0 35 |
| 27 | 1 30 | 2 1 | 1 09 | 1 4 | 1 06 | 0 50 | 1 05 | 0 35 |
| 28 | 1 20 | 1 5 | 1 19 | 2 1 | 1 06 | 0 50 | 1 05 | 0 35 |
| 29 | 1.30 | 2 3 | 1 17 | 1 9 | 1 05 | 0 40 | 1 05 | 0 35 |
| 30 | 1.30 | 2 4 | 1 22 | 2 2 | 1 05 | 0 40 | 1 20 | 1 1 |
| 31 | 1 30 | 2 5 | .... | .... | 1 05 | 0 40 | .... | ...... |

DAILY GAUGE HEIGHT AND DISCHARGE of Hay Creek at Hay Creek School, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.20 | 1.10 | ... | ... | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.8 |
| 2 | 1.70 | 4.90 | ... | ... | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.8 |
| 3 | 1.15 | 0.80 | | | 1.04 | 0.31 | 1.13 | 0.70 | 1.15 | 0.8 |
| 4 | 1.15 | 0.80 | | | 1.05 | 0.35 | 1.13 | 0.70 | ...... | *b* |
| 5 | 1.10 | 0.55 | | | 1.25 | 1.40 | 1.13 | 0.70 | .... | ..... |
| 6 | 1.05 | 0.35 | | | 1.25 | 1.40 | 1.13 | 0.70 | ...... | .... |
| 7 | 1.05 | 0.35 | | | 1.25 | 1.40 | 1.13 | 0.70 | ...... | ...... |
| 8 | 1.05 | 0.35 | | | 1.20 | 1.10 | 1.09 | 0.51 | ... | .... |
| 9 | | *a* | | | 1.15 | 0.80 | 1.09 | 0.51 | ... | ...... |
| 10 | | | | | 1.10 | 0.55 | 1.09 | 0.51 | ... | ...... |
| 11 | | | | | 1.07 | 0.43 | 1.09 | 0.51 | ...... | ...... |
| 12 | | | | | 1.07 | 0.43 | 1.09 | 0.51 | ... | ...... |
| 13 | | | | *a* | 1.07 | 0.43 | 1.09 | 0.51 | ...... | ...... |
| 14 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.09 | 0.51 | ... | ...... |
| 15 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | | ...... |
| 16 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | ... | ...... |
| 17 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | ... | ...... |
| 18 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | | ...... |
| 19 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | | ...... |
| 20 | | | 1.05 | 0.35 | 1.07 | 0.43 | 1.07 | 0.43 | ... | ...... |
| 21 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.07 | 0.43 | ...... | ...... |
| 22 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.07 | 0.43 | ...... | ...... |
| 23 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 24 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 25 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 26 | | | 1.05 | 0.35 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 27 | | | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 28 | | | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 29 | | | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 30 | | | 1.04 | 0.31 | 1.11 | 0.60 | 1.15 | 0.80 | ...... | ...... |
| 31 | | | 1.04 | 0.31 | ...... | ... | 1.15 | 0.80 | ...... | ...... |

*a* to *a* No observations made.
*b* Creek frozen.

MONTHLY DISCHARGE of Hay Creek at Hay Creek School, Sask., for 1911.

(Drainage area, 30 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (24-31) | 18.6 | 1.50 | 4.750 | 0.158 | 0.047 | 75.4 |
| April | 14.9 | 1.40 | 6.060 | 0.202 | 0.225 | 361.0 |
| May | 4.4 | 0.40 | 1.110 | 0.037 | 0.043 | 68.0 |
| June | 1.1 | 0.19 | 0.379 | 0.013 | 0.014 | 22.6 |
| July (1-8) | 4.9 | 0.35 | 1.150 | 0.038 | 0.011 | 18.0 |
| August (14-31) | 0.35 | 0.31 | 0.038 | 0.011 | 0.007 | 12.0 |
| September | 1.4 | 0.31 | 0.608 | 0.020 | 0.022 | 36.0 |
| October | 0.8 | 0.43 | 0.610 | 0.020 | 0.023 | 37.5 |
| November (1-3) | 0.8 | 0.80 | 0.800 | 0.027 | 0.003 | 4.8 |
| The period | .......... | .......... | .......... | .......... | .395 | 635.3 |

## HAY CREEK AT FAUQUIER'S RANCHE, SASK.

This station was established on April 22, 1909, by F. T. Fletcher. It is located on the N.E. ¼ Sec. 30, Tp. 10, Rge. 25, W. 3rd Mer., about seven miles southeast of Maple Creek. It is situated below the intake of H. Fauquier's irrigation ditch, and also below the intake of the Maple Creek waterworks. Hence, records of flow obtained at this station do not represent the total discharge of the stream. The flow of springs below the Maple Creek waterworks intake, together with drainage, and the overflow from the Maple Creek waterworks give a continuous flow in the creek above the station. This flow, which is very largely the overflow from the Maple Creek waterworks, varies greatly, depending upon the consumption of water by the town of Maple Creek and by the Canadian Pacific Railway. The disappearance of water before reaching this station is explained, in part, by the fact that Mr. Fauquier diverts water into his irrigation ditch. The remainder of the water must seep through the gravel of the creek-bed before it reaches this station. The fact that springs break out a short distance below the gauge and give a continuous flow (so far as is known) seems to bear out the seepage theory.

The channel is straight for 100 feet above and 200 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of sand and coarse gravel, and is liable to shift at high stages. The current is sluggish during low water, but is very swift at high stages.

Discharge measurements are made near the gauge by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank, marked "I.P."

The gauge, which is a plain staff graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to bench-marks as follows:—(1) a spike-head in the top of the initial-point stake on the left bank (elev., 6.62 feet above the zero of the gauge); (2) a "broad-arrow" marked with red paint on a large rock in the foundation of a frame out-building close to the gauge (elev., 9.34 feet above the zero of the gauge).

During 1911, the gauge was read by Mr. H. Fauquier.

DISCHARGE MEASUREMENTS of Hay Creek at Fauquier's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Mar. 24 | G. H. Whyte. | 8.0 | 11.75 | 1.58 | 2.65 | 18.53 |
| April 26 | do | 5.0 | 3.35 | 0.61 | 1.18 | 2.04 |
| May 31 | do | | | | 1.04 | 0.487* |
| July 19 | do | | | | 1.03 | 0.294* |
| Aug. 21 | do | | | | 1.06 | 0.323* |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Hay Creek at Fauquier's Ranche, Sask., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height | Discharge | Gauge Height. | Discharge. |
| | *Feet* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet* | *Sec.-ft.* |
| 1 | | | 7 | 0.37 | 0.70 | 0.37 | 0.51 | 0.06 |
| 2 | | | Frozen | | 0.98 | 1.27 | 0.50 | 0.05 |
| 3 | | | " | | 1.00 | 1.37 | 0.50 | 0.05 |
| 4 | | | " | | 0.96 | 1.19 | 0.51 | 0.06 |
| 5 | | | 0.70 | 0.37 | 0.86 | 0.81 | 0.65 | 0.27 |
| 6 | | | 0.70 | 0.37 | 0.69 | 0.35 | 0.56 | 0.13 |
| 7 | | | 0.70 | 0.37 | 0.60 | 0.18 | 0.60 | 0.18 |
| 8 | | | 0.80 | 0.62 | 0.57 | 0.14 | 1.11 | 2.00 |
| 9 | | | 1.20 | 2.5 | 0.55 | 0.11 | 0.58 | 0.15 |
| 10 | | | 1.50 | 4.7 | 0.56 | 0.13 | 0.55 | 0.11 |
| 11 | | | 1.20 | 2.5 | 0.55 | 0.11 | 0.58 | 0.15 |
| 12 | | | Frozen | | 0.57 | 0.14 | 0.53 | 0.09 |
| 13 | | | 0.70 | 0.37 | 0.57 | 0.14 | 0.51 | 0.06 |
| 14 | | | 0.70 | 0.37 | 0.57 | 0.14 | 0.53 | 0.09 |
| 15 | | | 1.00 | 1.37 | 0.57 | 0.14 | 0.52 | 0.07 |
| 16 | | | 1.20 | 2.5 | 0.86 | 0.81 | 0.48 | 0.03 |
| 17 | | | 1.30 | 3.2 | 0.59 | 0.17 | 0.41 | Nil. |
| 18 | | | 0.90 | 0.95 | 0.55 | 0.11 | Dry. | " |
| 19 | | | 1.10 | 1.9 | 0.56 | 0.13 | " | " |
| 20 | | | 1.00 | 1.37 | 0.53 | 0.09 | " | " |
| 21 | | | 1.00 | 1.37 | 0.55 | 0.11 | " | " |
| 22 | 1.2 | 2.50 | 1.20 | 2.5 | 0.55 | 0.11 | " | " |
| 23 | 1.2 | 2.50 | 1.00 | 1.37 | 0.60 | 0.18 | " | " |
| 24 | 1.6 | 5.70 | 1.00 | 1.37 | 0.60 | 0.18 | " | " |
| 25 | 1.3 | 3.20 | 1.00 | 1.37 | 0.63 | 0.23 | 0.60 | 0.18 |
| 26 | 1.0 | 1.37 | 0.90 | 0.95 | 0.60 | 0.18 | 0.60 | 0.18 |
| 27 | 0.8 | 0.62 | 0.68 | 0.33 | 0.62 | 0.21 | 0.56 | 0.11 |
| 28 | 1.2 | 2.50 | 0.69 | 0.35 | 0.59 | 0.17 | 0.56 | 0.11 |
| 29 | 1.1 | 1.90 | 0.70 | 0.37 | 0.57 | 0.14 | 0.49 | 0.04 |
| 30 | 0.8 | 0.62 | 0.70 | 0.37 | 0.54 | 0.10 | 0.55 | 0.11 |
| 31 | 0.7 | 0.37 | | | 0.54 | 0.10 | | ... |

Daily Gauge Height and Discharge of Hay Creek at Fauquier's Ranche, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.75 | 0.49 | Dry | Nil | Dry | Nil | 0.49 | 0.04 | 0.70 | 0.37 |
| 2 | 1.40 | 3.9 | " | " | " | " | 0.54 | 0.10 | 0.71 | 0.39 |
| 3 | 0.72 | 0.41 | " | " | " | " | 0.61 | 0.19 | 0.70 | 0.37 |
| 4 | 0.60 | 0.18 | " | " | 0.58 | 0.15 | 0.63 | 0.23 | 0.69 | 0.35 |
| 5 | 0.62 | 0.21 | 0.52 | 0.07 | 0.63 | 0.23 | 0.55 | 0.11 | 0.60 | 0.18 |
| 6 | 0.55 | 0.11 | 0.50 | 0.05 | 0.82 | 0.68 | 0.54 | 0.10 | 0.59 | 0.17 |
| 7 | 0.53 | 0.09 | 0.60 | 0.18 | 0.87 | 0.84 | 0.52 | 0.07 | Frozen | ....... |
| 8 | 0.53 | 0.09 | 0.55 | 0.11 | 0.58 | 0.15 | 0.52 | 0.07 | ....... | ....... |
| 9 | 0.55 | 0.11 | 0.54 | 0.10 | 0.54 | 0.10 | 0.53 | 0.09 | ....... | ....... |
| 10 | 0.52 | 0.07 | 0.50 | 0.05 | 0.53 | 0.09 | 0.51 | 0.06 | ....... | ....... |
| 11 | 0.50 | 0.05 | 0.49 | 0.04 | 0.50 | 0.05 | 0.53 | 0.09 | ....... | ....... |
| 12 | 0.50 | 0.05 | 0.45 | 0.01 | 0.48 | 0.03 | 0.54 | 0.10 | ....... | ....... |
| 13 | 0.49 | 0.04 | Dry | Nil | 0.50 | 0.05 | 0.53 | 0.09 | ....... | ....... |
| 14 | 0.40 | Nil | " | " | 0.54 | 0.10 | 0.50 | 0.05 | ....... | ....... |
| 15 | Dry | " | " | " | 0.51 | 0.06 | 0.52 | 0.07 | ....... | ....... |
| 16 | " | " | " | " | Dry | Nil | 0.58 | 0.15 | ....... | ....... |
| 17 | " | " | " | " | 0.45 | 0.01 | 0.58 | 0.15 | ....... | ....... |
| 18 | " | " | " | " | 0.55 | 0.11 | 0.60 | 0.18 | ....... | ....... |
| 19 | " | " | " | " | 0.53 | 0.09 | 0.55 | 0.11 | ....... | ....... |
| 20 | " | " | " | " | 0.51 | 0.06 | 0.57 | 0.14 | ....... | ....... |
| 21 | " | " | " | " | 0.48 | 0.03 | 0.55 | 0.11 | ....... | ....... |
| 22 | " | " | " | " | 0.52 | 0.07 | 0.54 | 0.10 | ....... | ....... |
| 23 | " | " | " | " | 0.56 | 0.13 | 0.57 | 0.14 | ....... | ....... |
| 24 | " | " | " | " | 0.60 | 0.18 | 0.60 | 0.18 | ....... | ....... |
| 25 | " | " | " | " | 0.55 | 0.11 | 0.61 | 0.19 | ....... | ....... |
| 26 | " | " | " | " | 0.54 | 0.10 | 0.62 | 0.21 | ....... | ....... |
| 27 | " | " | " | " | 0.54 | 0.10 | 0.63 | 0.23 | ....... | ....... |
| 28 | " | " | " | " | 0.53 | 0.09 | 0.63 | 0.23 | ....... | ....... |
| 29 | " | " | " | " | 0.52 | 0.07 | 0.62 | 0.21 | ....... | ....... |
| 30 | " | " | " | " | 0.50 | 0.05 | 0.63 | 0.23 | ....... | ....... |
| 31 | " | " | " | " | ...... | ....... | 0.68 | 0.23 | ....... | ....... |

Monthly Discharge of Hay Creek at Fauquier's Ranche, Sask., for 1911.

(Drainage area, 32 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-Feet. |
| March (22-31) | 5.50 | 0.37 | 2.110 | 0.066 | 0.024 | 42 |
| April | 4.70 | 0.33 | 1.140 | 0.036 | 0.040 | 68 |
| May | 1.37 | 0.10 | 0.310 | 0.010 | 0.012 | 19 |
| June | 2.00 | 0.00 | 0.142 | 0.004 | 0.004 | 8 |
| July | 3.90 | 0.00 | 0.187 | 0.006 | 0.007 | 12 |
| August | 0.18 | 0.00 | 0.020 | 0.001 | 0.001 | 1 |
| September | 0.84 | 0.00 | 0.120 | 0.004 | 0.004 | 7 |
| October | 0.33 | 0.04 | 0.140 | 0.004 | 0.005 | 9 |
| November (1-6) | 0.39 | 0.17 | 0.305 | 0.009 | 0.002 | 4 |
| The period | ....... | ......... | .......... | .......... | 0.099 | 170 |

MISCELLANEOUS DISCHARGE MEASUREMENTS of Hay Lake Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | Feet. | Sq. Feet. | Feet per Sec. | Sec.-Ft. |
| June 12........ | G. R. Elliott.. | Hay Creek Br. of | S. E. 16-10-25-3 | * | | ........ | 0 600 |
| do ..... | do | do | N.W. 3-10-25-3 | * | | ...... | 0 150 |
| do ... | " | Spring... | N.W. 10-10-25-3 | * | | ...... | 0 106 |
| do ... | do | do .. | N.E. 3-10-25-3 | * | | .... | 0 213 |

* Weir measurement.

## BIG STICK LAKE DRAINAGE BASIN.

*General Description.*

This lake is one of the largest in the northern Cypress Hills district. It is situated in township 15, range 25, west of the third meridian, covers an area of 35 square miles, is alkaline in character, and has no outlet.

Maple Creek, which rises in the Cypress Hills, with its tributary, Gap Creek, is its only source of supply. On the south and east the lake is bounded by the sandhills. The drainage area is 820 square miles.

The valley of Maple Creek is quite flat and shallow, and the surrounding bench-land is gently rolling prairie.

The annual precipitation is about twelve inches, and most of it falls during May, June and July.

There are several small irrigation ditches in the basin.

### MAPLE CREEK AT MAPLE CREEK, SASK.

This station was established May 9, 1908, by R. J. Burley. It is located at the highway bridge just north of the Canadian Pacific Railway tracks in the town of Maple Creek, on the road allowance east of the N.E. ¼ Sec. 16, Tp. 11, Rge. 16, W. 3rd Mer.

The channel is straight for 200 feet above and 100 feet below the station. Both banks are comparatively low, and will overflow at high-water stages of the stream. The bed of the stream is composed of sand, and may shift during flood stages. The current is moderate at high and sluggish at low stages of the stream.

The gauge, which is a plain staff graduated to feet and hundredths, is attached vertically to a pile on the upstream side of the bridge. The zero is referred to a permanent iron bench-mark located on the right bank and on the west side of the road allowance.

Discharge measurements are made from the downstream side of the bridge. The initial point for sounding is the inner face of the right, or south, abutment of the bridge. Low-water measurements are made at a point about fifty feet upstream from the gauge by wading, and at very low stages a weir is used. The light, sandy soil of the banks gives rise to a great amount of erosion during flood stages, and this fact, coupled with that of the low banks of the stream, makes this station a rather unsatisfactory one for gauging purposes. The bridge is not at right angles to the flow and measurements made from the bridge must be corrected.

The gauge was read daily by R. G. Williamson, from March 23 to June 23, and by Tom Williams from July 27 to November 4.

DISCHARGE MEASUREMENTS of Maple Creek at Maple Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| Mar. 23 ....... | G. H. Whyte................ | 38 0 | 78 07 | 0.734 | 2.950 | 57 28 |
| Mar. 25 ....... | do ........... | 40 9 | 121 20 | 0.965 | 3 800 | 116 90 |
| April 13 ..... | M. H. French.. ....... | 33 0 | 54 15 | 0 510 | 2 185 | 27.59 |
| April 22 ....... | G. H. Whyte............. | 37 9 | 61 44 | 0.532 | 2.225 | 32 71 |
| May 5.......... | M. H. French........... | 38 0 | 55 70 | 0 297 | 1 940 | 16 59† |
| May 5.......... | do ............ | 38 0 | 55.70 | 0 328 | 1.930 | 18.28‡ |
| May 5.......... | do ............... | 38 0 | 55 70 | 0 357 | 1 920 | 19 90▲ |
| May 29.......... | do ............... | 33 0 | 37 05 | 0 177 | 1.520 | 6 59 |
| June 23.......... | do ............... | 19 0 | 16 10 | 0 003 | 0 710 | 0 05* |
| Aug. 18.......... | do ............... | .. | ...... | ...... | 0 300 | Nil. |
| Sept. 11.......... | do ............ | 30 0 | 27.30 | 0 063 | 1 140 | 1 71 |
| Oct. 16.......... | do ............... | 20 0 | 18 90 | 0 008 | 0 740 | 0 15* |

* Weir measurement.
† Gauging made at a poor cross-section upstream, with meter of pattern No. 623.
‡ Gauging made at the same cross-section with meter of pattern No. 618.
▲ Gauging made at the same cross-section with meter of pattern No. 600.

DAILY GAUGE HEIGHT AND DISCHARGE of Maple Creek at Maple Creek, Sask., for 1911.

| Day | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 2.00 | 15.0 | 1.75 | 12.0 | 1.50 | 7.0 |
| 2 | | | 1.80 | 11.0 | 1.75 | 12.0 | 1.49 | 6.8 |
| 3 | | | 1.60 | 6.5 | 1.75 | 12.0 | 1.48 | 6.6 |
| 4 | | | 1.30 | 3.0 | 1.75 | 12.0 | 1.46 | 6.2 |
| 5 | | | 1.30 | 2.8 | 1.75 | 12.0 | 1.46 | 6.2 |
| 6 | | | 1.70 | 9.5 | 1.75 | 12.0 | 1.45 | 6.0 |
| 7 | | | 2.00 | 18.0 | 1.75 | 12.0 | 1.44 | 5.8 |
| 8 | | | 2.80 | 50.0 | 1.75 | 12.0 | 1.87 | 16.0 |
| 9 | | | 3.10 | 19.0 | 1.75 | 12.0 | 1.87 | 16.0 |
| 10 | | | 4.25 | 182.0 | 1.75 | 12.0 | 1.87 | 16.0 |
| 11 | | | 4.75 | 246.0 | 1.70 | 11.0 | 1.70 | 11.0 |
| 12 | | | 3.70 | 129.0 | 1.70 | 11.0 | 1.55 | 8.0 |
| 13 | | | 2.15 | 26.0 | 1.80 | 14.0 | 1.45 | 6.0 |
| 14 | | | 2.30 | 34.0 | 1.60 | 9.0 | 1.40 | 5.0 |
| 15 | | | 2.24 | 31.0 | 1.50 | 7.0 | 1.36 | 4.6 |
| 16 | | | 6.80 | 34.0 | 1.40 | 5.0 | 1.00 | 1.3 |
| 17 | | | 2.30 | 34.0 | 1.40 | 5.0 | 0.90 | 0.8 |
| 18 | | | 4.05 | 164.0 | 1.30 | 4.0 | 0.70 | 0.1 |
| 19 | | | 2.45 | 42.0 | 1.30 | 4.0 | 0.70 | 0.1 |
| 20 | | | 2.10 | 24.0 | 1.25 | 3.5 | 0.70 | 0.1 |
| 21 | | | 2.30 | 34.0 | 1.25 | 3.5 | 0.70 | 0.1 |
| 22 | | | 2.16 | 27.0 | 1.25 | 3.5 | 0.70 | 0.1 |
| 23 | 3.40 | 87.0 | 2.37 | 38.0 | 1.55 | 8.0 | 0.71 | 0.1 |
| 24 | 3.41 | 87.0 | 2.20 | 29.0 | 1.55 | 8.0 | ..... | ..... |
| 25 | 3.69 | 108.0 | 2.00 | 20.0 | 1.55 | 8.0 | ..... | ..... |
| 26 | 2.90 | 53.0 | 1.90 | 17.0 | 1.55 | 8.0 | ..... | ..... |
| 27 | 2.52 | 33.0 | 1.70 | 11.0 | 1.55 | 8.0 | ..... | ..... |
| 28 | 2.28 | 23.0 | 1.60 | 9.0 | 1.55 | 8.0 | ..... | ..... |
| 29 | 2.40 | 29.0 | 1.70 | 11.0 | 1.55 | 8.0 | ..... | ..... |
| 30 | 2.32 | 25.0 | 1.70 | 11.0 | 1.52 | 7.4 | ..... | ..... |
| 31 | 2.26 | 24.0 | | | 1.50 | 7.0 | ..... | ..... |

DAILY GAUGE HEIGHT AND DISCHARGE of Maple Creek at Maple Creek, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.44 | Nil | 0.15 | Nil | 0.89 | 0.8 | 0.97 | 1.2 |
| 2 | | | 0.43 | " | 0.14 | " | 0.86 | 0.6 | 0.99 | 1.2 |
| 3 | | | 0.41 | " | 0.19 | " | 0.84 | 0.6 | 0.94 | 1.0 |
| 4 | | | 0.40 | " | 0.31 | " | 0.82 | 0.5 | 0.91 | 0.8 |
| 5 | | | 0.38 | " | 0.47 | " | 0.90 | 0.8 | .... | ..... |
| 6 | | | 0.38 | " | 0.64 | " | 0.97 | 1.2 | ..... | ..... |
| 7 | | | 0.37 | " | 0.87 | 0.7 | 1.19 | 2.9 | ..... | ..... |
| 8 | | | 0.36 | " | 1.45 | 6.0 | 1.19 | 2.9 | ..... | ..... |
| 9 | | | 0.36 | " | 1.32 | 4.2 | 1.12 | 2.2 | ..... | ..... |
| 10 | | | 0.34 | " | 1.20 | 3.0 | 0.96 | 1.1 | ..... | ..... |
| 11 | | | 0.34 | " | 1.14 | 2.4 | 0.96 | 1.1 | ..... | ..... |
| 12 | | | 0.34 | " | 0.94 | 1.0 | 0.92 | 0.9 | ..... | ..... |
| 13 | | | 0.33 | " | 0.87 | 0.7 | 0.82 | 0.5 | ..... | ..... |
| 14 | | | 0.33 | " | 0.74 | 0.2 | 0.74 | 0.2 | ..... | ..... |
| 15 | | | 0.31 | " | 0.66 | 0.1 | 0.74 | 0.2 | ..... | ..... |
| 16 | | | 0.30 | " | 0.66 | 0.1 | 0.74 | 0.2 | ..... | ..... |
| 17 | | | 0.29 | " | 0.66 | 0.1 | 0.74 | 0.2 | ..... | ..... |
| 18 | | | 0.29 | " | 0.66 | 0.1 | 0.74 | 0.2 | ..... | ..... |
| 19 | | | 0.28 | " | 0.66 | 0.1 | 0.78 | 0.3 | ..... | ..... |
| 20 | | | 0.26 | " | 0.66 | 0.1 | 0.87 | 0.7 | ..... | ..... |
| 21 | | | 0.18 | " | 0.66 | 0.1 | 0.87 | 0.7 | ..... | ..... |
| 22 | | | 0.17 | " | 0.66 | 0.1 | 0.88 | 0.7 | ..... | ..... |
| 23 | | | 0.17 | " | 0.66 | 0.1 | 0.90 | 0.8 | ..... | ..... |
| 24 | | | 0.17 | " | 0.66 | 0.1 | 1.21 | 3.1 | ..... | ..... |
| 25 | | | 0.17 | " | 0.66 | 0.1 | 1.27 | 3.7 | ..... | ..... |
| 26 | | | 0.17 | " | 0.86 | 0.6 | 1.20 | 3.0 | ..... | ..... |
| 27 | 0.59 | Nil | 0.17 | " | 1.16 | 2.6 | 1.10 | 2.0 | ..... | ..... |
| 28 | 0.56 | " | 0.17 | " | 1.10 | 2.0 | 1.07 | 1.8 | ..... | ..... |
| 29 | 0.54 | " | 0.17 | " | 0.92 | 0.9 | 1.01 | 1.4 | ..... | ..... |
| 30 | 0.48 | " | 0.17 | " | 0.92 | 0.9 | 0.90 | 0.8 | ..... | ..... |
| 31 | 0.45 | " | 0.16 | " | .. | ..... | 0.96 | 1.1 | ..... | ..... |

NOTE.—The records for March, April, May, and June are only approximate as the observer was either incomtent or careles and did not perform his duties satisfactorily. There were no observations from June 24 to July 26, but there was considerable rain during the last few days of June, and the run-off during the period of no observations is estimated at 370 acre-feet.

MONTHLY DISCHARGE of Maple Creek at Maple Creek, Sask., for 1911.

(Drainage area, 87 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (23-31) | 108.0 | 23.0 | 52.1 | 0.599 | 0.200 | 930 |
| April | 246.0 | 2.8 | 45.2 | 0.520 | 0.580 | 2,690 |
| May | 14.0 | 3.5 | 8.7 | 0.100 | 0.115 | 535 |
| June (1-23) | 16.0 | 0.1 | 5.6 | 0.064 | 0.055 | 258 |
| July (27-31) | 00.0 | 0.0 | 0.0 | 0.000 | 0.000 | 00 |
| August | 00.0 | 0.0 | 0.0 | 0.000 | 0.000 | 00 |
| September | 6.0 | 0.0 | 0.9 | 0.010 | 0.011 | 54 |
| October | 3.7 | 0.2 | 1.2 | 0.138 | 0.159 | 74 |
| November (1-4) | 1.2 | 0.8 | 1.0 | 0.011 | 0.012 | 8 |
| The period | | | | | 1.132 | 4549 |

NOTE.—The records for March, April, May, and June are only approximate. Run-off from June 24 to July 26 is estimated at 370 acre-feet.

## Maple Creek near Maple Creek, Sask.

This station was established on May 4, 1910, by H. R. Carscallen. It is one mile north of the town of Maple Creek, on the bridge between Secs. 27 and 28, Tp. 11, Rge. 16, W. 3rd Mer.

The channel is straight for a distance of 100 feet upstream and 10 feet downstream. The right bank is high and sandy. The left is low, with a gradual slope, and is liable to overflow. The stream is sandy and liable to shift.

The gauge, which is a plain staff graduated to feet and hundredths, is securely fastened to the downstream side of the second pile from the right abutment. It is referred to two bench marks, viz.: (1) two spikes in the downstream side of the plank wing at the right abutment, marked "B.M." (elevation, 9.37); (2) a spike-head in a five-inch post on the right bank, 35 feet west of the gauge and marked "B.M." (elevation, 9.42).

Because of apparent inaccuracies in observations, the gauge-height records for 1911 are not considered satisfactory and have not been used. There is, therefore, no table of daily gauge-height and discharge for 1911.

### Discharge Measurements of Maple Creek near Maple Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Mar. 25 | G. H. Whyte | 40.0 | 72.25 | 1.118 | 5.250 | 80.750* |
| Mar. 31 | do | 27.5 | 51.77 | 0.451 | 3.695 | 23.338† |
| April 22 | do | 26.6 | 20.26 | 1.392 | 3.740 | 28.440 |
| May 5 | M. H. French | 30.0 | 56.51 | 0.102 | 3.520 | 15.930 |
| May 30 | do | 29.0 | 41.81 | 0.102 | 3.010 | 4.280 |
| June 22 | do | 27.0 | 31.06 | 0.008 | 2.700 | 0.270‡ |
| July 17 | G. H. Whyte | | | | 2.680 | 0.355‡ |

* Anchor drift ice and snow.
† Floating ice.
‡ Weir measurement.

## White Ditch near Cypress, Sask.

This station was established on June 15, 1911, by W. A. Fletcher. It is located in the S.W. ¼ Sec. 1, Tp. 9, Rge. 27, W. 3rd Mer.

The gauge, which consists of a board divided into feet and inches, is nailed to a stake driven in the ditch. The zero of the gauge is referred to the top of a stump on the left bank and upstream from the gauge.

Discharge measurements are made with a weir.

## Gap Creek at Small's Ranche, Sask.

This station was established April 25, 1909, by F. T. Fletcher. It is located on the S.E. ¼ Sec. 4, Tp. 10, Rge. 27, W. 3rd Mer., about 400 yards west of the surveyed trail from Maple Creek to Tenmile and about 12 miles south of Maple Creek.

The channel is straight for 60 feet above and 500 feet below the station. The right bank is high, and will not overflow except at very extreme flood stages; the left bank is much higher than the right, and will not overflow at any stage of the stream. The bed of the stream is composed of loose, coarse gravel. The current is sluggish.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked firmly to a vertical post sunk in the bed of the stream at the right bank and securely stayed to the bank. The zero (elev., 66.62) is referred to a permanent iron bench-mark (assumed elev., 100.00), near the McShane Creek bridge, and about 1,000 feet south of the gauge.

Discharge measurements are made at ordinary stages with a current-meter by wading, and from a cable-car at high stages. The initial point for soundings is a seven-eighths inch iron pin on the right bank. It stands about four inches above ground and is protected by a mound of stones. It is also about three feet west of the northwest corner of a log building used as a cattle shed.

During 1911, the gauge was read by William Small.

There are a few small irrigation ditches in course of construction above this station, but during 1911 little or no water was diverted.

DISCHARGE MEASUREMENTS of Gap Creek at Small's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 14 | M. H. French | 24.0 | 28.74 | 0.780 | 2.47 | 22.31 |
| May 8 | do | 44.0 | 24.20 | 0.238 | 2.25 | 5.78 |
| June 1 | do | 22.0 | 19.40 | 0.074 | 2.14 | 1.43* |
| June 26 | do | 34.0 | 47.10 | 1.230 | 2.81 | 58.10 |
| July 29 | do | ........ | ........ | ........ | ........ | Nil. |
| Aug. 18 | do | ........ | 16.10 | ........ | 1.90 | Nil. |
| Aug. 21 | do | ........ | 16.10 | ........ | 1.90 | Nil. |
| Sept. 9 | do | 29.0 | 29.55 | 0.895 | 2.55 | 26.46 |

* Weir measurement.

DAILY GAUGE HEIGHT AND DISCHARGE of Gap Creek at Small's Ranche, Sask., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec. ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ........ | ........ | 2.40 | 15.0 | 2.72 | 46.0 | 2.14 | 1.8 |
| 2 | ........ | ........ | 2.30 | 8.8 | 2.70 | 44.0 | 2.10 | 0.9 |
| 3 | ........ | ........ | 2.23 | 5.1 | 2.65 | 38.0 | 2.08 | 0.7 |
| 4 | ........ | ........ | 2.24 | 5.6 | 2.70 | 44.0 | 2.06 | 0.4 |
| 5 | ........ | ........ | 2.25 | 6.0 | 2.55 | 28.0 | 2.06 | 0.4 |
| 6 | ........ | ........ | 2.24 | 5.6 | 2.42 | 17.0 | 2.05 | 0.3 |
| 7 | ........ | ........ | 2.20 | 3.8 | 2.36 | 12.4 | 2.11 | 1.1 |
| 8 | ........ | ........ | 2.25 | 6.0 | 2.30 | 8.8 | 2.23 | 5.1 |
| 9 | ........ | ........ | 2.65 | † 38.0 | 2.22 | 4.7 | 2.23 | 5.1 |
| 10 | ........ | ........ | 3.25 | †146.0 | 2.19 | 3.4 | 2.21 | 4.2 |
| 11 | ........ | ........ | 3.40 | †181.0 | 2.21 | 4.2 | 2.14 | 1.8 |
| 12 | ........ | ........ | 2.46 | 20.0 | 2.23 | 5.1 | 2.10 | 0.9 |
| 13 | ........ | ........ | 2.40 | 15.0 | 2.25 | 6.0 | 2.06 | 0.4 |
| 14 | ........ | ........ | 2.40 | 15.0 | 2.18 | 3.1 | 2.02 | 0.1 |
| 15 | ........ | ........ | 2.81 | 58.0 | 2.15 | 2.0 | 2.00 | Nil. |
| 16 | ........ | ........ | 2.95 | 81.0 | 2.18 | 3.1 | 1.97 | " |
| 17 | 2.98* | ........ | 3.08 | 107.0 | 2.30 | 8.8 | 1.95 | " |
| 18 | 3.09* | ........ | 2.80 | 57.0 | 2.30 | 8.8 | 1.94 | " |
| 19 | 3.04* | ........ | 2.83 | 61.0 | 2.25 | 6.0 | 1.92 | " |
| 20 | 3.49* | ........ | 2.73 | 48.0 | 2.19 | 3.4 | 1.93 | " |
| 21 | 3.64* | ........ | 2.70 | 44.0 | 2.18 | 3.1 | 2.30 | 8.8 |
| 22 | 2.84 | 63.0 | 2.77 | 53.0 | 2.15 | 2.0 | 2.18 | 3.1 |
| 23 | 2.75 | 50.0 | 2.71 | 45.0 | 2.20 | 3.8 | 2.21 | 4.2 |
| 24 | 3.25 | 146.0 | 2.48 | 21.0 | 2.35 | 11.8 | 2.15 | 2.0 |
| 25 | 2.89 | 70.0 | 2.53 | 26.0 | 2.35 | 11.8 | 2.17 | 2.7 |
| 26 | 2.63 | 36.0 | 2.46 | 20.0 | 2.35 | 11.8 | 2.84 | ‡63.0 |
| 27 | 2.65 | 38.0 | 2.40 | 15.0 | 2.40 | 15.0 | 2.35 | ‡11.8 |
| 28 | 2.71 | 45.0 | 2.38 | 13.7 | 2.34 | 11.2 | 2.26 | 6.6 |
| 29 | 2.74 | 49.0 | 2.40 | 15.0 | 2.27 | 7.2 | 2.20 | 3.8 |
| 30 | 2.74 | 49.0 | 2.50 | 23.0 | 2.20 | 3.8 | 2.15 | 2.0 |
| 31 | 2.47 | 21.0 | ........ | ........ | 2.19 | 3.4 | ........ | ........ |

Daily Gauge Height and Discharge of Gap Creek at Small's Ranche, Sask., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height. | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 2.45 | 19.0 | 1.89 | Nil | 1.84 | Nil | 2.17 | 2.7 | 2.18 | 3.1 |
| 2 | 3.16 | ‡125.0 | 1.88 | " | 1.84 | " | 2.15 | 2.0 | 2.14 | 1.8 |
| 3 | 2.50 | 23.0 | 1.88 | " | 1.85 | " | 2.18 | 3.1 | 2.12 | 1.3 |
| 4 | 2.34 | 11.2 | 1.87 | " | 2.00 | " | 2.50 | 23.0 | 2.20 | 3.8 |
| 5 | 2.34 | 11.2 | 1.91 | " | 3.80 | ‡280.0 | 2.40 | 15.0 | 2.23 | 5.1 |
| 6 | 2.34 | 11.2 | 1.94 | " | 5.26 | ‡645.0 | 2.30 | 8.8 | 2.25 | 6.0 |
| 7 | 2.23 | 5.1 | 1.95 | " | 3.53 | ‡212.0 | 2.25 | 6.0 | 2.20 | 3.8 |
| 8 | 2.14 | 1.8 | 2.20 | 3.8 | 2.77 | 53.0 | 2.20 | 3.8 | 2.18 | 3.1 |
| 9 | 2.10 | 0.9 | 2.37 | 13.0 | 2.56 | 29.0 | 2.16 | 2.4 | 2.18 | 3.1 |
| 10 | 2.10 | 0.9 | 2.23 | 5.1 | 2.44 | 18.0 | 2.16 | 2.4 | 2.18 | 3.1 |
| 11 | 2.07 | 0.5 | 2.14 | 1.8 | 2.36 | 12.4 | 2.14 | 1.8 | 2.18 | 3.1 |
| 12 | 2.05 | 0.3 | 2.08 | 0.7 | 2.30 | 8.8 | 2.12 | 1.3 | 2.18 | 3.1 |
| 13 | 2.01 | 0.1 | 2.02 | 0.1 | 2.26 | 6.6 | 2.10 | 0.9 | 2.18 | 3.1 |
| 14 | 2.00 | Nil | 1.99 | Nil | 2.23 | 5.1 | 2.10 | 0.9 | 2.18 | 3.1 |
| 15 | 2.00 | " | 1.95 | " | 2.19 | 3.4 | 2.10 | 0.9 | 2.18 | 3.1 |
| 16 | 1.98 | " | 1.94 | " | 2.15 | 2.0 | 2.10 | 0.9 | | .... |
| 17 | 1.96 | " | 1.93 | " | 2.15 | 2.0 | 2.10 | 0.9 | | .... |
| 18 | 1.96 | " | 1.92 | " | 2.15 | 2.0 | 2.10 | 0.9 | | .... |
| 19 | 1.96 | " | 1.91 | " | 2.14 | 1.8 | 2.12 | 1.3 | | .... |
| 20 | 1.95 | " | 1.91 | " | 2.14 | 1.8 | 2.15 | 2.0 | | .... |
| 21 | 1.95 | " | 1.90 | " | 2.15 | 2.0 | 2.17 | 2.7 | | .... |
| 22 | 1.94 | " | 1.89 | " | 2.16 | 2.4 | 2.17 | 2.7 | | .... |
| 23 | 1.93 | " | 1.89 | " | 2.18 | 3.1 | 2.25 | 6.0 | | .... |
| 24 | 1.92 | " | 1.88 | " | 2.34 | 11.2 | 2.31 | 9.4 | | .... |
| 25 | 1.91 | " | 1.88 | " | 2.37 | 13.0 | 2.32 | 10.0 | | .... |
| 26 | 1.90 | " | 1.90 | " | 2.39 | 14.0 | 2.24 | 5.6 | | .... |
| 27 | 1.88 | " | 1.90 | " | 2.32 | 10.0 | 2.20 | 3.8 | | .... |
| 28 | 1.88 | " | 1.87 | " | 2.25 | 6.0 | 2.20 | 3.8 | | .... |
| 29 | 1.87 | " | 1.86 | " | 2.23 | 5.1 | 2.20 | 3.8 | | .... |
| 30 | 1.87 | " | 1.85 | " | 2.20 | 3.8 | 2.20 | 3.8 | | .... |
| 31 | 1.89 | " | 1.85 | " | | | 2.18 | 3.1 | | .... |

* Ice in stream. Not sufficient data to compute the discharge.
† Spring freshet.
‡ Heavy rain.

Monthly Discharge of Gap Creek at Small's Ranche, for 1911.

(Drainage area, 129 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet |
| March (22-31) | 146.0 | 21.0 | 56.7 | 0.440 | 0.164 | 1,125. |
| April | 181.0 | 3.8 | 38.6 | 0.299 | 0.334 | 2,297. |
| May | 46.0 | 2.0 | 12.3 | 0.095 | 0.110 | 756. |
| June | 63.0 | 0.0 | 4.4 | 0.034 | 0.038 | 262 |
| July | 125.0 | 0.0 | 6.8 | 0.053 | 0.061 | 418 |
| August | 13.0 | 0.0 | 0.8 | 0.006 | 0.007 | 49. |
| September | 645.0 | 0.0 | 45.1 | 0.350 | 0.390 | 2,684. |
| October | 23.0 | 0.9 | 4.4 | 0.034 | 0.039 | 270 |
| November (1-15) | 6.0 | 1.3 | 3.3 | 0.026 | 0.014 | 99. |
| The period | | | | | 1.157 | 7,960. |

McShane Creek at Small's Ranche, Sask.

This station was established April 23, 1909, by F. T. Fletcher. It is located on the S.W. ¼ Sec. 3, Tp. 10, Rge. 27, W. 3rd Mer., at the highway bridge on the surveyed trail from Maple Creek to Tenmile, about 12 miles south of Maple Creek. It is about 600 feet above the mouth of the creek and about 500 feet from Wm. Small's house. Mr. Small diverts water from the stream for irrigation purposes, and as the intake of his ditch is above the station, records of daily flow do not represent the full discharge of the creek when water is being used in the ditch.

The channel is straight for 100 feet above and 200 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of coarse gravel, and shifts at high stages. The current is swift.

The gauge, which is a plain staff graduated to feet and hundredths, is attached firmly to the right abutment on the downstream side of the bridge. The zero of the gauge (elev., 85.71) is referred to a permanent iron bench-mark (assumed elev., 100.00), located just east of the bridge upon the north side of the diversion of the road allowance. It stands about four inches above ground and is protected by stones.

High-water measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the right abutment of the bridge. Low-water measurements are made near the gauge by wading and at very low stages a weir is used.

During 1911, the gauge was read by William Small.

DISCHARGE MEASUREMENTS of McShane Creek at Small's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Ap 15 | M. H. French | 14 5 | 5 24 | 0 437 | 0 79 | 2 283 |
| July 29 | do | | | | | Nil. |
| Aug. 18 | do | | | | | Nil |
| Sept 10 | do | | | | 0 45 | Nil.* |

* Small seepage through gravel.

DAILY GAUGE HEIGHT AND DISCHARGE of McShane Creek at Small's Ranche, Sask., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0 57 | 0 6 | 0 82 | 2 7 | Dry. | Nil |
| 2 | | | 0 14 | Nil | 0 83 | 2 8 | " | " |
| 3 | | | Nil | " | 0 75 | 1 9 | " | " |
| 4 | | | " | " | 0 75 | 1 9 | " | " |
| 5 | | | " | " | 0 65 | 1 0 | " | " |
| 6 | | | " | " | 0 55 | 0 4 | " | " |
| 7 | | | " | " | 0 55 | 0 4 | " | " |
| 8 | | | 0.61 | 0 8 | 0 06 | Nil | 0 80 | 2 5 |
| 9 | | | 1.05 | 6 6 | Dry | " | 0 63 | 0 9 |
| 10 | | | 0 91 | 3 9 | " | " | 0 23 | Nil |
| 11 | | | 0 87 | 3 3 | " | " | Dry | " |
| 12 | | | 0 57 | 0 6 | 0.56 | 0 5 | " | " |
| 13 | | | 0 50 | 0 2 | 0 10 | Nil | " | " |
| 14 | | | 0 57 | 0 6 | Dry. | " | " | " |
| 15 | | | 0 78 | 2 2 | " | " | " | " |
| 16 | | | 0 90 | 3.7 | " | " | " | " |
| 17 | 1 13 | 8 5 | 0 90 | 3 7 | 0 72 | 1 6 | " | " |
| 18 | 0 94 | 4 4 | 0 80 | 2 4 | 0 49 | 0 2 | " | " |
| 19 | 1 02 | 5 9 | 0 85 | 3 0 | Dry | Nil | " | " |
| 20 | 1 14 | 8 7 | 0 80 | 2 4 | " | " | " | " |
| 21 | 1 07 | 7 0 | 0 84 | 2 9 | " | " | " | " |
| 22 | 0 90 | 3 7 | 0.85 | 3 0 | " | " | " | " |
| 23 | 0 93 | 4 2 | 0 82 | 2 7 | 0 72 | 1 6 | " | " |
| 24 | 0 98 | 5 1 | 0.75 | 1 9 | 0 65 | 1 0 | " | " |
| 25 | 0 85 | 3 0 | 0 74 | 1 8 | 0 70 | 1 4 | " | " |
| 26 | 0 73 | 1 7 | 0 72 | 1 6 | 0 70 | 1 4 | " | " |
| 27 | 0 68 | 1 3 | 0 65 | 1 0 | 0 69 | 1 3 | " | " |
| 28 | 0 76 | 2 0 | 0 62 | 0 8 | 0 60 | 0 7 | " | " |
| 29 | 0 80 | 2.4 | 0 85 | 3 0 | 0 55 | 0 4 | " | " |
| 30 | 0 84 | 2 9 | 0 73 | 1 7 | Dry | Nil | " | " |
| 31 | 0 76 | 2 0 | | | " | " | | |

DAILY GAUGE HEIGHT AND DISCHARGE of McShane Creek at Small's Ranche, Sask., for 1911.—*Continued.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.03 | 6.2 | Dry | Nil | Dry | Nil | Dry | Nil | Dry | Nil |
| 2 | 1.02 | 5.9 | " | " | " | " | " | " | " | " |
| 3 | 0.74 | 1.8 | " | " | " | " | " | " | " | " |
| 4 | 0.65 | 1.0 | " | " | " | " | 0.85 | 3.0 | " | " |
| 5 | 0.70 | 1.4 | " | " | 1.00 | 5.5 | 0.70 | 1.4 | " | " |
| 6 | 0.53 | 0.4 | " | " | 1.35 | 14.0 | 0.52 | 0.3 | " | " |
| 7 | Dry | Nil | " | " | 0.90 | 3.7 | Dry | Nil | " | " |
| 8 | " | " | 0.84 | 2.9 | 0.74 | 1.8 | " | " | " | " |
| 9 | " | " | 0.57 | 0.6 | 0.72 | 1.6 | " | " | " | " |
| 10 | " | " | Dry | " | 0.26 | Nil | " | " | " | " |
| 11 | " | " | " | " | Dry | " | " | " | " | " |
| 12 | " | " | " | " | " | " | " | " | " | " |
| 13 | " | " | " | " | " | " | " | " | " | " |
| 14 | " | " | " | " | " | " | " | " | " | " |
| 15 | " | " | " | " | " | " | " | " | " | " |
| 16 | " | " | " | " | " | " | " | " | ... | ... |
| 17 | " | " | " | " | " | " | " | " | ... | ... |
| 18 | " | " | " | " | " | " | " | " | ... | ... |
| 19 | " | " | " | " | " | " | " | " | ... | ... |
| 20 | " | " | " | " | " | " | " | " | ... | ... |
| 21 | " | " | " | " | " | " | " | " | ... | ... |
| 22 | " | " | " | " | " | " | " | " | ... | ... |
| 23 | " | " | " | " | " | " | " | " | ... | ... |
| 24 | " | " | " | " | 0.84 | 2.9 | " | " | ... | ... |
| 25 | " | " | " | " | 0.74 | 1.8 | 0.72 | 1.6 | ... | ... |
| 26 | " | " | " | " | 0.70 | 1.4 | 0.60 | 0.7 | ... | ... |
| 27 | " | " | " | " | 0.35 | Nil | Dry | Nil | ... | ... |
| 28 | " | " | " | " | Dry | " | " | " | ... | ... |
| 29 | " | " | " | " | " | " | " | " | ... | ... |
| 30 | " | " | " | " | " | " | " | " | ... | ... |
| 31 | " | " | " | " | ... | ... | " | " | ... | ... |

MONTHLY DISCHARGE of McShane Creek at Small's Ranche, Sask., for 1911.

(Drainage area, 24 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (17-31) | 8.7 | 1.3 | 4.2 | 0.175 | 0.098 | 125. |
| April | 6.6 | 0.0 | 1.8 | 0.075 | 0.084 | 107. |
| May | 2.8 | 0.0 | 0.7 | 0.029 | 0.033 | 43. |
| June | 2.5 | 0.0 | 0.1 | 0.004 | 0.004 | 6. |
| July | 6.2 | 0.0 | 0.5 | 0.021 | 0.024 | 31. |
| August | 2.9 | 0.0 | 0.1 | 0.004 | 0.005 | 6. |
| September | 14.0 | 0.0 | 1.1 | 0.005 | 0.006 | 66. |
| October | 3.0 | 0.0 | 0.2 | 0.008 | 0.009 | 18. |
| November (1-15) | 0.0 | 0.0 | 0.0 | 0.000 | 0.000 | 00. |
| The period | | | | | 0.263 | 402 |

NOTE.—To the above must be added the water diverted by William Small's irrigation ditch which took a large percentage of the year's run-off. There is a small flow near the head of the creek all summer, but it disappears in the gravel, evaporates, or is diverted by ditches, and the creek is dry almost all summer at the gauging station.

## Gap Creek near Maple Creek, Sask.

This station was established on May 3, 1910, by H. R. Carscallen. It is located at the traffic bridge on the road allowance between Sec. 31 and 32, Tp. 11, Rge. 26, W. 3rd Mer., which is about four and a half miles north of the town of Maple Creek.

The channel is straight for about 60 feet above the station, but is slightly curved for about 100 feet below. The left bank is high and the right low, but the stream is not liable to overflow. The bed is sandy, and shifts during flood stages of the stream.

During high water, discharge measurements are made from the bridge, and during ordinary stages by wading. The initial point for soundings is marked on the north end of the bridge in red paint. The bridge is not at right angles to the direction of the current, and a co-efficient is applied to the measured discharge to obtain the actual discharge. The discharge is determined in extreme low water by means of a weir.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the down-stream end of the south pier of the bridge. It is referred to a point marked "B.M." in red paint on the top of the cap of the left abutment (elevation, 13.48 above zero).

During 1911, the gauge was read by R. B. Williamson.

### Discharge Measurements of Gap Creek near Maple Creek, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Mar. 23 | G. H. Whyte | 29.7 | 43.71 | 1.796 | 3.205 | 78.49* |
| Mar. 31 | do | 44.0 | 30.19 | 1.536 | 2.300 | 46.37 |
| April 11 | M. H. French | 47.6 | 98.00 | 1.760 | 3.720 | 172.20 |
| April 22 | G. H. Whyte | 27.9 | 26.76 | 1.760 | 2.380 | 47.33* |
| May 4 | M. H. French | 46.4 | 38.58 | 0.744 | 2.345 | 28.73 |
| May 31 | do | 44.0 | 9.40 | 0.561 | 1.560 | 5.26 |
| May 31 | do | 44.0 | 9.40 | 0.605 | 1.560 | 5.69 |
| June 22 | do | 44.0 | 7.92 | 0.702 | 1.550 | 5.56 |
| July 17 | G. H. Whyte | 4.0 | 1.22 | 0.541 | 1.270 | 0.66* |

* Gauged below station.

## Daily Gauge Height and Discharge of Gap Creek near Maple Creek, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 2.20 | 37.0 | 2.30 | 32.0 | 1.55 | 5.1 | 2.41 | 33.0 |
| 2 | | | 2.90 | 94.0 | 2.28 | 29.0 | 1.51 | 4.4 | 5.45 | †361.0 |
| 3 | | | 2.00 | 25.0 | 2.27 | 27.0 | 1.50 | 4.2 | 3.80 | 163.0 |
| 4 | | | 1.84 | 19.0 | 2.26 | 25.0 | 1.61 | 6.2 | 3.70 | 151.0 |
| 5 | | | 1.70 | 14.0 | 2.25 | 25.0 | 1.39 | 2.4 | 3.40 | 117.0 |
| 6 | | | 1.80 | 8.0 | 2.20 | 23.0 | 1.44 | 3.2 | 2.76 | 56.0 |
| 7 | | | 1.80 | 16.0 | 2.18 | 22.0 | 1.39 | 2.4 | 1.83 | 11.0 |
| 8 | | | 2.90 | 85.0 | 2.16 | 21.0 | 1.39 | 2.4 | 1.68 | 7.6 |
| 9 | | | 3.00 | 94.0 | 2.15 | 21.0 | 1.39 | 2.4 | 1.59 | 5.8 |
| 10 | | | 4.35 | 251.0 | 2.12 | 20.0 | 1.41 | 2.7 | 1.54 | 4.9 |
| 11 | | | *4.85 | 307.0 | 2.09 | 19.0 | 1.49 | 4.0 | 1.47 | 3.7 |
| 12 | | | 4.53 | 274.0 | 2.10 | 19.0 | 1.44 | 3.2 | 1.44 | 3.2 |
| 13 | | | 3.80 | 185.0 | 2.00 | 16.0 | 1.34 | 1.6 | 1.40 | 2.5 |
| 14 | | | 3.85 | 192.0 | 1.70 | 8.0 | 1.36 | 1.9 | 1.37 | 2.0 |
| 15 | | | 3.96 | 207.0 | 1.70 | 8.0 | 1.40 | 2.5 | 1.36 | 1.9 |
| 16 | | | 3.96 | 209.0 | 1.60 | 6.0 | 1.38 | 2.2 | 1.32 | 1.3 |
| 17 | | | 4.00 | 214.0 | 1.60 | 6.0 | 1.35 | 1.8 | 1.32 | 1.3 |
| 18 | | | 4.76 | 306.0 | 1.60 | 6.0 | 1.20 | Nil | 1.28 | 0.8 |
| 19 | | | 2.86 | 86.0 | 1.50 | 4.2 | 1.18 | " | 1.28 | 0.8 |
| 20 | | | 2.71 | 72.0 | 1.70 | 8.0 | 1.16 | " | 1.28 | 0.8 |
| 21 | | | 2.48 | 54.0 | 1.70 | 8.0 | 1.20 | " | 1.26 | 0.6 |
| 22 | | | 2.35 | 45.0 | 1.70 | 8.0 | 1.27 | 0.7 | 1.25 | 0.5 |
| 23 | 3.20 | 78.0 | 2.45 | 52.0 | 1.60 | 6.0 | 1.30 | 1.0 | 1.23 | 0.3 |
| 24 | 3.50 | 115.0 | 2.40 | 48.0 | 1.80 | 10.0 | 1.34 | 1.6 | 1.19 | Nil |
| 25 | 3.66 | 141.0 | 2.40 | 47.0 | 1.90 | 13.0 | 1.50 | 4.2 | | |
| 26 | 2.86 | 66.0 | 2.38 | 44.0 | 1.90 | 13.0 | 1.92 | 14.0 | | |
| 27 | 2.40 | 36.0 | 2.37 | 42.0 | 1.70 | 8.0 | 2.39 | 32.0 | | |
| 28 | 2.16 | 27.0 | 2.35 | 39.0 | 1.70 | 8.0 | 2.15 | 21.0 | | |
| 29 | 2.30 | 38.0 | 2.34 | 37.0 | 1.70 | 8.0 | 1.94 | 14.0 | | |
| 30 | 2.28 | 39.0 | 2.32 | 35.0 | 1.66 | 7.2 | 1.64 | 6.8 | | |
| 31 | 2.25 | 41.0 | | | 1.50 | 4.2 | | | | |

* Observation made in the evening and may not be the mean for the day.
† Heavy rain.

Note.—The creek was dry from July 24 to Sept. 4. Rain on Sept. 5, 6 and 7 produced a large run-off during the first part of September, but as an observer could not be secured no records of it were obtained.

## Monthly Discharge of Gap Creek near Maple Creek, Sask., for 1911.

(Drainage area, 295 Square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (23-31) | 141.0 | 27.0 | 64.6 | 0.219 | 0.073 | 1,153 |
| April | 307.0 | 8.0 | 104.6 | 0.355 | 0.396 | 6,224 |
| May | 32.0 | 4.2 | 14.1 | 0.048 | 0.055 | 867 |
| June | 32.0 | 0.0 | 4.9 | 0.017 | 0.018 | 292 |
| July (1-24) | 361.0 | 0.0 | 38.8 | 0.132 | 0.118 | 1,813 |
| The period | | | | | 0.660 | 10,379 |

Miscellaneous Discharge Measurements of Bigstick Lake Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream | Location. | Width | Area of Section. | Mean. Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet* | *Feet per Sec.* | *Sec.-Ft.* |
| May 9....... | M. H. French. | Cypress Creek... | Sec. 6-9-27-3 | 5 80 | 3 89 | 0 034 | 1.340 |
| June 2....... | do .. | do .. | do | * | ... | ... | 0 691 |
| May 11..... . | do | Maple Creek... | S.E. 16-11-26-3 | 10 75 | 5 55 | 0 940 | 5 195 |

* Weir measurement.

## MANY ISLAND LAKE DRAINAGE BASIN.

### *General Description.*

Many Island Lake, about 25 square miles in area, is situated on the boundary line between the provinces of Alberta and Saskatchewan about ten miles north of the town of Walsh. It is the farthest west of the several lakes which receive the drainage of the north slope of the Cypress Hills. The water is shallow and alkaline. Its only source of water-supply is Mackay Creek with its tributaries, Stony and Boxelder Creeks.

The topography of the basin is very rough, and with the exception of a little timber around McAlister Lake at the head of the basin, the country is practically devoid of tree growth. The channels of all streams are deep and well defined. There is no irrigation work being done at present in this basin south of the main line of the Canadian Pacific Railway.

The annual precipitation, most of which falls during May, June and July, is usually about twelve inches. The run-off, therefore, all occurs in the first part of the summer and generally after that there is none for the remainder of the year.

### East Branch of Mackay Creek at Grant's Ranche, Alta.

This station was established on October 13, 1911, by M. H. French. It is located in the N.W. ¼ Sec. 36, Tp. 10, Rge. 1, W. 4th Mer., about 100 feet north of Arthur Grant's house. It is about five miles south of Walsh and one mile above the junction of the east and west branches of Mackay Creek.

The channel is straight for 50 feet above and below the station. The right bank is a cut-bank and will never overflow. The left bank is rather low, covered with brush, and will overflow in extreme floods. The bed of the channel is composed of coarse gravel, and will not shift.

Discharge measurements are made with a current-meter by wading. The initial point for soundings is the face of a five-inch stake on the right bank, ten feet from the water's edge, and is well protected by a mound of stones. The final point is a willow stump on the left bank, 45.1 feet from the initial point and protected by a mound of stones.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post sunk in the bed of the stream near the right bank and just below the cross-section. The zero of the gauge (elev., 93.54) is referred to a bench-mark on the top of the initial-point stake (assumed elevation, 100.00) and to a bench-mark on the top of the final point (elev., 99.29).

The gauge was read by Arthur Grant.

Discharge Measurements of East Branch Mackay Creek at Grant's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Oct. 13.......... | M. H. French............... | 16.7 | 12.54 | 0.223 | 1 00 | 2.80 |

MEAN DAILY GAUGE HEIGHT, in feet, of East Branch Mackay Creek at Grant's Ranche, Alta., for 1911.

| Day. | Oct. | Nov. |
|---|---|---|
| 1 | | 0 94 |
| 2 | | 0 94 |
| 3 | | 0 94 |
| 4 | | 0 94 |
| 5 | | 0 97 |
| 6 | | 1 00 |
| 7 | | 0 95 |
| 8 | | 0 94 |
| 9 | | 0 92 |
| 10 | | * |
| 11 | | |
| 12 | | |
| 13 | 1 00 | |
| 14 | 1 00 | |
| 15 | 1 02 | |
| 16 | 1 05 | |
| 17 | 1 07 | |
| 18 | 1 10 | |
| 19 | 1 13 | |
| 20 | 1 13 | |
| 21 | 1 13 | |
| 22 | 1 12 | |
| 23 | 1 17 | |
| 24 | 1 15 | |
| 25 | 1 15 | |
| 26 | 1 08 | |
| 27 | 1 06 | |
| 28 | 1 00 | |
| 29 | 1 07 | |
| 30 | 0 98 | |
| 31 | 0 96 | |

* Creek frozen.

## WEST BRANCH OF MACKAY CREEK AT SCHNEIDER'S RANCHE, ALTA.

This station was established on October 12, 1911, by M. H. French. It is located in the S.W. ¼ Sec. 23, Tp. 10, Rge. 2, W. 4th Mer., about 1000 feet from Jacob Schneider's house. It is twelve miles by trail southwest of Walsh.

The channel is straight for about 100 feet above and below the station. Both banks are high and not liable to overflow. The bed of the channel is composed of sand and gravel.

Discharge measurements are made with a current-meter by wading. The initial point for soundings is a four-inch stake on the left bank standing about three inches above ground and protected by a mound of stones. The final point is a similar stake on the right 50.5 feet from the initial point.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post sunk in the centre of the stream eighteen feet below the cross-section. The zero of the gauge (elev., 95.26) is referred to the top of the initial-point stake (assumed elevation, 100.00) and to the top of the final point (elev., 102.26).

The gauge was read by Jacob Schneider.

There is no flow for several months during the year at this point.

## MACKAY CREEK AT WALSH, ALTA.

This station was established on July 29, 1909, by F. T. Fletcher. It is located at the traffic bridge half a mile south of the Canadian Pacific Railway track at Walsh. The bridge is on the N.W. ¼ Sec. 26, Tp. 11, Rge. 1, W. 4th Mer.

The channel is straight for about 225 feet above and 500 feet below the station. Both banks are clean, but liable to overflow at high stages. The bed is clean, composed of clay, and not liable to shift. The current is sluggish.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to an upright timber on the up-stream side of the bridge near the right abutment.

During high water, discharge measurements are made from the downstream side of the bridge. At low stages, the discharge is measured by wading, and at extreme low water, a weir is used.

During 1911, the gauge was read by George Sept, general merchant, Walsh.

DISCHARGE MEASUREMENTS of Mackay Creek at Walsh, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 6 | J. C. Keith | 14 5 | 20 17 | 0.50 | 1.10 | 10.95 |
| May 24 | do | 12.5 | 14.45 | 0.27 | 0.86 | 3 96 |
| June 10 | do | 7.4 | 2.35 | 0.57 | 0.54 | 1 34* |
| July 6 | do | 14.0 | 21.72 | 6.71 | 1 25 | 14.59† |
| Sept. 6 | sdo | 57.0 | 164.81 | 1.27 | 4.43 | 210.08† |
| Oct. 27 | do | 13.5 | 18.35 | 0.448 | 1.045 | 8.22† |

* Gauging made 250 yards above traffic bridge.
† Gauging made from bridge.

DAILY GAUGE HEIGHT AND DISCHARGE of Mackay Creek at Walsh, Alta., for 1911.

| DAY. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.94 | 6.8 | 1.43 | 20.0 | 0 69 | 2.9 |
| 2 | | | 0.40 | 0 3 | 1 52 | 23 0 | 0.64 | 2.2 |
| 3 | | | * | | 1 42 | 20.0 | 0 55 | 1 2 |
| 4 | | | * | | 1 28 | 15.0 | 0.47 | 0.6 |
| 5 | | | * | | 1 17 | 12 0 | 0.57 | 1.4 |
| 6 | | | * | | 1.09 | 10.0 | 0.52 | 0.9 |
| 7 | | | * | | 0 92 | 6.5 | 0.45 | 0.5 |
| 8 | | | 0 36 | 0.2 | 0 91 | 6.2 | 0.53 | 1.0 |
| 9 | | | 0 51 | 0.8 | 0 76 | 4 0 | 0.51 | 0.8 |
| 10 | | | 1.78 | 33 0 | 0 67 | 2.6 | 0.52 | 0.9 |
| 11 | | | 2 31 | 58.0 | 0 65 | 2.3 | 0 44 | 0.5 |
| 12 | | | 2.57 | 71 0 | 0 65 | 2.3 | 0 40 | 0.3 |
| 13 | | | 1.31 | 16 0 | 0 77 | 4 0 | 0 55 | 1.2 |
| 14 | | | 0.96 | 7 0 | 0 68 | 2 7 | 0.24 | Nil |
| 15 | | | 0.83 | 5.0 | 0 62 | 2 0 | 0.19 | " |
| 16 | | | 1.29 | 16.0 | 0.73 | 3 4 | 0.14 | " |
| 17 | | | 2 70 | 79 0 | 1 26 | 15.0 | 0.40 | " |
| 18 | | | 2.37 | 60 0 | 1.15 | 12 0 | Dry | " |
| 19 | 1.62 | 27.0 | 1.91 | 38.0 | 0 88 | 5 7 | " | " |
| 20 | 1 75 | 32 0 | 2.01 | 42.0 | 0.80 | 4.5 | " | " |
| 21 | 2.50 | 67.0 | 1.92 | 39 0 | 0.77 | 4 0 | " | " |
| 22 | 1 72 | 31.0 | 1.81 | 34 0 | 0.74 | 3 6 | " | " |
| 23 | 1.22 | 14.0 | 1.84 | 36 0 | 0 90 | 6 0 | " | " |
| 24 | 1 71 | 30 0 | 1 65 | 28 0 | 0.92 | 6 4 | " | " |
| 25 | 1 71 | 30.0 | 1.48 | 21 0 | 1 02 | 8 4 | 0.90 | 6.0 |
| 26 | 1.40 | 19.0 | 1 43 | 20 0 | 1.06 | 9.2 | 1.00 | 8.0 |
| 27 | 1 04 | 8 8 | 1 23 | 14 0 | 1.22 | 13 6 | 1.15 | 11.5 |
| 28 | 0.98 | 7 6 | 1 21 | 13 0 | 1.13 | 10.9 | 0.90 | 0.6 |
| 29 | 0 79 | 4.4 | 1 17 | 12 0 | 1 04 | 8 8 | 0 77 | 4 0 |
| 30 | 1.10 | 10 0 | 1 23 | 14 0 | 0.92 | 6 4 | 0 66 | 2 5 |
| 31 | 1 12 | 11.0 | | | 0.80 | 4.5 | | |

DAILY GAUGE HEIGHT AND DISCHARGE of Mackay Creek at Walsh, Alta., for 1911.—*Con.*

| Day | July | | August | | September | | October | | November | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.29 | 16.0 | Dry | Nil | Dry | Nil | 0.77 | 4.0 | 0.86 | 5.4 |
| 2 | 3.56 | 137.0 | " | " | " | " | 0.72 | 3.3 | 0.60 | 1.7 |
| 3 | 1.77 | 33.0 | " | " | " | " | 0.69 | 2.9 | 0.66 | 2.5 |
| 4 | 1.21 | 13.0 | " | " | " | " | 0.79 | 4.4 | 0.65 | 2.3 |
| 5 | 1.25 | 14.0 | " | " | 0.65 | 2.3 | 1.16 | 11.8 | 0.65 | 2.3 |
| 6 | 1.24 | 14.0 | " | " | 4.58 | 222.0 | 1.02 | 8.4 | 0.56 | 1.3 |
| 7 | 0.93 | 7.0 | " | " | 6.22 | 388.0 | 0.91 | 6.2 | 0.72 | 3.3 |
| 8 | 0.74 | 3.6 | " | " | 3.15 | 108.0 | 0.83 | 4.9 | 0.78 | 4.2 |
| 9 | 0.66 | 2.5 | " | " | 2.55 | 70.0 | 0.76 | 3.9 | * | † |
| 10 | 0.57 | 1.4 | " | " | 1.52 | 23.0 | 0.70 | 3.0 | * | † |
| 11 | 0.50 | 0.7 | " | " | 1.25 | 14.5 | 0.66 | 2.5 | * | † |
| 12 | 0.49 | 0.7 | " | " | 1.06 | 9.2 | 0.64 | 2.2 | 2.30 | † |
| 13 | 0.43 | 0.4 | " | " | 0.92 | 6.5 | 0.60 | 1.7 | 1.10 | † |
| 14 | 0.29 | Nil | " | " | 0.80 | 4.5 | 0.58 | 1.5 | 1.21 | † |
| 15 | 0.20 | " | " | " | 0.72 | 3.3 | 0.60 | 1.7 | 1.40 | † |
| 16 | 0.11 | " | " | " | 0.64 | 2.2 | 0.58 | 1.5 | ... | ... |
| 17 | 0.10 | " | " | " | 0.57 | 1.5 | 0.56 | 1.3 | ... | ... |
| 18 | 0.06 | " | " | " | 0.56 | 1.3 | 0.60 | 1.7 | ... | ... |
| 19 | 0.02 | " | " | " | 0.58 | 1.5 | 0.66 | 2.5 | ... | ... |
| 20 | Dry | " | " | " | 0.82 | 4.8 | 0.67 | 2.6 | ... | ... |
| 21 | " | " | " | " | 0.70 | 3.0 | 0.70 | 3.0 | ... | ... |
| 22 | " | " | " | " | 0.67 | 2.7 | 0.75 | 3.8 | ... | ... |
| 23 | " | " | " | " | 0.70 | 3.0 | 0.78 | 4.2 | ... | ... |
| 24 | " | " | " | " | 0.82 | 4.8 | 1.00 | 8.0 | ... | ... |
| 25 | " | " | " | " | 0.96 | 7.2 | 1.03 | 8.6 | ... | ... |
| 26 | " | " | " | " | 1.02 | 8.4 | 1.20 | 13.0 | ... | ... |
| 27 | " | " | " | " | 0.96 | 7.2 | 0.92 | 6.4 | ... | ... |
| 28 | " | " | " | " | 0.87 | 5.5 | 0.80 | 4.5 | ... | ... |
| 29 | " | " | " | " | 0.78 | 4.2 | 0.75 | 3.8 | ... | ... |
| 30 | " | " | " | " | 0.74 | 3.6 | 0.78 | 4.2 | ... | ... |
| 31 | " | " | " | " | .... | | 0.82 | 4.8 | ... | ... |

* Frozen over.
† Ice conditions Nov. 8 to Nov. 15.

MONTHLY DISCHARGE of Mackay Creek at Walsh, Alta., for 1911.

(Drainage area, 201 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (19-31) | 67.0 | 4.4 | 22.40 | 0.111 | 0.050 | 577 |
| April | 79.0 | 0.0 | 22.10 | 0.110 | 0.120 | 1315 |
| May | 23.0 | 2.0 | 8.23 | 0.041 | 0.050 | 506 |
| June | 11.5 | 0.0 | 1.74 | 0.009 | 0.010 | 105 |
| July | 137.0 | 0.0 | 7.80 | 0.039 | 0.040 | 480 |
| August | 00.0 | 0.0 | 0.00 | 0.000 | 0.000 | 000 |
| September | 388.0 | 0.0 | 30.50 | 0.152 | 0.170 | 1815 |
| October | 13.0 | 1.3 | 4.40 | 0.022 | 0.030 | 270 |
| November (1-8) | 5.4 | 1.3 | 2.90 | 0.014 | 0.004 | 46 |
| The period | ... | ... | ... | ..... | 0.474 | 5114 |

## Boxelder Creek near Walsh, Alta.

This station was established May 24, 1909, by P. M. Sauder. It is located at John Young's farm on Sec. 2, Tp. 12, Rge. 30, W. 4th Mer., two miles east of Walsh.

The stream flows in one channel, which is crooked both above and below the gauge. The banks are high and not liable to overflow. The bed of the stream is composed of clay.

Discharge measurements are generally made by wading at or near the gauge, but during floods it may be measured from the Canadian Pacific Railway bridge a few hundred feet below the gauge.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to a post at the right bank. It is referred to bench-marks as follows:—(1) the top of the frame of the outside cellar entrance of Mr. Young's house (elevation, 17.36 feet); (2) two spikes driven near the southeast corner of Mr. Young's house (elevation, 16.40 feet above the datum of the gauge).

During 1911, the gauge was read by John Young.

### Discharge Measurements of Boxelder Creek near Walsh, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet* | *Sq.-ft.* | *Ft. per sec.* | *Feet* | *Sec.-ft.* |
| May 6 | J. C. Keith | 9 5 | 5 36 | 0.710 | 1 05 | 3 825 |
| May 24 | do | 9 0 | 4 48 | 0 540 | 0 95 | 2 394 |
| June 10 | do | 8 0 | 2 98 | 0 270 | 0 76 | 0 810 |
| July 6 | do | 13 6 | 15 94 | 0 788 | 2 04 | 12 560 |
| Sept. 6 | do | 30 0 | 55 50 | 0 540 | 3 42 | 29 810† |
| Oct. 27 | do | | | | | Nil |

† Gauging made from the C P.R bridge.

### Daily Gauge Height and Discharge of Boxelder Creek near Walsh, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0 95 | 2 4 | 1.50 | 7 3 | 0 65 | 0 7 |
| 2 | | | 0.55 | 0 4 | 2 05 | 13 0 | 0 55 | 0 4 |
| 3 | | | 0 60 | 0.5 | 1 95 | 12.0 | 0 50 | 0 2 |
| 4 | | | 0 55 | 0 4 | 1 80 | 10 0 | 0.50 | 0 2 |
| 5 | | | 0 50 | 0 2 | 1 30 | 5 4 | Dry | Nil |
| 6 | | | Dry | Nil | 1 07 | 3 4 | " | " |
| 7 | | | " | " | 1 00 | 2 8 | " | " |
| 8 | | | " | " | 0 90 | 2 0 | " | " |
| 9 | | | " | " | 0 85 | 1 8 | 1 15 | 4 0 |
| 10 | | | 1 80 | 10 0 | 0.70 | 0 9 | 0 90 | 2 1 |
| 11 | 4 30 | 45 0 | 2 55 | 18 0 | 0.70 | 0 9 | 0 75 | 1 2 |
| 12 | 3 70 | 34 0 | 2 60 | 19 0 | 0 65 | 0 7 | 0 55 | 0 4 |
| 13 | 3 20 | 26 0 | 1 75 | 9 8 | 0 55 | 0 4 | 0 30 | Nil |
| 14 | 3 50 | 31 0 | 1 05 | 3 2 | 0 50 | 0 2 | Dry | " |
| 15 | 3 40 | 29 0 | 0 95 | 2 4 | 0 50 | 0 2 | " | " |
| 16 | 2 65 | 20 0 | 1 50 | 7 3 | 0 55 | 0 4 | " | " |
| 17 | 2 55 | 18 0 | 3 05 | 24 0 | 0 90 | 2 1 | " | " |
| 18 | 2 55 | 18 0 | 3 70 | 34 0 | 1 65 | 8.8 | " | " |
| 19 | 2 35 | 16 0 | 2 35 | 16 0 | 1 05 | 3 2 | " | " |
| 20 | 2 90 | 23 0 | 2 30 | 16 0 | 0.95 | 2 4 | " | " |
| 21 | 3 10 | 25 0 | 2 30 | 16 0 | 0 70 | 0 9 | " | " |
| 22 | 3 60 | 32 0 | 1 85 | 11 0 | 0 65 | 0 7 | " | " |
| 23 | 1.50 | 7 0 | 1 95 | 12 0 | 1 70 | 9 3 | " | " |
| 24 | 2 45 | 17 0 | 1 80 | 10 0 | 0 95 | 2 4 | " | " |
| 25 | 2 65 | 20 0 | 1 50 | 7.3 | 1 15 | 4 0 | " | " |
| 26 | 2 00 | 12 0 | 1 45 | 6 8 | 1 05 | 3 2 | " | " |
| 27 | 1 25 | 5 0 | 1 30 | 5 4 | 1 05 | 3 2 | 2 75 | 21 0 |
| 28 | 0 95 | 2 4 | 1 30 | 5 4 | 1 10 | 3 6 | 2 05 | 13 0 |
| 29 | 0 85 | 1 8 | 1 10 | 3 6 | 0 95 | 2 4 | 1 50 | 7 3 |
| 30 | 1 00 | 2 8 | 1 00 | 2 8 | 0 85 | 1 8 | 1 15 | 4 0 |
| 31 | 1 20 | 4 5 | | | 0 75 | 1 2 | | |

Daily Gauge Height and Discharge of Boxelder Creek near Walsh, Alta., for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.70 | 9.3 | Dry | Nil | Dry | Nil | 0.75 | 1.2 |
| 2 | 6.30 | 99.0 | " | " | " | " | 0.70 | 0.9 |
| 3 | 5.00 | 60.0 | " | " | " | " | 0.60 | 0.5 |
| 4 | 2.80 | 21.4 | " | " | " | " | 0.50 | 0.2 |
| 5 | 2.85 | 22.0 | " | " | 3.40 | 29.0 | 0.55 | 0.4 |
| 6 | 2.20 | 14.0 | " | " | 3.42 | 30.0 | 1.25 | 5.0 |
| 7 | 1.80 | 10.3 | " | " | 5.95 | 88.0 | 1.15 | 4.0 |
| 8 | 1.35 | 5.8 | " | " | 6.15 | 94.0 | 0.95 | 2.4 |
| 9 | 1.15 | 4.0 | " | " | 4.70 | 53.0 | 0.80 | 1.4 |
| 10 | 0.90 | 2.1 | " | " | 3.50 | 31.0 | 0.75 | 1.2 |
| 11 | 0.85 | 1.8 | " | " | 2.25 | 15.0 | 0.70 | 0.9 |
| 12 | 0.65 | 0.7 | " | " | 1.70 | 9.3 | 0.60 | 0.5 |
| 13 | 0.55 | 0.4 | " | " | 1.45 | 6.8 | 0.45 | 0.1 |
| 14 | 0.50 | 0.2 | " | " | 1.25 | 5.0 | 0.25 | Nil |
| 15 | 0.50 | 0.2 | " | " | 1.15 | 4.0 | ...... | ...... |
| 16 | Dry. | Nil | " | " | 1.00 | 2.8 | ...... | ...... |
| 17 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 18 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 19 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 20 | " | " | " | " | 0.85 | 1.8 | ...... | ...... |
| 21 | " | " | " | " | 0.80 | 1.4 | ...... | ...... |
| 22 | " | " | " | " | 0.80 | 1.4 | ...... | ...... |
| 23 | " | " | " | " | 0.80 | 1.4 | ...... | ...... |
| 24 | " | " | " | " | 0.80 | 1.4 | ...... | ...... |
| 25 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 26 | " | " | " | " | 0.85 | 1.8 | ...... | ...... |
| 27 | " | " | " | " | 2.60 | 19.0 | ...... | ...... |
| 28 | " | " | " | " | 1.95 | 12.0 | ...... | ...... |
| 29 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 30 | " | " | " | " | 0.90 | 2.1 | ...... | ...... |
| 31 | " | " | " | " | ...... | ...... | ...... | ...... |

Monthly Discharge of Boxelder Creek near Walsh, Alta., for 1911.

(Drainage area, 99 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (11-31) | 45.0 | 1.8 | 18.56 | 0.186 | 0.148 | 783 |
| April | 34.0 | 0.0 | 8.13 | 0.082 | 0.091 | 484 |
| May | 13.0 | 0.2 | 3.57 | 0.036 | 0.042 | 220 |
| June | 21.0 | 0.0 | 1.82 | 0.018 | 0.020 | 108 |
| July | 99.0 | 0.0 | 8.10 | 0.082 | 0.095 | 498 |
| August | 00.0 | 0.0 | 0.00 | 0.000 | 0.000 | 000 |
| September | 94.0 | 0.0 | 14.02 | 0.142 | 0.158 | 834 |
| October (1-14 | 5.0 | 0.0 | 1.34 | 0.135 | 0.070 | 37 |
| The period | | | | | 0.624 | 2964 |

MISCELLANEOUS DISCHARGE MEASUREMENTS of Many Island Lake Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | Feet. | Sq. Feet. | Feet per Sec. | Sec.-Ft. |
| June 16 | M. H. French | McKay Creek | Sec. 21-9-1-4 | | | | * 0 185 |
| Nov. 4 | W. A. Fletcher | do | Sec. 23-13-1-4 | | | | * 1 760 |
| July 25 | M. H. French | McKay Cr. East Br. | Sec. 36-8-1-4 | | | | * 0 440 |
| do | do | McKay Creek West Br. | Sec. 36-8-2-4 | | | | * 0 300 |

* Weir measurement.

## ROSS CREEK DRAINAGE BASIN.

### *General Description.*

Ross Creek rises in Elkwater Lake, a small body of water covering an area of approximately two square miles, situated in Tp. 8, Rge. 3, west of the fourth meridian. The creek flows in a northerly direction as far as Irvine and then turns sharply to the westward, and closely parallels the main line of the Canadian Pacific Railway to Medicine Hat. Here it is joined by Seven-persons River, and the combined flow empties into the South Saskatchewan in Sec. 32, Tp. 12, Rge. 5, west of the fourth meridian. The tributaries of Ross Creek are Bullshead Creek, which joins it in Sec. 21, Tp. 12, Rge. 5, west of the fourth meridian, and Grosventre Creek, which joins it in Sec. 14, Tp. 11, Rge. 3, west of the fourth meridian

The topography of this basin is exceedingly rough and rolling and almost totally devoid of tree growth. The one exception is a small area of the Forest Reserve, just south of Elkwater Lake, which has a good stand of pine and spruce.

The Canadian Pacific Railway takes the water-supply for its tank at Irvine from Ross Creek.

### ROSS CREEK AT ROBINSON'S RANCHE, ALTA.

This station was established on October 11, 1911, by M. H. French. It is located about 200 feet south of James Robinson's house, in the N.W. ¼ Sec. 24, Tp. 9, Rge. 3, W. 4th Mer., and is about thirty miles southeast of Medicine Hat.

The channel is straight for about 75 feet above and 50 feet below the station. Both banks are high enough to carry all stages of the stream. The bed of the stream is composed of very coarse gravel and will not shift.

The fall of the stream at this point is very great. Water runs here all summer, but the discharge being very small, it is soon lost by seepage and evaporation a short distance down-stream.

Discharge measurements are made with a current-meter by wading. The initial point for sounding is a five-inch stake on the right bank 56 feet from the water's edge. It is painted red and is protected by a mound of stones. The final point for soundings is a stake on the left bank 103.2 feet from the initial point.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post sunk in the bed of the stream near the right bank, eighteen feet above the cross-section. The zero of the gauge (elev., 92.91 )is referred to the top of the initial-point stake (assumed elevation, 100.00) and to the top of the final point (elev., 99.41).

The gauge was read by James Robinson.

DISCHARGE MEASUREMENTS of Ross Creek at Robinson's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| Oct. 11 | M. H. French | 14 3 | 4.58 | 0 555 | 1.11 | 2 54 |

Mean Daily Gauge Height, in feet, of Ross Creek at Robinson's Ranche, Alta., for 1911.

| Day | Oct. | Nov. |
|---|---|---|
| 1 | ... | 1 15 |
| 2 | ... | 1 13 |
| 3 | .... | 1 13 |
| 4 | ....... | 1 16 |
| 5 | .... | 1 14 |
| 6 | .. | 1 12 |
| 7 | .. | 1 12 |
| 8 | . | 1 09 |
| 9 | .. | 1 08 |
| 10 | . | 1 00 |
| 11 | 1 11 | 0 75 |
| 12 | 1.11 | 0 75 |
| 13 | 1 11 | 0 70 |
| 14 | 1 10 | 0 60 |
| 15 | 1.10 | 0 60 |
| 16 | 1 10 | * |
| 17 | 1 10 | .... |
| 18 | 1 13 | ... |
| 19 | 1 16 | .. |
| 20 | 1 19 | ...... |
| 21 | 1 20 | ......... |
| 22 | 1 20 | ... |
| 23 | 1 22 | ..... |
| 24 | 1 24 | ....... |
| 25 | 1 30 | ......... |
| 26 | 1 35 | ......... |
| 27 | 1.40 | ......... |
| 28 | 1.35 | ......... |
| 29 | 1 18 | ......... |
| 30 | 1.13 | ......... |
| 31 | 1.13 | ........ |

* Creek frozen.

## Grosventre Creek at Tothill's Farm, Alta.

This station was established on October 10, 1911, by M. H. French. It is located about 50 feet west of Mr. Tothill's house in the S.E. ¼ Sec. 27. Tp. 9, Rge. 4, west of the 4th meridian, and is about 28 miles southeast of Medicine Hat. This stream runs every spring while the snow is melting, and is then dry during the remainder of the summer excepting after a heavy fall of rain when the water comes down in a flood.

The channel is straight for 50 feet above and 100 feet below the station. Both banks are high enough to hold all stages. The bed of the stream is composed of coarse gravel, and is not liable to shift.

The gauge, which is a plain staff graduated to feet and hundredths, is firmly nailed to a post sunk in the bed of the stream near the right bank, eighteen feet above the cross-section. The zero of the gauge (elev., 94.12) is referred to the top of a rock (assumed elev., 100.00), situated on the left bank just behind a stake used as the initial point for soundings. This rock is about two feet long, stands out of the ground about one foot, and is about 40 feet from the water's edge in low water.

Discharge measurements are made with a current-meter by wading.

The gauge was read daily by Kate Tothill till it froze up in November. The flow was only a small seepage through the gravel.

Discharge Measurements of Grosventre Creek at Tothill's Farm, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Oct. 10.......... | M. H. French............ | 13.5 | 6 33 | 0.042 | 0 50 | 0.27* |

* Gauged down stream.

PLATE No. 30.

Canadian Pacific Railway Company's Dam in Ross Creek at Irvine.

PLATE No. 31.

Gauging Station on Ross Creek at Irvine. Taken by J. C. Keith.

DAILY GAUGE HEIGHT AND DISCHARGE of Grosventre Creek at Tothill's Farm, Alta., for 1911

| Day. | October | | November | |
|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-Ft. |
| 1 | | | | |
| 2 | | | 0 52 | |
| 3 | | | 0 52 | |
| 4 | | | 0 64 | |
| 5 | | | 0 74 | |
| 6 | | | 0 62 | |
| 7 | | | 0 64 | |
| 8 | | | Frozen | |
| 9 | | | " | |
| 10 | 0 50 | | " | |
| 11 | 0 47 | | " | |
| 12 | 0 46 | | " | |
| 13 | 0 46 | | Open. | |
| 14 | 0 46 | | " | |
| 15 | 0 46 | | | |
| 16 | 0 48 | | | |
| 17 | 0 47 | | | |
| 18 | 0 56 | | | |
| 19 | 0 54 | | | |
| 20 | 0 54 | | | |
| 21 | 0 57 | | | |
| 22 | 0 58 | | | |
| 23 | 0 60 | | | |
| 24 | 0 61 | | | |
| 25 | 0 58 | | | |
| 26 | 0 55 | | Ice on Creek | |
| 27 | 0 55 | | " | |
| 28 | 0 56 | | " | |
| 29 | 0 55 | | " | |
| 30 | 0 54 | | " | |
| 31 | | | | |

## ROSS CREEK AT IRVINE, ALTA.

This station was established on July 28, 1909, by F. T. Fletcher. It is located at the traffic bridge in the town of Irvine, on Sec. 31, Tp. 11, Rge. 2, west of the 4th meridian, and about 400 yards below the Canadian Pacific Railway dam.

The stream flows in one channel, which is slightly curved for 75 feet above the station, and almost straight for 600 feet below. The banks are composed of clay, high and not liable to overflow. The bed is composed of sand and gravel, and may shift at high stages.

Discharge measurements are made from the downstream side of the bridge during high stages of the stream, and during low water it is waded. During extreme low water a weir is used.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the downstream pile of the first row from the left abutment. It is referred to bench-marks as follows:—(1) the top of the downstream pile in the first row from the left abutment (elevation, 15.52 feet above the datum of the gauge); (2) the top of the south rail of the Canadian Pacific Railway track (elevation, 23.11).

During 1911, the gauge was read by H. G. Price.

DISCHARGE MEASUREMENTS of Ross Creek at Irvine, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | Feet. | Sq.-ft. | Ft. per sec. | Feet. | Sec.-ft. |
| May 6 | J. C. Keith | 10 0 | 5 00 | 1 074 | 1 18 | 5 372* |
| May 24 | do | 12 0 | 7 08 | 1 140 | 1 31 | 8 090* |
| June 12 | do | 3 1 | 0 46 | 0.344 | 0.79 | 0 167 |
| July 7 | do | 15 7 | 11 71 | 1 340 | 1 70 | 15 650 |
| Sept. 7 | do | 32 0 | 75 86 | 1 520 | 4 14 | 115 680 |
| Oct. 28 | do | | | | 1 05 | 9 300 |

* Gauging 200 feet upstream.

DAILY GAUGE HEIGHT AND DISCHARGE of Ross Creek at Irvine, Alta., for 1911.

| Day. | March. | | April. | | May. | | June. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ... | ... | 1.70 | 15.0 | 1.98 | 22.0 | 1.28 | 7.4 |
| 2 | ... | ...... | 1.42 | 9.8 | 1.89 | 20.0 | 1.28 | 7.4 |
| 3 | | | 1.12 | 4.7 | 1.79 | 17.0 | 1.26 | 7.0 |
| 4 | | | 0.92 | 1.8 | 1.78 | 17.0 | 1.24 | 6.7 |
| 5 | 0.04 | Nil | 0.92 | 1.8 | 1.77 | 17.0 | 1.21 | 6.2 |
| 6 | 0.02 | " | 0.95 | 2.2 | 1.20 | 6.0 | 1.17 | 5.5 |
| 7 | 0.22 | " | 0.80 | 0.5 | 1.20 | 6.0 | 1.14 | 5.0 |
| 8 | 1.18 | 5.7 | 0.82 | 0.7 | 1.18 | 5.7 | 1.12 | 4.7 |
| 9 | 3.28 | 71.0 | 1.35 | 8.6 | 1.17 | 5.5 | 1.10 | 4.4 |
| 10 | 2.38 | 34.0 | 2.60 | 42.0 | 1.16 | 5.4 | 1.02 | 3.1 |
| 11 | 2.89 | 54.0 | 3.82 | 98.0 | 1.16 | 5.4 | 0.87 | 1.3 |
| 12 | 3.92 | 103.0 | 3.15 | 64.0 | 1.16 | 5.4 | 0.80 | 0.5 |
| 13 | 3.48 | 81.0 | 2.75 | 48.0 | 1.15 | 5.2 | 0.78 | 0.4 |
| 14 | 3.60 | 87.0 | 2.06 | 24.0 | 1.16 | 5.4 | 0.75 | 0.2 |
| 15 | 3.25 | 70.0 | 3.55 | 84.0 | 1.16 | 5.4 | 0.72 | 0.1 |
| 16 | 4.58 | 143.0 | 4.11 | 115.0 | 1.18 | 5.7 | 0.72 | 0.1 |
| 17 | 2.18 | 28.0 | 3.82 | 98.0 | 1.17 | 5.5 | 0.72 | 0.1 |
| 18 | 3.35 | 74.0 | 3.36 | 75.0 | 1.17 | 5.5 | 0.72 | 0.1 |
| 19 | 5.15 | 177.0 | 2.28 | 30.0 | 1.19 | 5.8 | 0.72 | 0.1 |
| 20 | 4.60 | 144.0 | 2.16 | 27.0 | 1.22 | 6.3 | 0.72 | 0.1 |
| 21 | 5.00 | 168.0 | 2.08 | 25.0 | 1.20 | 6.0 | 0.72 | 0.1 |
| 22 | 4.60 | 141.0 | 2.00 | 22.0 | 1.18 | 5.7 | 0.72 | 0.1 |
| 23 | 3.32 | 73.0 | 1.98 | 22.0 | 1.23 | 6.5 | 0.70 | 0.0 |
| 24 | 2.46 | 36.0 | 1.90 | 20.0 | 1.29 | 7.5 | 0.70 | 0.0 |
| 25 | 2.75 | 48.0 | 1.85 | 19.0 | 1.39 | 9.2 | 0.70 | 0.0 |
| 26 | 1.95 | 21.0 | 1.84 | 19.0 | 1.46 | 10.0 | 0.70 | 0.0 |
| 27 | 1.82 | 18.0 | 1.85 | 19.0 | 1.46 | 10.0 | 0.91 | 1.7 |
| 28 | 1.76 | 17.0 | 2.15 | 27.0 | 1.32 | 8.0 | 0.94 | 2.1 |
| 29 | 1.84 | 19.0 | 2.10 | 25.0 | 1.31 | 7.9 | 1.18 | 5.7 |
| 30 | 1.89 | 20.0 | 2.08 | 25.0 | 1.30 | 7.7 | 1.20 | 6.0 |
| 31 | 2.00 | 22.0 | | .... | 1.28 | 7.4 | ...... | ...... |

DAILY GAUGE HEIGHT AND DISCHARGE of Ross Creek, at Irvine, Alta. for 1911.—*Con.*

| Day. | July. | | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.26 | 7.0 | 0.69 | Nil | 0.73 | 0.2 | 1.02 | 3.1 | 1.01 | 3.0 |
| 2 | 3.98 | 107.0 | 0.69 | " | 0.73 | 0.2 | 1.00 | 2.8 | 1.01 | 3.0 |
| 3 | 3.80 | 97.0 | 0.69 | " | 0.85 | 1.0 | 1.10 | 4.4 | 1.00 | 2.8 |
| 4 | 3.50 | 82.0 | 0.69 | " | 1.66 | 14.5 | 1.18 | 5.7 | 0.99 | 2.7 |
| 5 | 2.70 | 46.0 | 0.69 | " | 2.62 | 43.0 | 1.25 | 6.8 | 0.99 | 2.7 |
| 6 | 2.10 | 25.0 | 0.69 | " | 4.30 | 126.0 | 1.24 | 6.7 | 0.99 | 2.7 |
| 7 | 1.74 | 16.0 | 0.85 | 1.0 | 4.10 | 114.0 | 1.19 | 5.8 | 0.99 | 2.7 |
| 8 | 1.44 | 10.0 | 1.02 | 3.1 | 3.30 | 72.0 | 1.14 | 5.0 | 0.99 | 2.7 |
| 9 | 1.26 | 7.0 | 1.10 | 4.4 | 2.45 | 36.0 | 1.08 | 4.1 | 0.99 | 2.7 |
| 10 | 1.01 | 3.0 | 1.09 | 4.2 | 1.86 | 19.0 | 1.03 | 3.3 | 0.99 | 2.7 |
| 11 | 0.98 | 2.6 | 1.08 | 4.1 | 1.59 | 13.0 | 0.98 | 2.6 | 0.99 | 2.7 |
| 12 | 0.96 | 2.3 | 1.06 | 3.8 | 1.40 | 9.4 | 0.96 | 2.3 | 0.99 | 2.7 |
| 13 | 0.84 | 0.9 | 0.98 | 2.6 | 1.28 | 7.4 | 0.99 | 2.7 | 0.99 | 2.7 |
| 14 | 0.80 | 0.5 | 0.90 | 1.6 | 1.26 | 7.0 | 1.02 | 3.1 | 1.00 | 2.8 |
| 15 | 0.76 | 0.3 | 0.82 | 0.7 | 1.23 | 6.5 | 1.02 | 3.1 | 1.00 | 2.8 |
| 16 | 0.74 | 0.2 | 0.78 | 0.4 | 1.19 | 5.8 | 1.01 | 3.0 | ...... | ...... |
| 17 | 0.73 | 0.2 | 0.74 | 0.2 | 1.09 | 4.2 | 1.02 | 3.1 | ...... | ...... |
| 18 | 0.72 | 0.1 | 0.74 | 0.2 | 1.04 | 3.4 | 1.04 | 3.4 | ...... | ...... |
| 19 | 0.70 | Nil | 0.74 | 0.2 | 1.02 | 3.1 | 1.08 | 4.1 | ...... | ...... |
| 20 | 0.69 | " | 0.74 | 0.2 | 1.01 | 3.4 | 1.11 | 4.6 | ...... | ...... |
| 21 | 0.69 | " | 0.74 | 0.2 | 1.05 | 3.6 | 1.14 | 5.0 | ...... | ...... |
| 22 | 0.69 | " | 0.74 | 0.2 | 1.04 | 3.4 | 1.15 | 5.2 | ...... | ...... |
| 23 | 0.69 | " | 0.74 | 0.2 | 1.12 | 4.7 | 1.14 | 5.0 | ...... | ...... |
| 24 | 0.69 | " | 0.74 | 0.2 | 1.20 | 6.0 | 1.12 | 4.7 | ...... | ...... |
| 25 | 0.69 | " | 0.74 | 0.2 | 1.29 | 7.5 | 1.11 | 4.6 | ...... | ...... |
| 26 | 0.69 | " | 0.74 | 0.2 | 1.24 | 6.7 | 1.10 | 4.4 | ...... | ...... |
| 27 | 0.69 | " | 0.74 | 0.2 | 1.20 | 6.0 | 1.08 | 4.1 | ...... | ...... |
| 28 | 0.69 | " | 0.74 | 0.2 | 1.14 | 5.0 | 1.06 | 3.8 | ...... | ...... |
| 29 | 0.69 | " | 0.73 | 0.2 | 1.10 | 4.4 | 1.04 | 3.4 | ...... | ...... |
| 30 | 0.69 | " | 0.73 | 0.2 | 1.06 | 3.8 | 1.03 | 3.3 | ...... | ...... |
| 31 | 0.69 | " | 0.73 | 0.2 | ...... | ..... | 1.07 | 3.9 | ...... | ...... |

MONTHLY DISCHARGE of Ross Creek at Irvine, Alta., for 1911.

(Drainage area, 240 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (5-31) | 177.0 | 0.0 | 61.30 | 0.255 | 0.256 | 3284 |
| April | 115.0 | 0.5 | 32.40 | 0.135 | 0.151 | 1928 |
| May | 22.0 | 5.2 | 8.49 | 0.035 | 0.040 | 522 |
| June | 7.4 | 0.0 | 2.54 | 0.011 | 0.012 | 151 |
| July | 107.0 | 0.0 | 13.10 | 0.055 | 0.063 | 805 |
| August | 4.4 | 0.0 | 0.93 | 0.004 | 0.005 | 57 |
| September | 126.0 | 0.2 | 18.00 | 0.075 | 0.084 | 1071 |
| October | 6.8 | 2.3 | 4.10 | 0.017 | 0.020 | 252 |
| November (1-15) | 3.0 | 2.7 | 2.76 | 0.012 | 0.007 | 82 |
| The period | ......... | ......... | ......... | ......... | 0.638 | 8152 |

BULLSHEAD CREEK AT CLARK'S RANCHE, ALTA.

This station was established on October 9, 1911, by M. H. French. It is located about 200 feet north of Mr. Clark's house, in the N.W. ¼ Sec. 15, Tp. 9, Rge. 5, west of the 4th meridian, and is about 25 miles from Medicine Hat.

The channel is straight for about 100 feet above and below the station. Both banks are high enough to carry anything but an extreme flood. The bed of the stream is composed of coarse gravel and small stones, and will not shift.

Discharge measurements are made by wading at a section about 1133 feet below the gauge.

The gauge, which is a plain staff graduated to feet and hundredths, is firmly nailed to a post sunk in the bed of the stream near the left bank. The zero (elev., 95.28) is referred to the top of a six-inch stake, four feet long, driven flush with the ground, situated thirteen feet south of the gauge and protected by a mound of stones (assumed elev., 100.00).

The gauge was read by Mr. Edward Clark.

Discharge Measurements of Bullshead Creek at Clark's Ranche, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Oct. 9 | M. H. French.......... | 16 0 | 3.80 | 0 184 | 1.18 | 0.70* |

* Gauged 100 feet down stream.

Daily Gauge Height and Discharge of Bullshead Creek at Clark's Ranche, Sask., for 1911.

| Day. | October. | | November. | |
|---|---|---|---|---|
| | Gauge Height | Discharge. | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | | | 1 28 | |
| 2 | | | 1 25 | |
| 3 | | | 1 29 | |
| 4 | | | 1 30 | |
| 5 | | | 1 35 | |
| 6 | | | 1 40 | |
| 7 | | | 1 35 | |
| 8 | | | 1 25 | |
| 9 | 1 18 | | 1 20 | |
| 10 | 1 19 | | Frozen Over. | |
| 11 | 1 19 | | " | |
| 12 | 1 19 | | | |
| 13 | 1 18 | | | |
| 14 | 1 19 | | | |
| 15 | 1.18 | | | |
| 16 | 1.18 | | | |
| 17 | 1 17 | | | |
| 18 | 1 25 | | | |
| 19 | 1 20 | | | |
| 20 | 1 25 | | | |
| 21 | | | | |
| 22 | 1 30 | | | |
| 23 | 1 32 | | | |
| 24 | 1 35 | | | |
| 25 | 1 30 | | | |
| 26 | 1 30 | | | |
| 27 | 1 25 | | | |
| 28 | 1 25 | | | |
| 29 | 1 25 | | | |
| 30 | 1 30 | | | |
| 31 | 1 27 | | | |

## Starks and Burton Ditch near Woolchester, Alta.

This station was established on October 9, 1911, by W. A. Fletcher. It is located on the S.E. 1/4 Sec. 17, Tp. 11, Rge. 5, W. 4th Mer., about 260 feet below the head-gate at the intake to the ditch.

The gauge, which is a plain staff graduated to feet and inches, is nailed to a post at the right bank. The zero of the gauge (elev., 97.87) is referred to the top of a stake (assumed elev., 100.00), in the right bank and six feet upstream from the gauge.

The ditch is straight for 250 feet above and 50 feet below the gauge. The cross-section is uniform, and the bed and banks of the ditch are in good condition at this point.

Discharge measurements may be made with a current-meter by wading near the gauge at ordinary stages and with a weir at very low stages.

No water was used after the gauge was installed.

### Bullshead Creek near Dunmore, Alta.

This station was established July 26, 1909, by F. T. Fletcher. It is located at the traffic bridge on the S.W. 1/4 Sec. 16, Tp. 12, Rge. 5, W. 4th Mer. It is four miles from Medicine Hat, and one mile above the junction of Ross and Bullshead Creeks.

The stream flows in one channel, which is straight for about 200 feet above and 450 feet below the station. The banks are high, clean and not liable to overflow. The bed is composed of sand, and shifts.

During high water discharge measurements are made from the bridge, but during low water the discharge is measured by wading, or by means of a weir.

The gauge, which is a plain staff graduated to feet and hundredths, is spiked to the downstream side of the first row of piles from the right abutment. It is referred to the following bench-marks:)—(1), a spike driven in the top of the centre row of piles (elevation, 7.39); (2) the top of a wooden plug driven flush with the ground in the road mound on right bank (elevation, 6.34).

During 1911, the gauge was read by G. G. Trimble.

Discharge Measurements of Bullshead Creek near Dunmore, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 8 | J. C. Keith. | 6 7 | 2 46 | 0 77 | 0 68 | 1 900 |
| May 25 | do | 6 7 | 1 87 | 0 52 | 0 70 | 0 970 |
| June 12 | do | | | | 0 55 | 0 012 |
| July 7 | do | 9 3 | 4 59 | 1 17 | 0 97 | 5 390 |
| Sept. 9 | do | 10 1 | 7 25 | 1 98 | 1 15 | 14 340 |
| Nov. 1 | do | 2 0 | 0 43 | 0 44 | 0 60 | 0 190 |

Miscellaneous Discharge Measurements of Ross Creek Drainage Basin, in 1911.

| Date | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 15 | M. H. French | Ross Creek | Sec. 25-9-3-4. | | | | * 0 71 |
| July 24 | do | do | Sec. 36-8-3-4 | | | | * 0 85 |
| Oct. 28 | W. A. Fletcher. | do | N E. 7-12-3-4 | | | | * 0 42 |

* Weir measurement.

## SEVENPERSONS RIVER DRAINAGE BASIN.

*General Description.*

Sevenpersons River lies between the South Saskatchewan River and the Cypress Hills, and empties into the South Saskatchewan River at Medicine Hat. The catchment area consists almost entirely of open level prairie, with a small rainfall and very little run-off. During the early spring freshets and after very heavy rains there is a good flow for a few days, but at other times the stream is either dry or almost dry.

The soil is good, and dry farming is carried on quite successfully, but, owing to the limited water supply, irrigation is not likely to be attempted.

Records on this stream are taken for general statistical purposes.

### Sevenpersons River at Medicine Hat, Alta.

This station was established on April 27, 1910, by H. R. Carscallen. It is located in the N.E. 1/4 Sec. 30, Tp. 12, Rge. 5, W. 4th Mer., at the bridge on the road from Medicine Hat to Dunmore Junction and about one and a half miles east of the Canadian Pacific Railway station at Medicine Hat.

The channel is straight for about 100 feet above and below the station. Both banks are high and wooded. The stream-bed is sandy and liable to change at high water.

During high-water stages, discharge measurements are made with a current-meter. The initial point of soundings is the inner face of the left abutment of the bridge. Low-water measurements are made with a weir.

The gauge, which is a plain staff graduated to feet and hundredths, is attached to the west, or left, abutment of the bridge. It is referred to two bench-marks, viz.:—(1) the top of a bolt-head in the cap of the right abutment (elevation, 10.41 above the datum of the gauge); (2) the head of a spike driven into a large stump about 100 feet east of the gauge (elevation, 11.40 above the zero of the gauge).

Because of apparent inaccuracies in observations, the gauge-height records for 1911 are not considered satisfactory and have not been used. There is, therefore, no table of daily gauge-height and discharge for 1911.

Discharge Measurements of Sevenpersons River at Medicine Hat, Alta., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 8 | J. C. Keith | 6.8 | 1.17 | 0.480 | 0.840 | 0.571 |
| May 25 | do | | | | 0.780 | 0.208* |
| June 12 | do | | | | 0.540 | 0.008* |
| July 7 | do | 15.5 | 14.52 | 2.216 | 1.385 | 32.290 |
| Sept. 9 | do | | | | 0.540 | 0.009* |
| Nov. 1 | do | 2.2 | 0.25 | 0.430 | 0.550 | 0.107 |

* Weir measurement.

## LAKE JOHNSTON DRAINAGE BASIN.

### *General Description.*

Lake Johnston lies about twenty miles southwest of the City of Moose Jaw. It is about twenty-five miles long and fifteen wide and covers an area of nearly five townships. Almost all the drainage into the lake comes from the south and west through Wood River. The main tributaries of Wood River are Wiwa Cree,k Notukeu Creek, Pinto Creek and Wood Creek. These drain a large area, but, owing to the limited rainfall and the small slope of the drainage basin, the run-off is comparatively small.

Lake Johnston has no surface outlet and there has been no surface flow from Lake Chaplin to Lake Johnston for several years, but it will be noted that the elevation of the two lakes is the same. There is often considerable flow in Wood River in the spring, and there is always some discharge, but the lake has during recent years receded.

The lower part of Wood River has a very small fall, and is more of the nature of a long slough than that of a running stream. The channel is from twenty to fifty feet wide, and is from two to five feet deep. The bottom is composed of soft clay and is covered with weeds and grass. There is so little fall that it would be impossible to take out water by gravity and a dam would flood a large area of good agricultural land. There is, therefore, little possibility of irrigation development in this basin.

This drainage basin includes a large area of very good agricultural lands. These are pretty well taken up by settlers and are being farmed with good results.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Lake Johnston Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 13 | N.M. Sutherland | Bull Creek | S.W. 6-8-14-3 | | | | * 0 202 |
| July 10 | do | do | do | | | | * 1 249 |
| July 29 | do | do | do | | | | * 0 139 |
| Aug. 12 | do | do | do | | | | * 1 163 |
| June 28 | do | Chaplin River | S.W. 12-14-3-3 | | | | 0 000 |
| June 22 | do | Creek, A | Sec. 20-4-3-3 | | | | * 0 050 |
| June 25 | do | do | Sec. 28-7-5-3 | | | | 0 000 |
| June 25 | do | do | S.W. 24-5-7-3 | | | | 0 000 |
| June 25 | do | do | N.W. 9-5-6-3 | | | | 0 000 |
| June 25 | do | do | N.W. 4-5-5-3 | | | | 0 262 |
| June 25 | do | do | N.E. 4-5-5-3 | | | | 0.000 |
| June 25 | do | do | N.W. 5-5-5-3 | | | | 0 344 |
| June 25 | do | do | S.W. 3-5-5-3 | | | | 0.000 |
| June 25 | do | do | S.E. 24-5-7-3 | | | | 0.000 |
| June 26 | do | do | S.E. 21-5-9-3 | | | | 0.000 |
| July 24 | do | do | Sec. 20-4-3-3 | | | | 0.100 |
| July 26 | do | McDonald Creek | Sec. 25-9-8-3 | | | | 0.000 |
| Sept. 20 | do | Mosquito Creek | Sec. 20-11-10-3 | | | | 0.000 |
| June 13 | do | Notukeu Creek | N.W. 3-9-14-3 | | | | * 0.309 |
| June 26 | do | do | N.E. 24-11-5-3 | 18 0 | 16 4 | 0 23 | 3.830 |
| July 9 | do | do | N.W. 3-9-14-3 | | | | * 2.257 |
| July 29 | do | do | Sec. 18-9-14-3 | | | | * 0.139 |
| July 31 | do | do | Sec. 29-9-12-3 | 4.4 | 1.09 | 0 61 | 0 670 |
| Aug. 11 | do | do | N.W. 18-9-13-3 | | | | * 0 056 |
| Sept. 14 | do | do | N.E. 24-11-5-3 | 12 8 | 13.89 | 0.30 | 4 180 |
| Sept. 19 | do | do | Sec. 5-11-10-3 | 11 8 | 9 88 | 1 20 | 11.760 |
| June 12 | do | Pierce Creek | S.W. 34-10-14-3 | | | | * 0.505 |
| July 8 | do | do | do | | | | * 0 629 |
| July 31 | do | do | S.W. 36-9-13-3 | | | | 0 030 |
| Aug. 11 | do | do | S.W. 34-10-14-3 | | | | * 0.446 |
| June 25 | do | Pinto Creek | Sec. 23-8-6-3 | | | | 0.050 |
| July 24 | do | Sixmile Creek | S.W. 17-4-4-3 | | | | 0 050 |
| Aug. 1 | do | Whiskey Creek | S.E. 36-11-13-3 | 4 6 | 1 47 | 1.04 | 1.530 |
| Sept. 19 | do | do | S.W. 17-11-10-3 | | | | * 1 183 |
| Sept. 26 | do | Wiwa Creek | Sec. 36-12-5-3 | | | | 0.000 |
| Sec. 14 | do | do | do | | | | 0 000 |
| June 26 | do | Wood River | Sec. 31-9-4-3 | 10 0 | 18 8 | 0.36 | 6 760 |
| June 25 | do | do | S.E. 23-5-7-3 | | | | 0.030 |
| June 26 | do | do | N W. 9-5-10-3 | | | | 0.000 |
| Sept. 12 | do | do | N.W. 18-10-4-3 | 12 2 | 4 31 | 1.21 | 5.210 |
| Sept. 14 | do | do | N.W. 4-13-4-3 | 32 0 | 15 7 | 0.53 | 8.270 |
| Sept. 11 | do | Wood Creek | Sec. 20-4-3-3 | | | | * 0 822 |
| Sept. 11 | do | do | N.E. 4-6-3-3 | 7 0 | 5.87 | 0.74 | 4 360 |

* Weir measurement.

## ROCKY CREEK DRAINAGE BASIN.

### *General Description.*

Rocky Creek lies between Frenchman River and Poplar River. With its many tributaries it drains the southwestern slope of Wood Mountain. The main stream has its source in Tp. 3, Rge. 5, west of the third meridian, and crossing the international boundary near the southwest corner of Sec. 2, Tp. 1, Rge. 6, west of the third meridian, eventually finds its way into Milk River near Hinsdale in Montana. There is only a small portion of the drainage basin of this stream in Canada.

Owing, possibly, to the elevation, the precipitation in the upper part of this basin is a little above the average for the surrounding prairie. All the streams in the basin have a good flow during the spring freshet period, but soon recede, and most of the time they are all dry or have water only in pools, except the main stream, which generally has at least a small flow at all seasons. The upper portion of the drainage basin consists of rolling prairie land very much cut up by coulees and ravines. There are small areas of heavy gumbo land, but for the most part the soil is good and productive, and that portion of the drainage basin lying in Canada is quite suitable for ranching or mixed farming. Being remote from railways, very little of the land has been taken up by settlers.

Owing to the rolling nature of the lands and the limited water supply, irrigation can be developed but little in this basin.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Rocky Creek Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 18... | N. M. Sutherland | Bluff Creek... | S.W. 1-1-9-3 | | | | Nil. |
| July 14. | do | do | do | | | | Nil. |
| Aug. 16. | do | do | do | | | | Nil. |
| June 19... | do | Creek, A. | S.W. 1-1-7-3 | | | | Nil. |
| June 19.... | do | do | N.W. 3-1-6-3. | 3.1 | 0.38 | 0.87 | 0.72 |
| June 19... | do | do | Sec. 12-1-6-3 | | | | Nil. |
| July 17... | do | do | N.W. 3-1-6-3... | | | | 0.05 |
| June 18.. | do | Coulee, A.. | S.E. 6-1-9-3.. | | | | Nil. |
| July 14. | do | do | do | | | | Nil. |
| July 18.. | do | do | Sec. 6-1-4-3... | | | | Nil. |
| June 18... | do | McEachran Cr. | S.W. 6-1-7-3... | | | | Nil. |
| July 15.... | do | do | do | | | | Nil. |
| Aug. 17... | do | do | do | | | | Nil. |
| Aug. 19... | do | Rice Creek...... | N.W. 3-1-6-3... | | | | * 0.03 |
| June 19.. | do | Rocky Creek... | S.E. 5-1-6-3.... | 10.3 | 4.18 | 0.77 | 3.20 |
| June 20.... | do | do | Sec. 18-2-4-3... | 4.2 | 2.55 | 1.48 | 3.78 |
| June 21.... | do | do | do | 4.1 | 3.54 | 1.96 | 6.93 |
| July 17.... | do | do | S.E. 5-1-6-3.... | 5.0 | 1.47 | 0.69 | 1.01 |
| Aug. 19.... | do | do | do | | | | * 0.918 |
| Aug. 19.... | do | do | do | | | | * 1.05 |
| July 15... | do | Rocky Creek, West Br... | S.W. 1-1-7-3 | | | | * Nil. |
| Aug. 17... | do | do | S.W. 1-1-7-3 | | | | Nil. |

* Weir measurement.

## POPLAR RIVER DRAINAGE BASIN.

### *General Description.*

Poplar River rises in Tp. 3, Rge. 3, west of the third meridian, and with its many tributaries drains the southeastern slope of Wood Mountain. The main stream crosses the International Boundary near the southwest corner of Sec. 1, Tp. 1, Rge. 29, west of the second meridian, and empties into Missouri River near Poplar in Montana. There is only a small portion of the drainage basin of this stream in Canada.

Owing, possibly, to the elevation, the precipitation in the upper part of this basin is a little above the average for the surrounding prairie. All the streams in the basin have a good flow during the spring freshet period, but soon recede and most of the time they have only a very small flow.

In the lower part of the basin the fall in the main stream is very small. The channel is from thirty to seventy-five feet wide and from two to three feet deep. The current is sluggish and the channel is full of weeds. The banks of the stream are low, and liable to overflow at the time of the spring freshet.

The upper portion of the drainage basin consists of rolling prairie and that portion lying in Canada is quite suitable for ranching or mixed farming. Being remote from railways, little of the land has been taken up by settlers. Irrigation development will be limited to the water-supply.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Poplar River Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| July 20 | N.M.Sutherland | Creek, A | S.W. 3-2-29-2 | | | | Nil. |
| July 21 | do | do | Sec. 13-14-29-2 | | | | 0.020 |
| Sept. 5 | do | do | N.W. 2-4-1-3. | | | | * 0.994 |
| Sept. 5 | do | do | N.W. 28-3-30-2 | | | | * 0.110 |
| Aug. 22 | do | Coulee, A | Sec. 1-1-3-3. | | | | Nil. |
| Aug. 22 | do | do | Sec. 3-1-3-3. | | | | Nil. |
| Aug. 23 | do | do | Sec. 5-1-28-2 | | | | Nil. |
| Aug. 22 | do | Cool Creek | Sec. 5-1-1-3. | | | | Nil. |
| Sept. 9 | do | Hay Meadow Cr | N.E. 3-4-30-2 | 8.90 | 7.04 | 1.88 | 13.260 |
| Sept. 10 | do | do | S.W. 17-4-1-3 | | | | * 0.369 |
| Aug. 16 | do | Police Creek | S.E. 6-1-9-3 | | | | Nil. |
| July 20 | do | Poplar River | S.E. 8-1-29-2 | | | | * 0.837 |
| Aug. 23 | do | do | S.E. 1-1-29-2 | | | | * 0.467 |
| Aug. 23 | do | do East Br | S.E. 4-1-26-2 | 13.80 | 6.33 | 0.79 | 5.060 |
| July 19 | do | do West Br | S.W. 5-1-3-3 | | | | 0.077 |
| Aug. 20 | do | do | S.E. 5-1-3-3 | | | | 0.050 |

* Weir measurement.

## BIGMUDDY CREEK DRAINAGE BASIN.

### *General Description.*

Bigmuddy Creek has no well defined course in Canada, but develops from a depression running southeast from Bigmuddy Lake, and after crossing the International Boundary flows southward and empties into the Missouri River near Cuthbertson, Montana.

The source of Beaver Creek, a tributary of Bigmuddy Creek, is in Canada, but it, too, is a small and unimportant stream.

That portion of the drainage basin lying in Canada consists of alkali flats and rough rolling prairie. It is quite suitable for ranching purposes, but, being remote from railways, few settlers have taken up land in this drainage basin.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Bigmuddy Creek Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| Aug. 24 | N.M. Sutherland | Beaver Creek | S.E. 5-1-23-2 | | | | * 0.539 |
| Aug. 30 | do | Bigmuddy Flat | Sec. 10-1-22-2 | | | | Nil |
| Aug. 31 | do | Beaver Crk. Br | Sec. 33-1-23-2 | | | | Nil. |
| Aug. 24 | do | Creek A | Sec. 3-1-23-2 | | | | 0.100 |
| Aug. 23 | do | Coulee A | Sec. 5.1-25-2 | | | | Nil. |
| Aug 28 | do | do | Sec. 1-1-21-2. | | | | Nil. |

* Weir measurement.

## QU'APPELLE RIVER DRAINAGE BASIN.

### *General Description.*

Qu'Appelle River rises in Township 23, Range 4, west of the third meridian, and flows eastward into the Assiniboine River in Township 28, Range 17, west of the first meridian. These waters eventually find their way into Hudson Bay through the Red River, Lake Winnipeg and Nelson River.

The chief tributaries of Qu'Appelle River are Moosejaw Creek, Last Mountain, Waskana Creek and Loon Creek. Last Mountain is the largest lake in the basin, being some sixty miles long and from one to three miles wide.

The valley of the main stream is from two to three hundred feet deep, with a flat from one to three miles wide along the river. This flat is covered in many places with brush, and the hill-sides are in many places well wooded. The bench-lands above the river are mostly level prairie, much of which is now under cultivation.

The mean annual rainfall at Moosejaw is fourteen inches, at Regina fifteen inches, and at Indian Head nineteen inches. The streams are frozen during the winter months and there is usually an abundant snow-fall.

There are several irrigation and many industrial water-rights in this basin.

## Qu'Appelle River at Lumsden, Sask.

This station was established on May 12, 1911, by J. C. Keith. It is located at a private bridge on the N.W. ¼ Sec. 33, Tp. 19, Rge. 21, W. 2nd Mer., in the north end of the town of Lumsden, and is about three miles below the mouth of Waskana Creek and a little over a mile above the mouth of Boggy Creek.

The gauge, which is a plain staff graduated to feet and hundredths, is fastened to the down-stream side of the left abutment of the bridge. The zero of the gauge (elev., 85.33) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated 34 feet from the southeast corner of the bridge.

The channel is straight for 200 feet above and 100 feet below the station. Both banks are fairly high, but may overflow in an excessive flood. The bed of the stream is composed of gravel, and is not likely to shift. The current is moderate.

Discharge measurements are made from the bridge at all stages. The initial point for soundings is the inner face of the left abutment.

The gauge was read by R. T. Raven. Tables of daily gauge-height and discharge and monthly discharge will be computed during 1912 and published with the records for that year.

### Discharge Measurements of Qu'Appelle River at Lumsden, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 17 | W. H. Green | 45.5 | 292.84 | 1.830 | .......... | 537.000 |
| May 12 | J. C. Keith | 27.0 | 101.50 | 0.643 | 3.06 | 65.479 |
| May 27 | do | 25.0 | 96.40 | 0.710 | 3.12 | 68.540 |
| June 15 | do | 27.0 | 117.00 | 1.000 | 3.82 | 117.910* |
| July 11 | do | 25.0 | 79.01 | 0.370 | 2.50 | 28.920 |
| Aug. 18 | do | 24.0 | 66.36 | 0.202 | 2.00 | 13.410 |
| Oct. 6 | do | 24.0 | 67.53 | 0.210 | 2.07 | 14.300 |
| Dec. 1 | do | | 6.60 | 0.470 | 1.98 | 3.110 |

* Gauged at bridge.

## Qu'Appelle River at Fort Qu'Appelle, Sask.

This station was established on July 26, 1911, by J. C. Keith. It is located at the traffic bridge on the N.W. ¼ Sec. 7, Tp. 21, Rge. 13, W. 2nd Mer., and is between the Upper Fishing and the Lower Fishing Lakes.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the down-stream face of the north abutment. The zero of the gauge (elev., 86.68) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated 34 feet from the southwest corner of the bridge.

The channel is straight for about 50 feet above, but curves directly below the station. The right bank is high, while the left is low, and will overflow at high stages of the stream. The bed of the stream is sandy and partly covered with weeds. The fall is small, the current slow and the bed is, therefore, not liable to shift.

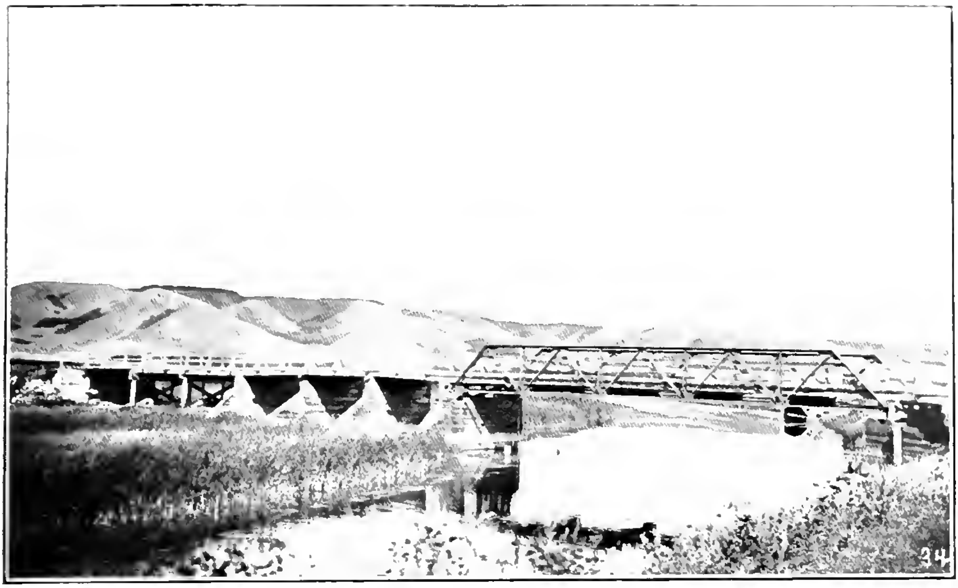
Discharge measurements are made from the bridge at all stages. The initial point for soundings is the inner face of the first pile at the north approach of the bridge.

The gauge was read by W. M. Thomson, but, as only three discharge measurements were made, there are not sufficient data to compute the daily discharges. It will be noted that the highest discharge was obtained at the lowest gauge-height. This is probably due largely to the weeds, but may also be partly due to the effect of the wind. It should also be noted that the mean velocities are very small, and the results are, therefore, not thoroughly reliable.

### Discharge Measurements of Qu'Appelle River near Fort Qu'Appelle, Sask., in 1911.

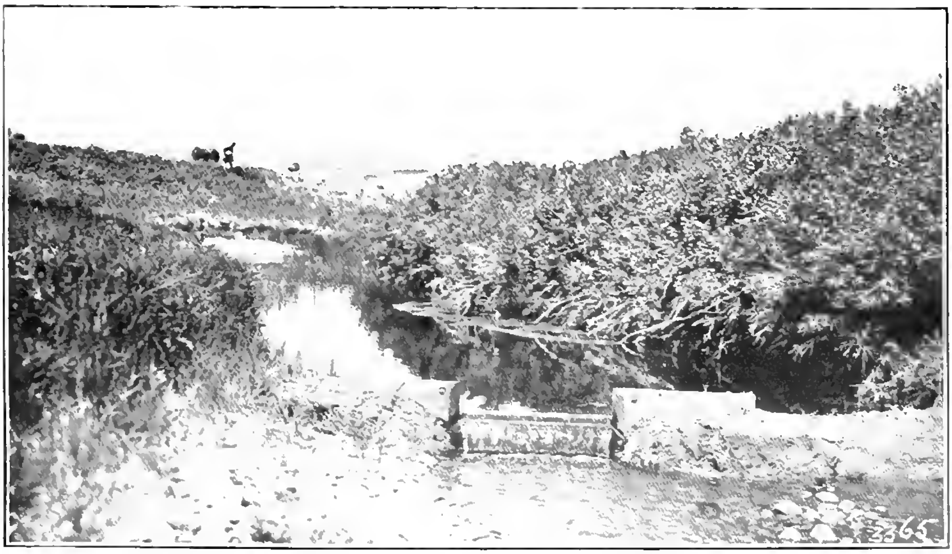
| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 25 | J. C. Keith | 67.0 | 163.32 | 0.17 | 2.63 | 28.57 |
| Aug. 30 | do | 66.0 | 156.17 | 0.13 | 2.52 | 21.17 |
| Oct. 12 | do | 66.0 | 154.37 | 0.28 | 2.50 | 42.59 |

PLATE No. 32.



Bridge over Qu'Appelle River near Katepwe, Sask   Taken by J. C. Keith

PLATE No. 33.



Gauging Notukeu Creek with a 15-inch Weir.   Taken by P. M. Sauder.

Mean Daily Gauge Height, in feet, of Qu'Appelle River near Fort Qu'Appelle, Sask., for 1911.

| Day. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|
| 1 | | 2.58 | 2.54 | 2.50 | 2.35 |
| 2 | | 2.58 | 2.52 | 2.50 | 2.35 |
| 3 | | 2.54 | 2.52 | 2.54 | 2.35 |
| 4 | | 2.54 | 2.60 | 2.50 | 2.35 |
| 5 | | 2.54 | 2.56 | 2.50 | 2.35 |
| 6 | | 2.54 | 2.54 | 2.50 | 2.35 |
| 7 | | 2.54 | 2.51 | 2.50 | 2.35 |
| 8 | | 2.66 | 2.50 | 2.50 | 2.35 |
| 9 | | 2.62 | 2.50 | 2.50 | 2.35 |
| 10 | | 2.58 | 2.50 | 2.50 | 2.35 |
| 11 | | 2.54 | 2.50 | 2.50 | 2.35 |
| 12 | | 2.54 | 2.50 | 2.50 | 2.35 |
| 13 | | 2.54 | 2.49 | 2.50 | 2.35 |
| 14 | | 2.60 | 2.54 | 2.50 | 2.35 |
| 15 | | 2.56 | 2.52 | 2.50 | 2.35 |
| 16 | | 2.56 | 2.52 | 2.50 | .......... |
| 17 | | 2.56 | 2.52 | 2.50 | .......... |
| 18 | | 2.54 | 2.58 | 2.50 | .......... |
| 19 | | 2.54 | 2.52 | 2.50 | .......... |
| 20 | | 2.54 | 2.52 | 2.50 | .......... |
| 21 | | 2.60 | 2.52 | 2.46 | .......... |
| 22 | | 2.56 | 2.50 | 2.46 | .......... |
| 23 | | 2.54 | 2.50 | 2.44 | .......... |
| 24 | | 2.54 | 2.50 | 2.44 | .......... |
| 25 | 2.63 | 2.52 | 2.54 | 2.42 | .......... |
| 26 | 2.62 | 2.50 | 2.52 | 2.42 | .......... |
| 27 | 2.64 | 2.58 | 2.52 | 2.42 | .......... |
| 28 | 2.64 | 2.54 | 2.52 | 2.42 | .......... |
| 29 | 2.60 | 2.52 | 2.50 | 2.42 | .......... |
| 30 | 2.60 | 2.52 | 2.50 | 2.42 | .......... |
| 31 | 2.60 | 2.52 | ...... | 2.35 | .......... |

## Qu'Appelle River near Katepwe, Sask.

This station was established on July 27, 1911, by J. C. Keith. It is located at the traffic bridge on the N.E. ¼ Sec. 22, Tp. 19, Rge. 12, W. 2nd Mer., and is about half a mile below Lake Katepwe and twelve miles north of the town of Indian Head.

The gauge, which is a plain staff graduated to feet and hundredths, is fixed near the downstream end of the north face of the centre pier. The zero of the gauge (elev., 89.83) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated 73 feet from the southwest corner of the bridge.

The channel is straight for 100 feet above and below the station. The right bank is high, while the left is low and will overflow. The bed is sandy, and is almost covered with vegetation. The current is sluggish.

The cross-section at the gauge is not suitable, and discharge measurements are, therefore, made from the bridge on the S.E. ¼ Sec. 13, Tp. 19, Rge. 12, W. 2nd Mer., where there is a clean firm gravel bed. The initial point for soundings is a spike on the guard-rail marked "O."

The gauge was read by Clem Peltier, but as only three discharge meaurements were made there is not sufficient data to compute the daily discharges. It will be noted that the discharges do not vary in accordance with the gauge-heights. This is probably due largely to the weeds, but may also be partly due to the effect of the wind. It should also be noted that the mean velocities are very small and the results are, therefore, not thoroughly reliable.

Discharge Measurements of Qu'Appelle River near Katepwe, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| July 13 | J. C. Keith | 50.0 | 80.95 | 0.83 | ...... | 67.41 |
| July 27 | do | 48.0 | 73.43 | 0.57 | 2.05 | 41.76x |
| Aug. 31 | do | 47.0 | 60.35 | 0.26 | 1.46 | 15.80* |
| Oct. 13 | do | 48.5 | 77.00 | 0.46 | 1.18 | 35.49* |

x Gauge established.
* Gauged at bridge.

MEAN DAILY GAUGE HEIGHT, in feet, of Qu'Appelle River near Katepwe, Sask., for 1911.

| Day | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|
| 1 | | 2.04 | 1.42 | | 1.06 |
| 2 | | 2.03 | 1.40 | 1.54 | 1.04 |
| 3 | | 2.03 | | 1.54 | 1.00 |
| 4 | | 2.02 | 1.37 | 1.55 | 0.96 |
| 5 | | 2.02 | 1.32 | 1.53 | ........ |
| 6 | | | 1.30 | 1.53 | 0.94 |
| 7 | | 2.02 | 1.28 | 1.54 | 0.93 |
| 8 | | 2.03 | 1.25 | | 0.93 |
| 9 | | 2.04 | 1.22 | 1.45 | 0.91 |
| 10 | | 2.04 | | 1.33 | 0.90 |
| 11 | | 2.03 | 1.30 | 1.30 | 0.90 |
| 12 | | 2.03 | 1.39 | 1.30 | ...... |
| 13 | | | 1.44 | 1.22 | 0.91 |
| 14 | | 2.01 | 1.49 | 1.16 | 0.90 |
| 15 | | 1.94 | 1.53 | .... | 0.89 |
| 16 | | 1.96 | 1.55 | 1.15 | ...... |
| 17 | | 1.94 | | 1.15 | ...... |
| 18 | | 1.91 | 1.55 | 1.14 | ...... |
| 19 | | 1.90 | 1.54 | 1.14 | ...... |
| 20 | | | 1.54 | 1.13 | ...... |
| 21 | | 1.85 | 1.52 | 1.13 | ...... |
| 22 | | 1.83 | 1.52 | | ...... |
| 23 | | 1.80 | 1.54 | 1.10 | .. |
| 24 | | 1.75 | .... | 1.08 | .. |
| 25 | | 1.69 | 1.52 | 1.08 | ...... |
| 26 | | 1.65 | 1.54 | 1.05 | ...... |
| 27 | 2.05 | | 1.54 | 1.03 | ...... |
| 28 | 2.05 | 1.60 | 1.53 | 1.00 | ...... |
| 29 | 2.04 | 1.55 | 1.55 | .... | ...... |
| 30 | | 1.49 | 1.52 | 1.10 | ...... |
| 31 | 2.02 | 1.46 | ...... | 1.10 | ........ |

MISCELLANEOUS DISCHARGE MEASUREMENTS of Qu'Appelle River Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet* | *Feet per Sec.* | *Sec.-Ft.* |
| July 12. | J. C. Keith | Kaposvar Creek | N.W. 7-21-3-2. | 55.0 | 162.20 | 0.473 | 76.630 |
| May 17..... | do | Qu'Appelle.... | S.W. 6-19-24-2 | 3.7 | 0.720 | 0.320 | 0.230 |
| Aug. 28..... | do | do | do | 7.0 | 1.530 | 0.238 | 0.364 |
| Oct. 9...... | do | do | do | 2.5 | 0.158 | 0.270 | 0.043 |

## MOOSEJAW CREEK DRAINAGE BASIN.

### *General Description.*

Moosejaw Creek rises in the vicinity of Yellowgrass and flows in a northwesterly direction until it reaches the city of Moosejaw, and thence in an easterly and northerly direction, finally emptying into the Qu'Appelle River near Buffalo Pound Lake. From the head-waters to the city of Moosejaw, the drainage area is estimated at about one thousand eight hundred and thirty square miles. This area is almost entirely devoid of tree growth, except that the valley is lined with brush in the vicinity of Moosejaw.

Throughout its entire length the creek flows in a very crooked but well defined channel. The upper portion of the valley is small, being merely a depression, but it gradually increases in size until at Drinkwater it is about thirty feet deep and at Moosejaw about eighty feet deep. The fall in the creek is very small, particularly so between Drinkwater and Moosejaw, where the total fall is only 67.5 feet, or an average of 2.3 feet per mile of valley.

The Canadian Pacific Railway Company has dams at Milestone, Rouleau, Drinkwater, two at Moosejaw and one at Pasque. There is also a municipality dam in Sec. 19, Tp. 15, Rge. 24, W. 2nd Mer., which supplies water to the neighbourhood in periods when there is no flow in the creek. The amount of water diverted in each case is small, as the Canadian Pacific Railway use the water only to operate their railway, and only a small quantity of stock has been watered at the municipal dam during late years.

## Moosejaw Creek near Lang, Sask.

This station was established on June 21, 1911, by J. C. Keith. It is located at the traffic bridge on the road allowance east of the N.E. ¼ Sec. 24, Tp. 11, Rge. 19, W. 2nd Mer., and is four miles west of the village of Lang.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the downstream face of the centre row of piles. The zero of the gauge (elev., 94.80) is referred to the top of a pile (assumed elev., 100.00) on the downstream side of the south approach of the bridge.

The channel is straight for 200 feet above and 150 feet below the station. Both banks are low and overflow in high stages of the stream. The bed of the stream is composed of clay, and in summer, when the stream is very low, becomes overgrown with vegetation. The current is sluggish at all stages.

Discharge measurements are made from the bridge in high stages of the stream and by wading or with a weir at some other section during low stages. The initial point for soundings at the bridge is the inner face of the south abutment.

The gauge was read by Miss Irene Irvine.

### Discharge Measurements of Moosejaw Creek near Lang, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| May 30 | J. C. Keith | 49.0 | 57.45 | 0.579 | | 33.27 |
| June 21 | do | 10.0 | 4.55 | 0.360 | 1.84 | 1.64 |
| July 17 | do | 11.6 | 14.28 | 0.270 | 2.43 | 3.85 |
| Aug. 22 | do | 12.0 | 13.24 | 0.210 | 2.28 | 2.80 |
| Oct. 17 | do | 17.5 | 17.00 | 0.245 | 2.46 | 4.18 |

### Daily Gauge Height and Discharge of Moosejaw Creek near Lang, Sask., for 1911.

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge |
| | *Feet* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.80 | 1.6 | 2.56 | 5.3 | 2.21 | 2.5 | 1.99 | 1.9 |
| 2 | | | 1.79 | 1.6 | 2.57 | 5.4 | 2.20 | 2.5 | 2.05 | 2.1 |
| 3 | | | 1.78 | 1.6 | 2.58 | 5.5 | 2.19 | 2.5 | 2.10 | 2.2 |
| 4 | | | 1.77 | 1.5 | 2.59 | 5.6 | 2.16 | 2.4 | 2.15 | 2.4 |
| 5 | | | 2.00 | 2.0 | 2.61 | 5.8 | 2.16 | 2.4 | 2.20 | 2.5 |
| 6 | | | 2.05 | 2.1 | 2.63 | 6.1 | 2.15 | 2.4 | 2.21 | 2.5 |
| 7 | | | 2.20 | 2.5 | 2.63 | 6.1 | 2.14 | 2.3 | 2.30 | 2.9 |
| 8 | | | 2.30 | 2.9 | 2.76 | 7.8 | 2.13 | 2.3 | 2.35 | 3.2 |
| 9 | | | 2.50 | 4.6 | 2.65 | 6.4 | 2.13 | 2.3 | 2.35 | 3.2 |
| 10 | | | 2.50 | 4.6 | 2.76 | 7.8 | 2.14 | 2.3 | 2.35 | 3.2 |
| 11 | | | 2.45 | 4.1 | 2.74 | 7.6 | 2.15 | 2.4 | 2.36 | 3.3 |
| 12 | | | 2.45 | 4.1 | 2.78 | 8.0 | 2.16 | 2.4 | 2.37 | 3.4 |
| 13 | | | 2.45 | 4.1 | 2.69 | 6.9 | 2.17 | 2.4 | 2.40 | 3.6 |
| 14 | | | 2.41 | 3.7 | 2.66 | 6.5 | 2.18 | 2.4 | 2.40 | 3.6 |
| 15 | | | 2.40 | 3.6 | 2.60 | 5.7 | 2.18 | 2.4 | 2.41 | 3.7 |
| 16 | | | 2.40 | 3.6 | 2.58 | 5.5 | 2.19 | 2.5 | 2.41 | 3.7 |
| 17 | | | 2.45 | 4.1 | 2.56 | 5.3 | 2.19 | 2.5 | 2.46 | 4.2 |
| 18 | | | 2.44 | 4.0 | 2.54 | 5.0 | 2.18 | 2.4 | 2.49 | 4.5 |
| 19 | | | 2.44 | 4.0 | 2.52 | 4.8 | 2.16 | 2.4 | 2.51 | 4.7 |
| 20 | | | 2.50 | 4.6 | 2.41 | 3.7 | 2.14 | 2.3 | 2.52 | 4.8 |
| 21 | 1.84 | 1.7 | 2.50 | 4.6 | 2.30 | 2.9 | 2.10 | 2.2 | 2.55 | 5.2 |
| 22 | 1.80 | 1.6 | 2.50 | 4.6 | 2.30 | 2.9 | 2.07 | 2.1 | 2.57 | 5.4 |
| 23 | 1.75 | 1.5 | 2.55 | 5.2 | 2.25 | 2.7 | 2.05 | 2.1 | 2.58 | 5.5 |
| 24 | 1.76 | 1.5 | 2.55 | 5.2 | 2.25 | 2.5 | 2.03 | 2.1 | 2.59 | 5.6 |
| 25 | 1.75 | 1.5 | 2.55 | 5.2 | 2.20 | 2.5 | 2.01 | 2.0 | 2.60 | 5.7 |
| 26 | 1.70 | 1.4 | 2.55 | 5.2 | 2.25 | 2.7 | 2.00 | 2.0 | 2.61 | 5.8 |
| 27 | 1.65 | 1.4 | 2.55 | 5.2 | 2.26 | 2.7 | 2.00 | 2.0 | 2.61 | 5.8 |
| 28 | 1.65 | 1.4 | 2.55 | 5.2 | 2.25 | 2.7 | 1.99 | 2.0 | 2.61 | 5.8 |
| 29 | 1.61 | 1.3 | 2.55 | 5.2 | 2.24 | 2.7 | 1.96 | 1.9 | * | |
| 30 | 1.61 | 1.3 | 2.55 | 5.2 | 2.24 | 2.7 | 1.93 | 1.9 | | |
| 31 | | | 2.55 | 5.2 | 2.22 | 2.6 | | | | |

* Creek frozen over.

MONTHLY DISCHARGE of Moosejaw Creek near Lang, Sask., for 1911.

(Drainage area, 189 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| June (21-30)... | 1 7 | 1 3 | 1 46 | 0 008 | 0 003 | 29 |
| July | 5 2 | 1 5 | 3 90 | 0 021 | 0 024 | 240 |
| August | 8 0 | 2 5 | 4 88 | 0 026 | 0 030 | 300 |
| September | 2 5 | 1 9 | 2 28 | 0 012 | 0 013 | 136 |
| October (1-28). | 5 8 | 1 9 | 3 94 | 0 021 | 0 022 | 219 |
| The period | | | | | 0 092 | 924 |

## MOOSEJAW CREEK AT BRYCE'S FARM, SASK.

This station was established on April 13, 1910, by P. M. Sauder. It is located at the traffic bridge on the road allowance east of the N.E. ¼ Sec. 15, Tp. 15, Rge. 25, W. 2nd Mer., and is about seventeen and one half miles southeast of Moosejaw.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a pile on the downstream side of the bridge. The zero of the gauge (elev., 87.29) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated on the left bank 51 feet downstream from the bridge.

The channel is straight for 200 feet above and 100 feet below the station. The right bank is partly covered with brush, and overflows during flood stages of the stream. The left bank is also partly covered with brush, but is high and not liable to overflow. The bed is composed of soft clay (mud), but is free from vegetation and is not liable to shift except during very high water.

Discharge measurements are made from the bridge during high water. The initial point for soundings is the south end of the hand-rail of the bridge. During low water the discharge is measured by wading or with a weir near the bridge.

During 1911, the gauge was read by W. F. Bryce from April 9 to June 3, and by Gerry Chevrier from June 25 to November 11.

DISCHARGE MEASUREMENTS of Moosejaw Creek at Bryce's Farm, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| April 22 | W. H. Greene.. | 84 3 | 329 00 | 0.969 | 7 39 | 318 48 |
| May 2 | J. C. Keith.. | 67 5 | 118 57 | 0 600 | 4 67 | 71 20 |
| May 20 | do | 57 5 | 51 59 | 0 620 | 3 54 | 32 20 |
| May 29 | do | 64 0 | 97 22 | 0 633 | 4 30 | 61 58 |
| June 19 | do | 28 5 | 13 57 | 0 560 | 2 70 | 7 55 |
| July 3 | do | 27.5 | 11 87 | 0 380 | 2 66 | 4 71 |
| Sept. 1 | do | ...... | ........ | ........ | ..... | Nil. |
| Oct. 10 | do | 63 0 | 102 08 | 0 470 | 4.32 | 48 38a |

a. Channel choked with grass.

DAILY GAUGE HEIGHT AND DISCHARGE of Moosejaw Creek at Bryce's Farm, Sask., for 1911.

| Day. | April. | | May | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height. | Dis-charge. |
| | Feet. | Sec.-ft. | Feet. | Sec.-ft | Feet. | Sec.-ft. | Feet | Sec.-ft. |
| 1 | | | 5.0 | 90.0 | 5.70 | 132.0 | 2.70 | 6.7 |
| 2 | | | 4.7 | 75.0 | 6.50 | 201.0 | 2.55 | 3.3 |
| 3 | | | 4.5 | 66.0 | 7.20 | 290.0 | 2.60 | 4.4 |
| 4 | | | 4.3 | 58.0 | † | | 2.60 | 4.4 |
| 5 | | | 2.9 | 12.0 | | | 2.60 | 4.4 |
| 6 | | | 2.5 | 2.3 | | | 2.50 | 2.3 |
| 7 | | | 2.4 | 1.3 | | | 2.70 | 6.7 |
| 8 | | | 2.3 | 0.5 | | | 2.70 | 6.7 |
| 9 | 7.6 | 352. | 2.2 | Nil | | | 2.75 | 7.9 |
| 10 | 7.8 | 384 | 2.0 | " | | | 2.75 | 7.9 |
| 11 | 7.7 | 368 | 2.0 | " | | | 2.60 | 4.4 |
| 12 | 7.6 | 352 | 2.0 | " | | | 2.60 | 4.4 |
| 13 | 7.6 | 352 | 2.0 | " | | | 2.60 | 4.4 |
| 14 | 6.9 | 248 | 2.4 | 1.3 | | | 2.60 | 4.4 |
| 15 | 7.0 | 262 | 2.2 | 0.0 | | | 2.60 | 4.4 |
| 16 | 7.3 | 305 | 2.0 | 0.0 | | | 2.70 | 6.7 |
| 17 | 7.4 | 320 | 2.4 | 1.3 | | | 2.70 | 6.7 |
| 18 | 7.7 | 368 | 2.8 | 9.3 | † | | 2.60 | 4.4 |
| 19 | 7.7 | 368 | 3.1 | 18.0 | 2.70 | 6.7 | 2.55 | 3.3 |
| 20 | 7.5 | 336 | 3.5 | 30.0 | 2.60 | 4.4 | 2.50 | 2.3 |
| 21 | 7.5 | 336 | 4.1 | 50.0 | 2.55 | 3.3 | 2.50 | 2.3 |
| 22 | 7.4 | 320 | 4.5 | 66.0 | 2.50 | 2.3 | 2.50 | 2.3 |
| 23 | 7.1 | 276 | 4.5 | 66.0 | 2.50 | 2.3 | 2.65 | 5.6 |
| 24 | 6.6 | 212 | 4.5 | 66.0 | 2.60 | 4.4 | 2.70 | 6.7 |
| 25 | 6.3 | 181 | 4.3 | 58.0 | 3.00 | 15.0 | 2.70 | 6.7 |
| 26 | 6.1 | 163 | 4.2 | 54.0 | 2.90 | 12.0 | 2.60 | 4.4 |
| 27 | 5.7 | 132 | 3.8 | 39.0 | 2.85 | 11.0 | 2.50 | 2.3 |
| 28 | 5.5 | 118 | 4.0 | 46.0 | 2.80 | 9.3 | 2.50 | 2.3 |
| 29 | 5.5 | 118 | 4.3 | 58.0 | ‡2.90 | 12.0 | 2.45 | 1.8 |
| 30 | 5.3 | 106. | 4.4 | 62.0 | 2.80 | 9.3 | 2.40 | 1.3 |
| 31 | | | 5.0 | 90.0 | | ... | 2.35 | 0.9 |

DAILY GAUGE HEIGHT AND DISCHARGE of Moosejaw Creek at Bryce's Farm, Sask., for 1911.—*Con.*

| Day. | August. | | September. | | October. | | November. | |
|---|---|---|---|---|---|---|---|---|
| | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height | Dis-charge | Gauge Height. | Dis-charge. |
| | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* |
| 1 | 2 30 | 0 5 | Dry | Nil | Dry | Nil | 2 30 | 0 5 |
| 2 | 2 30 | 0 5 | " | " | " | " | 2 30 | 0 5 |
| 3 | 2 30 | 0 5 | " | " | 0 60 | " | 2 25 | 0 2 |
| 4 | 2 30 | 0 5 | " | " | 0 50 | " | 2 25 | 0 2 |
| 5 | 2 30 | 0 5 | " | " | 0 40 | " | 2 20 | Nil |
| 6 | 2 30 | 0 5 | " | " | 0 00 | " | 2 00 | " |
| 7 | 2 20 | 0 0 | " | " | 0 00 | " | 2 00* | " |
| 8 | 2 35 | 0 9 | " | " | Dry | " | 2 00 | " |
| 9 | 2 30 | 0 5 | " | " | 3 95 | 35 0 | 2 00 | " |
| 10 | 2 30 | 0 5 | " | " | 4 30 | 47 0 | 1 90 | " |
| 11 | 2 25 | 0 2 | " | " | 4 00 | 37 0 | 1 90 | " |
| 12 | 2 11 | Nil | " | " | 3 70 | 27 0 | | |
| 13 | 1 80 | " | " | " | 3 50 | 21 0 | | .. |
| 14 | 1 50 | " | " | " | 3 35 | 17 0 | | .. |
| 15 | 1 20 | " | " | " | 3 00 | 10 0 | | .. |
| 16 | 1 00 | " | " | " | 2 90 | 8 0 | | |
| 17 | 0 00 | " | " | " | 2 90 | 8 0 | | |
| 18 | 0 70 | " | " | " | 2 80 | 6 0 | | |
| 19 | Dry | " | " | " | 2 80 | 6 0 | | |
| 20 | " | " | " | " | 2 70 | 4 6 | | ... |
| 21 | " | " | " | " | 2 70 | 4 6 | | .. |
| 22 | " | " | " | " | 2 70 | 4 6 | | ... |
| 23 | " | " | " | " | 2 70 | 4 6 | | .. |
| 24 | " | " | " | " | 2 65 | 4 0 | | .. |
| 25 | " | " | " | " | 2 60 | 3 4 | | .. |
| 26 | " | " | " | " | 2 60 | 3 4 | | |
| 27 | " | " | " | " | 2 55 | 3 0 | | ... |
| 28 | " | " | " | " | 2 50 | 2 3 | | .. |
| 29 | " | " | " | " | 2 50 | 2 3 | | ... |
| 30 | " | " | " | " | 2 40 | 1 3 | | .. |
| 31 | " | " | " | " | 2 40 | 1 3 | | .. |

† No observer from June 4 to 18.
* Changing conditions. Oct. 8—Oct. 28.
‡ Used hydrographer's gauge-height.

MONTHLY DISCHARGE of Moosejaw Creek at Bryce's Farm, Sask., for 1911.

(Drainage area, 1350 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| April (9-30) | 384 0 | 106 0 | 272 00 | 0 202 | 0 165 | 11,855 |
| May | 90 0 | 00 0 | 32 90 | 0 024 | 0 028 | 2,023 |
| June | 290 0 | 00 0 | 47 60 | 0 035 | 0 020 | 1,416 |
| July | 7 9 | 0 9 | 4 41 | 0 003 | 0 003 | 271 |
| August | 0 9 | 0 0 | 0 16 | 0 000 | 0 000 | 10 |
| September | 0 0 | 0 0 | 0 00 | 0 000 | 0 000 | 00 |
| October | 47 0 | 0 6 | 8 43 | 0 006 | 0 007 | 518 |
| November (1-11) | 0 5 | 0 0 | 0 13 | 0 000 | 0 000 | 3 |
| The period | | | | | 0 223 | 16,096 |

## MOOSEJAW CREEK AT MCCARTHY'S FARM, SASK.

This station was established on April 7, 1910, by P. M. Sauder and W. H. Greene. It is located at the traffic bridge on the N.W. ¼ Sec. 16, Tp. 16, Rge. 26, W. 2nd Mer., and is three miles south of Moosejaw post office.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the inner face of the right abutment. The zero of the gauge (elev., 83.03) is referred to a permanent iron bench-mark (assumed elev., 100.00), situated 33.5 feet northeast of the gauge.

The stream flows in one channel, which is straight for about 100 feet above and 300 feet below the station. The right bank is high, slightly wooded, and not liable to overflow. The left bank is low, partly wooded, and liable to overflow. The bed of the stream is composed of mud at the bridge, but a short distance below it is composed of gravel, and is not liable to shift except during high water.

During high water discharge measurements are made from the downstream side of the bridge, but in low water they are made by wading at a section about 30 feet downstream. The initial point for soundings is at the west end of the hand-rail of the bridge.

The gauge was read during 1911 by V. J. McCarthy and members of his household.

Discharge Measurements of Moosejaw Creek at McCarthy's Ranche, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| Mar. 28 | G. H. Whyte | 32.0 | 68.75 | 0.420 | 1.63 | 28.720 |
| May 2 | J. C. Keith | 32.0 | 77.04 | 1.454 | 1.91 | 112.040 |
| April 21 | W. H. Greene | 33.0 | 137.27 | 2.599 | 3.52 | 356.810 |
| May 9 | J. C. Keith | 16.5 | 6.42 | 0.593 | 0.63 | 3.810 |
| May 20 | do | 17.5 | 7.32 | 0.740 | 0.65 | 5.400 |
| May 29 | do | 32.0 | 57.98 | 0.788 | 1.25 | 45.750 |
| June 5 | do | 49.0 | 140.94 | 2.269 | 3.20 | 282.450 |
| June 19 | do | 25.0 | 11.90 | 0.840 | 0.77 | 9.970 |
| July 3 | do | 20.0 | 7.28 | 0.800 | 0.68 | 5.830 |
| July 22 | do | 17.3 | 3.70 | 0.370 | 0.51 | 1.380 |
| Sept. 1 | do | | | | 0.37 | Nil. |
| Oct. 11 | do | 16.5 | 4.07 | 0.270 | 0.52 | Nil. |
| Dec. 4 | do | 9.0 | 4.17 | 0.224 | 0.55 | 0.919 |
| Dec. 19 | do | 4.3 | 0.87 | 0.430 | 0.51 | 0.376 |

Daily Gauge Height and Discharge of Moosejaw Creek at McCarthy's Ranche, Sask., for 1911.

| Day. | March. | | April. | | May. | | June. | | July. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Discharge. | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge | Gauge Height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.08 | 29 | 2.02 | 123.0 | 1.57 | 75.0 | 0.97 | 21.0 |
| 2 | | | 1.08 | 29 | 1.92 | 112.0 | 1.99 | 120.0 | 0.76 | 9.3 |
| 3 | | | 1.08 | 29 | 1.77 | 96.0 | 2.48 | 181.0 | 0.68 | 6.1 |
| 4 | | | 1.08 | 29 | 1.60 | 78.0 | 2.97 | 250.0 | 0.65 | 5.2 |
| 5 | | | 1.08 | 29 | 1.33 | 51.0 | 3.18 | 285.0 | 0.64 | 4.8 |
| 6 | | | 1.08 | 29 | 0.96 | 21.0 | 3.11 | 273.0 | 0.59 | 3.2 |
| 7 | | | 1.07 | 29 | 0.76 | 9.3 | 2.74 | 217.0 | 0.57 | 2.8 |
| 8 | | | 1.06 | 28 | 0.70 | 6.8 | 2.29 | 156.0 | 0.55 | 2.2 |
| 9 | | | 1.16 | 36 | 0.68 | 6.1 | 1.84 | 103.0 | 0.54 | 2.0 |
| 10 | | | 2.25 | 152 | 0.63 | 4.5 | 1.67 | 85.0 | 0.54 | 2.0 |
| 11 | | | 2.90 | 240 | 0.60 | 3.5 | 1.53 | 70.0 | 0.58 | 3.0 |
| 12 | | | 3.22 | 295 | 0.58 | 3.0 | 1.34 | 52.0 | 0.58 | 3.0 |
| 13 | | | 3.32 | 311 | 0.58 | 3.0 | 1.22 | 41.0 | 0.56 | 2.5 |
| 14 | | | 2.97 | 250 | 0.56 | 2.5 | 1.19 | 38.0 | 0.54 | 2.0 |
| 15 | | | 2.78 | 222 | 0.54 | 2.0 | 1.14 | 34.0 | 0.52 | 1.5 |
| 16 | | | 2.99 | 254 | 0.60 | 3.5 | 1.04 | 26.0 | 0.47 | 0.7 |
| 17 | | | 3.13 | 276 | 0.62 | 4.2 | 0.93 | 19.0 | 0.47 | 0.7 |
| 18 | | | 3.34 | 314 | 0.60 | 3.5 | 0.82 | 12.0 | 0.49 | 0.9 |
| 19 | 1.57 | 24.0 | 3.54 | 354 | 0.60 | 3.5 | 0.78 | 10.0 | 0.49 | 0.9 |
| 20 | 1.64 | 29.5 | 3.61 | 365 | 0.65 | 5.2 | 0.77 | 9.7 | 0.50 | 1.0 |
| 21 | 1.82 | 45.0 | 3.51 | 352 | 0.90 | 17.0 | 0.72 | 7.6 | 0.50 | 1.0 |
| 22 | 2.09 | 72.0 | 3.49 | 342 | 1.18 | 37.0 | 0.67 | 5.8 | 0.53 | 1.8 |
| 23 | 1.72 | 36.0 | 3.44 | 333 | 1.46 | 63.0 | 0.64 | 4.8 | 0.55 | 2.2 |
| 24 | 1.48 | 18.0 | 3.22 | 293 | 1.53 | 70.0 | 0.66 | 5.5 | 0.54 | 2.0 |
| 25 | 1.56 | 24.0 | 3.03 | 260 | 1.54 | 71.0 | 0.69 | 6.5 | 0.51 | 1.2 |
| 26 | 1.72 | 36.0 | 2.73 | 215 | 1.51 | 68.0 | 0.69 | 6.5 | 0.49 | 0.9 |
| 27 | 1.84 | 47.0 | 2.53 | 188 | 1.56 | 74.0 | 0.72 | 7.4 | 0.47 | 0.7 |
| 28 | 1.55 | 23.0 | 2.35 | 164 | 1.40 | 57.0 | 0.80 | 11.0 | 0.46 | 0.6 |
| 29 | 1.32 | 20.0 | 2.21 | 146 | 1.27 | 45.0 | 0.74 | 8.5 | 0.45 | 0.5 |
| 30 | 1.15 | 21.0 | 2.10 | 133 | 1.45 | 62.0 | 0.75 | 8.9 | 0.45 | 0.5 |
| 31 | 1.08 | 29.0 | | | 1.48 | 65.0 | | | 0.45 | 0.5 |

DAILY GAUGE HEIGHT AND DISCHARGE of Moosejaw Creek at McCarthy's Ranche, Sask., for 1911. *Continued.*

| Day. | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge | Gauge Height. | Dis-charge. | Gauge Height | Dis-charge. | Gauge Height. | Dis-charge. |
| | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0 44 | 0 4 | 0 38 | Nil | 0 38 | Nil | 0 74 | 8 5 | 0 57 | 1 50 |
| 2 | 0 44 | 0 4 | 0 38 | " | 0 40 | " | 0 74 | 8 5 | 0.56 | 1 30 |
| 3 | 0 43 | 0 3 | 0 37 | " | 0 48 | 0 8 | 0 74 | 8 5 | 0 57 | 1.40 |
| 4 | 0 43 | 0 3 | 0 38 | " | 0 55 | 2 2 | 0 74 | 8 5 | 0 55 | 0 92 |
| 5 | 0 42 | 0 2 | 0 40 | " | 0 56 | 2 5 | 0 72 | 7 6 | 0.54 | 0.81 |
| 6 | 0 42 | 0 2 | 0 40 | " | 0 55 | 2 2 | 0 69 | 6 5 | 0 55 | 0 92 |
| 7 | 0 43 | 0 3 | 0 40 | " | 0 55 | 2 2 | 0 65 | 4 9 | 0 55 | 0 91 |
| 8 | 0 48 | 0 8 | 0 40 | " | 0 60 | 3 5 | 0 65 | 4 8 | 0 53 | 0 72 |
| 9 | 0 46 | 0 6 | 0 42 | 0 2 | 0 62 | 4 2 | 0 64 | 4 5 | 0 51 | 0.41 |
| 10 | 0 45 | 0 5 | 0 42 | 0 2 | 0 56 | 2 5 | 0 64 | 4 4 | 0.55 | 0 80 |
| 11 | 0 45 | 0 5 | 0 44 | 0 4 | 0 79 | 10 0 | 0 65 | 4 8 | 0 55 | 0 78 |
| 12 | 0 45 | 0 5 | 0 43 | 0 3 | 1 20 | 39 0 | 0 63 | 4 2 | 0 54 | 0 64 |
| 13 | 0 44 | 0 4 | 0 44 | 0 4 | 1 16 | 36 0 | 0 63 | 4 1 | 0 52 | 0.50 |
| 14 | 0 43 | 0 3 | 0 44 | 0 4 | 1 08 | 29 0 | 0 62 | 3 8 | 0.52 | 0.49 |
| 15 | 0 43 | 0 3 | 0 43 | 0 3 | 1 07 | 29 0 | 0 62 | 3 7 | 0 52 | 0.46 |
| 16 | 0 42 | 0 2 | 0 42 | 0 2 | 1 03 | 25 0 | 0 62 | 3 6 | 0 52 | 0 48 |
| 17 | 0 42 | 0 2 | 0 41 | 0 1 | 0 94 | 19 0 | 0 62 | 3 6 | 0.52 | 0 48 |
| 18 | 0 40 | 0 0 | 0 40 | Nil | 0 90 | 17 0 | 0 61 | 3 2 | 0 52 | 0.45 |
| 19 | 0 38 | Nil | 0 40 | " | 0 85 | 14.0 | 0 60 | 2 9 | 0.51 | 0.38 |
| 20 | 0 37 | " | 0.40 | " | 0 80 | 11 0 | 0 60 | 2 8 | 0.51 | 0.40 |
| 21 | 0 39 | " | 0 38 | " | 0 77 | 9 7 | 0 60 | 2 9 | 0.51 | 0 38 |
| 22 | 0 36 | " | 0 37 | " | 0 75 | 8 9 | 0 59 | 2 6 | 0 51 | 0 37 |
| 23 | 0 35 | " | 0 40 | " | 0 78 | 10 0 | 0 60 | 2 5 | 0.50 | 0 29 |
| 24 | 0 35 | " | 0.39 | " | 0 79 | 10 0 | 0 60 | 2 5 | 0.50 | 0 28 |
| 25 | 0 35 | " | 0 39 | " | 0.80 | 11 0 | 0.58 | 2 1 | 0.49 | 0 22 |
| 26 | 0 36 | " | 0 38 | " | 0 80 | 11 0 | 0 58 | 2 0 | 0.48 | 0.19 |
| 27 | 0.39 | " | 0 38 | " | 0 79 | 10 0 | 0 57 | 1 7 | 0.47 | 0.14 |
| 28 | 0 37 | " | 0 38 | " | 0 78 | 10 0 | 0 56 | 1 5 | 0 46 | 0 11 |
| 29 | 0 38 | " | 0 38 | " | 0 76 | 9 3 | 0 57 | 1 7 | 0 46 | 0 09 |
| 30 | 0 40 | " | 0 38 | " | 0 76 | 9 3 | 0 57 | 1 6 | 0.47 | 0.10 |
| 31 | 0.38 | " | .... | ...... | 0 76 | 9 3 | ... | ... | 0 46 | 0 08 |

Gauge-heights for November and December interpolated.

MONTHLY DISCHARGE of Moosejaw Creek at McCarthy's Ranche, Sask., for 1911.

(Drainage area, 1790 square miles.)

| Month. | Discharge in Second-Feet. | | | | Run-Off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum | Mean. | Per square Mile. | Depth in inches on Drainage Area. | Total in Acre-feet. |
| March (19-31) | 72 0 | 0 70 | 31 90 | 0.0180 | 0 0090 | 8225 |
| April | 365 0 | 29 00 | 188 00 | 0.1060 | 0 1180 | 11187 |
| May | 123 0 | 2 00 | 37 80 | 0 0210 | 0 0240 | 2324 |
| June | 285 0 | 4 80 | 71 00 | 0 0390 | 0 0440 | 4225 |
| July | 21 0 | 0 50 | 2 80 | 0.0020 | 0 0020 | 172 |
| August | 0 8 | 0 00 | 0 21 | 0.0000 | 0 0000 | 13 |
| September | 0.4 | 0 00 | 0 08 | 0.0000 | 0 0000 | 5 |
| October | 39 0 | 0 00 | 11 50 | 0 0060 | 0 0070 | 707 |
| November (28 days) | 8 5 | 1 60 | 4 15 | 0.0020 | 0 0020 | 247 |
| December | 1 5 | 0 08 | 0 55 | 0 0003 | 0 0003 | 33 |
| The period | | | | | 2063 | 27138 |

MISCELLANEOUS DISCHARGE MEASUREMENTS of Moosejaw Creek Drainage Basin, in 1911.

| Date. | Hydrographer. | Stream. | Location. | Width. | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 14........ | J. C. Keith ..... | Moosejaw Creek | Sec. 34-16-26-2 | 35.5 | 33.74 | 1.540 | 52.07 |
| June 17........ | do .... | do | do | 35.5 | 15.040 | 0.977 | 14.70 |

## SOURIS RIVER DRAINAGE BASIN.

*General Description.*

The Source of Souris River is in marshes near Yellowgrass, Saskatchewan. From here it flows in a southeasterly direction, almost parallelling the Soo Line of the Canadian Pacific Railway to Estevan, where a loop crosses the International boundary in Range 34, west of the Principal Meridian. After making a loop into North Dakota it recrosses the International Boundary in Range 27, west of the Principal Meridian, and flows in a northeasterly direction to Souris, Manitoba, where it turns east and finally joins the Assiniboine River in Tp. 8, Rge. 16, W. 1st Mer.

This stream drains a large tract of typical Western Plains. The rain-fall will probably average very little over fifteen inches, and is usually sufficiently divided over the year to prevent excessive run-off, or floods. At times when there is an unusual amount of rain-fall and in the early spring, the water drains into the streams very rapidly and causes a flood of short duration.

There are towns, villages and farms all along the course of this stream and its tributaries which depend on it for a domestic and industrial water-supply. In North Dakota it has been proposed to divert water for irrigation purposes.

### LONG CREEK NEAR ESTEVAN, SASK.

This station was established on June 22, 1911, by J. C. Keith. It is located on the S.E. ¼ Sec. 10, Tp. 2, Rge. 8, W. 2nd Mer., and is about half a mile above the mouth of the creek and about two and a half miles south of the town of Estevan.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to the shore face of the first row of piles from the north end of the bridge. The zero of the gauge (elev., 83.87) is referred to a permanent iron bench-mark (assumed elev., 100.00) on the right bank near the end of the bridge.

The channel is straight for 100 feet above and below the station. Both banks are steep, but are liable to be flooded during very high stages of the stream. Both are also covered with brush. The bed of the stream is composed of clean gravel, which is not liable to shift. The current is sluggish.

During high water, discharge measurements are made from the bridge, but during low stages a wading section elsewhere, where the current is swifter, must be used. The initial point for soundings at the bridge is the inner face of the left abutment.

The gauge was read by Mr. George Pawson, but as only a few gaugings were made, the daily discharges cannot be computed.

DISCHARGE MEASUREMENTS of Long Creek near Estevan, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 22.......... | J. C. Keith.................. | 23.0 | 28.01 | 0.395 | 1.445 | 11.19x |
| July 18.......... | do .............. | 10.5 | 2.80 | 0.610 | 0.810 | 1.71* |
| Aug. 23 ......... | do .............. | 5.6 | 1.44 | 0.430 | 0.720 | 0.62* |
| Oct. 18 ......... | do .............. | 34.5 | 116.13 | 0.750 | 3.350 | 86.80§ |

x Gauge established.
* Measured at wading section.
Measured at Pawson's bridge.

MEAN DAILY GAUGE HEIGHT, in feet, of Long Creek near Estevan, Sask., for 1911.

| Day. | June. | July. | August. | Sept. | Oct. |
|---|---|---|---|---|---|
| 1 | | 1.16 | 0.69 | 0.69 | 0.75 |
| 2 | | 1.10 | 0.69 | 0.68 | 0.95 |
| 3 | | 1.08 | 0.80 | 0.67 | 0.93 |
| 4 | | 1.06 | 0.76 | 0.67 | 0.90 |
| 5 | | 1.04 | 0.75 | 0.69 | 0.86 |
| 6 | | 0.99 | 0.75 | 0.61 | 0.82 |
| 7 | | 0.95 | 0.74 | 0.72 | 0.82 |
| 8 | | 1.03 | 0.71 | 0.75 | 0.79 |
| 9 | | 0.95 | 0.74 | 0.72 | 0.76 |
| 10 | | 0.95 | 0.74 | 0.70 | 0.76 |
| 11 | | 0.92 | 0.71 | 0.67 | 0.75 |
| 12 | | 0.90 | 0.73 | 0.67 | 0.75 |
| 13 | | 0.85 | 0.72 | 0.67 | 0.75 |
| 14 | | 0.83 | 0.72 | 0.67 | 0.75 |
| 15 | | 0.85 | 0.72 | 0.67 | 0.73 |
| 16 | | 0.83 | 0.82 | 0.68 | 0.73 |
| 17 | | 0.81 | 0.80 | 0.68 | 3.20 |
| 18 | | 0.81 | 0.78 | 0.68 | 3.40 |
| 19 | | 0.85 | 0.76 | 0.68 | 3.20 |
| 20 | | 0.82 | 0.75 | 0.69 | 3.04 |
| 21 | | 0.80 | 0.76 | 0.71 | 2.90 |
| 22 | 1.44 | 0.76 | 0.75 | 0.71 | 2.75 |
| 23 | 1.44 | 0.81 | 0.72 | 0.74 | 2.62 |
| 24 | 1.44 | 0.79 | 0.71 | 0.81 | 2.48 |
| 25 | 1.42 | 0.75 | 0.71 | 0.76 | 2.35 |
| 26 | 1.39 | 0.71 | 0.71 | 0.76 | 2.25 |
| 27 | 1.36 | 0.71 | 0.73 | 0.75 | 2.20 |
| 28 | 1.35 | 0.71 | 0.72 | 0.76 | 2.13 |
| 29 | 1.29 | 0.70 | 0.71 | 0.84 | 1.95 |
| 30 | 1.21 | 0.70 | 0.71 | 0.75 | 1.90 |
| 31 | | 0.69 | 0.90 | | |

## SOURIS RIVER NEAR ESTEVAN, SASK.

This station was established on June 23, 1911, by J. C. Keith. It is located about 50 feet below the Canadian Pacific Railway Company's dam on the N.E. ¼ Sec. 11, Tp. 2, Rge. 8, W. 2nd Mer., and is about two miles south and three-quarters of a mile east of the town of Estevan, and about three-quarters of a mile below the mouth of Long Creek.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a heavy timber sunk in, and anchored to, the left bank. The zero of the gauge (elev., 82.45) is referred to a permanent iron bench-mark (assumed elev., 100.00) on the right bank and about 47 feet southeast of the end of the Canadian Pacific Railway dam.

The channel is straight for about 100 feet above and below the gauge. Both banks are steep, but become submerged in very high water. Both are also covered with brush. The bed of the stream is covered with cinders from the Canadian Pacific Railway power-house and is hard and permanent.

Discharge measurements can be made only by wading at the gauge, as the cross-sections at the bridges in that locality are affected by back-water. The flood discharge is estimated by use of suitable weir formulae for the dam above.

The gauge was read by Mr. William Bevan, but as only a few discharge measurements were made the daily discharges cannot be computed.

DISCHARGE MEASUREMENTS of Souris River near Estevan, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 23 | J. C. Keith.......... | 14.4 | 7.61 | 1.59 | 1.36 | 12.130x |
| July 18 | do | 10.0 | 2.64 | 1.17 | 0.98 | 3.100x |
| Aug 23 | do | 7.1 | 1.43 | 0.69 | 0.79 | 0.995x |

x Measured 50 feet below C.P.R. dam.

Mean Daily Gauge Height, in feet, of Souris River near Estevan, Sask., for 1911.

| Day. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|
| 1 | | 1.08 | 0.75 | 0.74 | 1.08 | 2.05 |
| 2 | | 1.02 | 0.75 | 0.75 | 1.10 | 2.04 |
| 3 | | 1.00 | 0.88 | 0.76 | 1.60 | 2.00 |
| 4 | | 1.00 | 0.90 | 0.76 | 1.65 | 1.90 |
| 5 | | 0.94 | 0.88 | 0.74 | 1.64 | 1.87 |
| 6 | | 0.90 | 0.90 | 0.77 | 1.60 | 1.64 |
| 7 | | 0.89 | 0.91 | 0.76 | 1.50 | 1.48 |
| 8 | | 1.70 | 0.93 | 0.78 | 1.50 | 1.40 |
| 9 | | 1.67 | 0.89 | 0.81 | 1.48 | 1.40 |
| 10 | | 1.37 | 0.88 | 0.81 | 1.40 | 1.38 |
| 11 | | 1.07 | 0.86 | 0.82 | 1.35 | 1.35 |
| 12 | | 1.03 | 0.85 | 0.86 | 1.30 | 1.34 |
| 13 | | 1.00 | 0.83 | 0.86 | 1.28 | 1.30 |
| 14 | | 0.97 | 0.81 | 0.88 | 1.26 | 1.28 |
| 15 | | 0.97 | 0.85 | 0.87 | 1.22 | 1.27 |
| 16 | | 0.97 | 1.04 | 0.87 | 1.20 | |
| 17 | | 0.91 | 1.00 | 0.89 | 3.20 | |
| 18 | | 0.98 | 0.91 | 0.90 | 3.30 | |
| 19 | | 0.98 | 0.92 | 0.90 | 3.34 | |
| 20 | | 0.99 | 0.86 | 0.92 | 3.10 | |
| 21 | | 0.99 | 0.85 | 0.93 | 3.10 | |
| 22 | | 1.01 | 0.82 | 0.95 | 3.05 | |
| 23 | 1.37 | 1.02 | 0.79 | 0.95 | 3.01 | |
| 24 | 1.35 | 1.00 | 0.78 | 0.95 | 2.96 | |
| 25 | 1.50 | 0.98 | 0.76 | 0.97 | 2.87 | |
| 26 | 1.40 | 0.87 | 0.75 | 0.98 | 2.72 | |
| 27 | 1.37 | 0.87 | 0.79 | 1.00 | 2.40 | |
| 28 | 1.37 | 0.84 | 0.76 | 1.02 | 2.15 | |
| 29 | 1.32 | 0.84 | 0.75 | 1.04 | 2.12 | |
| 30 | 1.20 | 0.76 | 0.77 | 1.07 | 2.10 | |
| 31 | | 0.76 | 0.74 | | 2.10 | |

## Souris River near Glen Ewen, Sask.

This station was established on June 26, 1911, by J. C. Keith. It is located near D. F. Preston's house on the N.E. ¼ Sec. 36, Tp. 2, Rge. 1, W. 2nd Mer., and is about three miles south and half a mile east of Glen Ewen.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a post sunk in the bed of the stream at the left bank. The zero (elev., 79.98) is referred to a permanent iron bench-mark (assumed elev., 100.00) on the left bank and within a few feet of the gauge.

The channel is slightly curved for some distance above and below the gauge. Both banks are steep, but will overflow in very high stages of the stream. Both are partly covered with woods. The bed of the stream is composed of clean sand and gravel, and may shift during high water. Beavers may affect the records at the gauge by building dams and causing back-water.

Discharge measurements are made during ordinary stages by wading at a point about 400 yards below the gauge. During high-water stages, they are made at the traffic bridge on the road allowance east of Sec. 2, Tp. 3, Rge. 1, W. 2nd Mer.

The gauge was read by Mr. D. F. Preston, but as only a few gaugings were made, there are not sufficient data to compute the daily discharge.

Discharge Measurements of Souris River near Glen Ewen, Sask., in 1911.

| Date. | Hydrographer. | Width. | Area of Section | Mean Velocity | Gauge Height. | Discharge |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 26 | J. C. Keith. | 49.0 | 52.89 | 0.51 | 2.000 | 27.090x |
| July 19 | do | 30.5 | 14.80 | 0.86 | 1.755 | 12.730 |
| Aug. 24 | do | 29.0 | 10.54 | 0.50 | 1.630 | 5.257 |
| Oct. 19 | do | 45.5 | 31.17 | 1.07 | 2.350 | 33.520* |

x Gauge established.
* Gauged at ford.

Mean Daily Gauge Height, in feet, of Souris River near Glen Ewen, Sask., for 1911.

| Day. | June. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|
| 1 | | | 1.62 | 1.57 | 2.06 | 2.42 |
| 2 | | 2.05 | 1.66 | 1.56 | 2.08 | 2.52 |
| 3 | | 1.98 | 1.70 | 1.58 | 2.26 | 2.40 |
| 4 | | 1.95 | 1.75 | 1.57 | 2.40 | 2.34 |
| 5 | | 1.86 | 1.85 | 1.57 | 2.43 | 2.31 |
| 6 | | 1.85 | 1.79 | 1.58 | 2.42 | 2.33 |
| 7 | | 1.79 | 1.77 | 1.58 | 2.50 | 2.32 |
| 8 | | 1.79 | 1.75 | 1.58 | 2.50 | 2.29 |
| 9 | | 1.76 | 1.78 | 1.61 | 2.45 | 2.17 |
| 10 | | 1.69 | 1.83 | 1.67 | 2.50 | 2.28 |
| 11 | | 1.67 | 1.83 | 1.68 | 2.50 | 2.25 |
| 12 | | 1.66 | 1.82 | 1.70 | 2.47 | 2.24 |
| 13 | | 1.65 | 1.83 | 1.73 | 2.45 | 2.28 |
| 14 | | 1.65 | 1.85 | 1.77 | 2.45 | 2.23 |
| 15 | | 1.64 | 1.83 | 1.76 | 2.45 | 2.20 |
| 16 | | 1.64 | 1.79 | 1.77 | 2.44 | |
| 17 | | 1.64 | 1.78 | 1.75 | 2.40 | |
| 18 | | 1.70 | 1.77 | 1.75 | 2.36 | |
| 19 | | 1.74 | 1.75 | 1.76 | 2.35 | |
| 20 | | 1.73 | 1.70 | 1.87 | 2.34 | |
| 21 | | 1.72 | 1.69 | 1.91 | 2.31 | |
| 22 | | 1.70 | 1.68 | 1.95 | 2.34 | |
| 23 | | 1.75 | 1.65 | 2.00 | 2.79 | |
| 24 | | 1.75 | 1.64 | 2.00 | 2.85 | |
| 25 | | 1.76 | 1.63 | 2.04 | 2.83 | |
| 26 | 2.00 | 1.75 | 1.57 | 2.02 | 2.80 | |
| 27 | 1.98 | 1.75 | 1.57 | 2.05 | 2.79 | |
| 28 | 1.96 | 1.70 | 1.57 | 2.06 | 3.04 | |
| 29 | 2.05 | 1.69 | 1.56 | 2.02 | 2.55 | |
| 30 | 2.10 | 1.66 | 1.57 | 2.05 | 3.00 | |
| 31 | 2.11 | 1.62 | 1.57 | | 2.49 | |

## Souris River near Melita, Man.

This station was established on July 20, 1911, by J. C. Keith. It is located at the traffic bridge on Sec. 6, Tp. 4, Rge. 26, W. 1st Mer.

The gauge, which is a plain staff graduated to feet and hundredths, is nailed to a pile on the downstream side of the bridge. The zero of the gauge (elev., 84.02) is referred to a permanent iron bench-mark (assumed elev., 100.00), on the right bank about fifty feet from the end of the bridge.

The channel is straight for a distance above the station, but curves to the right a short distance below. The banks are high and partly wooded. The bed of the stream is composed of clean sand and gravel, which may shift during high water.

Discharge measurements are made from the bridge, except during extreme low water, when they are made by wading.

The gauge was read by Mrs. Andrew Lawson, but as only a few gaugings were made, the daily discharges cannot be computed.

Discharge Measurements of Souris River at Melita, Man., in 1911.

| Date. | Hydrographer. | Width. | Area of Section. | Mean Velocity. | Gauge Height. | Discharge. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 30 | J. C. Keith | 76.0 | 137.70 | 0.410 | 2.02 | 56.45* |
| July 20 | do | 72.0 | 107.65 | 0.230 | 1.55 | 24.83* |
| Aug. 25 | do | 52.0 | 48.25 | 0.704 | 1.57 | 33.96 |
| Oct. 20 | do | 54.0 | 45.16 | 0.890 | 1.62 | 40.39x |

x Measured at wading section.
* Measured at bridge.

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Mean Daily Gauge Height, in feet, of Souris River at Melita, Man, for 1911.

| Day. | July. | August. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|
| 1 | | 1.40 | 1.66 | 1.98 | 1.51 |
| 2 | | 1.41 | 1.66 | 1.99 | 1.51 |
| 3 | | 1.42 | 1.68 | 2.00 | 1.51 |
| 4 | | 1.70 | 1.68 | 2.00 | 1.51 |
| 5 | | 169 | 1.68 | 2.00 | 1.51 |
| 6 | | 1.55 | 1.68 | 2.00 | 1.51 |
| 7 | | 1.56 | 1.68 | 2.00 | 1.51 |
| 8 | | 1.59 | 1.69 | 1.82 | 1.51 |
| 9 | | 1.57 | 1.69 | 1.82 | 1.51 |
| 10 | | 1.57 | 1.69 | 1.81 | 1.51 |
| 11 | | 1.56 | 1.62 | 1.80 | 1.51 |
| 12 | | 1.55 | 1.64 | 1.80 | 1.51 |
| 13 | | 1.52 | 1.69 | 1.80 | 1.51 |
| 14 | | 1.50 | 1.70 | 1.85 | 1.51 |
| 15 | | 1.50 | 1.80 | 1.76 | 1.51 * |
| 16 | | 1.51 | 1.86 | 1.75 | |
| 17 | | 1.52 | 1.89 | 1.73 | |
| 18 | | 1.52 | 1.87 | 1.70 | |
| 19 | | 1.51 | 1.87 | 1.66 | |
| 20 | 1.55 | 1.60 | 1.88 | 1.62 | |
| 21 | 1.54 | 1.59 | 1.87 | 1.56 | |
| 22 | 1.56 | 1.59 | 1.88 | 1.59 | |
| 23 | 1.58 | 1.57 | 1.88 | 1.57 | |
| 24 | 1.53 | 1.57 | 1.65 | 1.57 | |
| 25 | 1.50 | 1.57 | 1.65 | 1.55 | |
| 26 | 1.49 | 1.57 | 1.66 | 1.55 | |
| 27 | 1.48 | 1.59 | 1.66 | 1.55 | |
| 28 | 1.46 | 1.62 | 1.66 | 1.53 | |
| 29 | 1.46 | 1.66 | 1.66 | 1.54 | |
| 30 | 1.40 | 1.66 | 1.68 | 1.52 | |
| 31 | 1.40 | 1.67 | | 1.52 | |

Miscellaneous Discharge Measurements of Souris Drainage Basin, in 1911.

| Date. | Hydrographer | Stream. | Location. | Width | Area of Section. | Mean Velocity. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Sq. Feet.* | *Feet per Sec.* | *Sec.-Ft.* |
| June 27 | J. C. Keith | Graham Creek | Sec. 2-4-27-1 | | | | * 0.070 |
| June 24 | do | Moose Mountain Creek | Sec. 22-3-2-2 | 39.5 | 17.69 | 0.61 | 10.830 |
| June 27 | do | North Antler Creek | Sec. 3-3-1-2 | 1.6 | 0.17 | 0.35 | 0.060 |
| June 27 | do | South Antler Creek | Sec. 6-3-32-1 | 3.3 | 0.53 | 0.67 | 0.359 |

* Approximate.

# APPENDIX No. 1.

## REPORT ON THE FIELD-WORK IN THE WOOD MOUNTAIN DISTRICT, DURING 1911, BY N. M. SUTHERLAND, DISTRICT HYDROGRAPHER.

On May 23, 1911, I proceeded to Maple Creek, Saskatchewan, where I received my camp outfit including horses, etc., from Mr. R. J. Burley.

One June 6th we left Maple Creek and proceeded along the Canadian Pacific Railway to Swift Current, arriving there on June 10th. At Swift Current, we met Mr. P. M. Sauder and accompanied by him, we left Swift Current on June 11th.

We at first travelled south from Swift Current and inspected Pierce, Notukeu and Bull Creeks. There are small flats along these creeks which are suitable for irrigation, and during dry years require irrigation to grow a crop. The water-supply in this district, however, is very limited. When the snow is melting, or during periods of heavy and continuous rain, there are small floods, but in a dry year, as near as can be learned from the older settlers, the flow in these streams gradually diminishes and stops altogether early in the summer. We did not establish any regular stations or gauge-rods at any of these creeks, as at Pierce Creek the only available place to gauge it was some three miles from Mr. Pierce's house, and at Notukeu and Bull Creeks the land is homesteaded but there is no one with permanent residence, and, therefore, no gauge-rod readers were available.

From Bull Creek we proceeded to Huff's ranche on the Frenchman River and re-established the gauge on N.W. ¼ Sec. 5, Tp 5, Rge. 14, W. 3rd Mer. From Huff's ranche we followed the north shore of the Frenchman River to Seventy Mile crossing in Sec. 32, Tp. 3, Rge. 13, W. 3rd Mer., where we crossed the river, and after following the south shore for a couple of miles pulled west out on the bench, and did not touch the river again until we crossed it in Sec. 4, Tp. 1, Rge. 10, W. 3rd Mer., near the International Boundary. Along the Frenchman River there are large flats, which are quite suitable for irrigation, but there is little opprotunity of storing water. Most of the level land has been filed on by homesteaders.

Following the International Boundary towards the east, we crossed a very rolling prairie which is quite suitable for ranching and grazing purposes. There are a number of streams flowing south and southeast, which had water in pools. From what we could learn from the older settlers, these streams remain in this condition almost every summer but do not have any flow except during the spring freshets.

The streams were all of this nature until we reached Rocky Creek in Tp. 1, Rge. 6, west of the 3rd Meridian. This creek had a flow of over three second-feet, is fed by some very strong springs and drains several townships. It has a constant flow and would probably irrigate several hundred acres. Near the International Boundary this stream traverses a large flat of several hundred acres which could be irrigated. After following upstream for a few miles we found that Rocky Creek passed through "bad lands," which were impassable with a wagon. We therefore left the creek and turned northeastward and after crossing a very hilly district, quite suitable for ranching and grazing purposes, we crossed Rocky Creek in Sec. 18, Tp. 2, Rge. 4, W 3rd Mer. In this locality the creek flows though a narrow valley, with little opportunity to irrigate. Rainy weather had made travelling very difficult, and, as our supply of oats and food was almost exhausted, we decided to go to Wood Mountain for supplies. On reaching there we found that there was no store and we could not get either groceries or oats. It was therefore decided to leave the boundary line and inspect Wood River.

One branch of Wood River rises near Wood Mountain post office. This had almost ceased flowing, but a rainstorm started a very small flow while we were there. There was a small flow into Twelvemile Lake, but no overflow. Following this branch of Wood River, which had a little water in pools, we reached the main stream on Sec. 6, Tp. 8, Rge. 5, W. 3rd Mer., near Capital post office, and inspected it at several points between Capital and Lake Johnston. There is only a very small flow in this stream, and, as it has a very small fall, there is scarcely any current at all. It was impossible to find a place where a meter could be used near Capital. We made a slope measurement, but, owing to the dense growth of grass in the channel, the results were very unsatisfactory. We made a gauging on Sec. 31, Tp. 10, Rge. 4, W. 3rd Mer. near Gravelbourg and found the discharge to be about 6.5 second-feet, but it was impossible to gauge the river near Lake Johnston.

Wood River has a very small fall and is more of the nature of a long slough than that of a running stream. The channel is from twenty to fifty feet wide, and is from two to five feet deep. The bottom is composed of soft clay and is covered with weeds and grass. There is so little fall that it would be impossible to take out water by gravity, and a dam would flood a large area of good agricultural land. The drainage basin includes a very good agricultural district, but there is little possibility of irr'gation development. Notukeu Creek had a small flow near its mouth, but Pinto and Wiwa Creeks were practically dry at their mouths. There was no flow at all from Lake Chaplin to Lake Johnston and there has not been for several years.

Mr. Sauder left the party at Courval post office on June 28th. Following Mr. Sauder's instructions, I proceeded north to Morse and then to Swift Current.

From Swift Current we proceeded south over the same route as that followed on the previous occasion as far as Seventy Mile crossing, in Tp. 3, Rge. 13, W. 3rd Mer. On this occasion we struck east from Seventy Mile for several miles and then south, coming to the Frenchman River in Sec. 34, Tp. 2, Rge. 12, W. 3rd Mer., We crossed the river here and followed the west shore to McArthur's ranche on Sec. 18, Tp. 2, Rge. 11, W. 3rd Mer. Here we left the river and struck southeast across the bench until we reached the boundary line and then east to the river. We passed several coulees running into the Frenchman river in Tp. 2, Rges. 11 and 12, but none had running water.

Leaving Frenchman River we proceeded east along the boundary line over the same route as on the previous occasion as far as Rocky Creek in Sec., Tp. 1, Rge. 6, W. 3rd Mer. From here we followed east, touching the west branch of Poplar River in Sec. 5, Tp. 1, Rge. 3, W. 3rd Mer., and the centre or main fork of Poplar River in Sec. 8, Tp. 1, Rge. 29, W. 2nd Mer. The west branch of Poplar River had a very small flow of about 0.08 second-feet. It resembles Wood River in many ways being from 30 to 75 feet wide and is from two to three feet deep. It is full of weeds and is very sluggish. The main fork of Poplar River is also sluggish in many places. The banks are very low for some distance on both sides of it, and are probably covered with water during the early spring. The discharge of this stream was 0.8 second-feet.

On account of running short of provisions we travelled north from Poplar River to Willowbunch, where, on account of my teamster giving notice of leaving, I decided to return to Swift Current.

From Willowbunch we followed the Pole trail to Wood Mountain and then took the old police or Hudson Bay trail to Seventy Mile crossing. From Willowbunch to Wood Mountain we did not pass any streams, though there is considerable moisture supplied by springs. On leaving Wood Mountain we travelled by a good trail over a rolling country which brought us across the head-waters of Wood River, which consist of about 12 creeks running north and northeast. Of these creeks only four had running water in them, and, as the country is rolling, there is little possibility of irrigation. Leaving the head-waters of Wood River we crossed the head-waters of several creeks running south into Frenchman River. These were following deep coulees but did not have any flow. Apparently the only time of the year that these creeks run is during the time that the snow is melting or during very heavy rains. From Seventy Mile crossing we travelled north to Notukeu Creek by way of Huff's ranche, following the same trails as we did travelling south. We then travelled along Notukeu Creek to N.E. ¼ Sec. 29, Tp. 9, Rge. 12, W. 3rd Mer., passing Pierce Creek on the way. Pierce Creek had a very small flow at its mouth, but I do not think that this flow would be added to if Mr. Pierce were to discontinue using the north fork of this creek for irrigation purposes. The flow above his head-gates is very small and would in all probability disappear before reaching Notukeu Creek. After leaving Sec. 29, Tp. 9, Rge. 12, W. 3rd Mer., we travelled north to the head-waters of Whisky (or Russell) Creek in Sec. 36, Tp. 11, Rge. 13, W. 3rd Mer. This had a discharge of 1.5 second-feet, but there is little possibility of irrigation. From this point we travelled northwest to Swift Current and did not pass any further streams on the way.

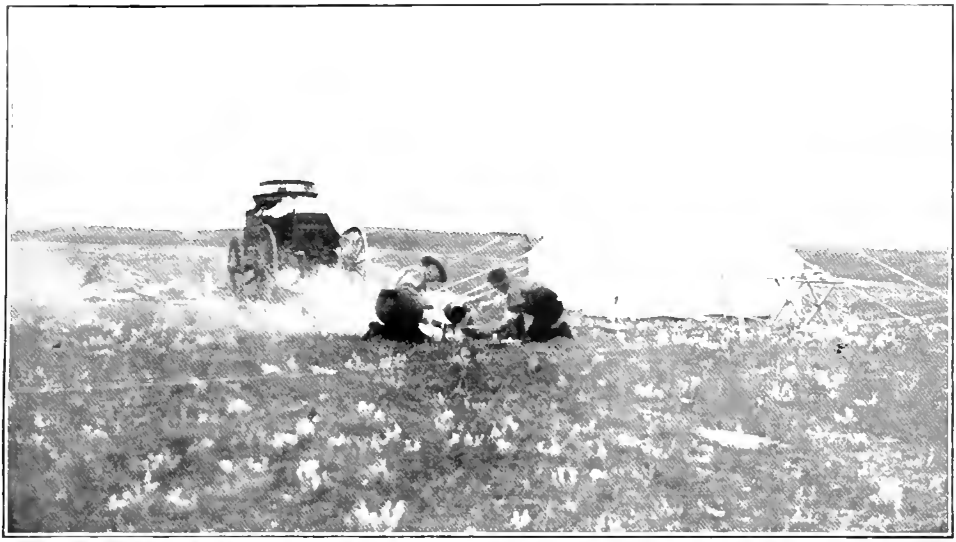
After obtaining another teamster I again left Swift Current and travelled south to Frenchman river at the boundary line, inspecting Pierce, Notukeu and Bull Creeks on the way, also Frenchman River at Huff's ranche. We followed the same route as on the previous occasion with the exception that when travelling from Seventy Mile crossing to the boundary line we followed the west shore of Frenchman River as far as Heinrich's ranche in Tp. 1, Rge. 11, W. 3rd Mer., before striking on to the bench. There are flats along the Frenchman River between McArthur's ranche and Heinrich's ranche which could probably be irrigated by storing waters in the coulees which run into Frenchman river.

From Frenchman River we followed the boundary line over the same route as on the former trip as far as Poplar River, inspecting Rocky Creek and others crossed on the previous occasions. Levels were run on Rocky Creek and the West Branch of Poplar River. The fall in Rocky Creek taken in Sec. 5, Tp. 1, Rge. 6, W. 3rd Mer., is 2.225 feet per mile; that in the West Branch of Poplar River in Sec. 5, Tp. 1, Rge. 3, W. 3rd Mer., is 0.5 feet per mile.

From Poplar River (Sec. 1, Tp. 1, Rge. 29, W. 2nd Mer.) we continued east over a very rough rolling prairie, crossing the East Fork of Poplar River in Sec. 4, Tp. 1, Rge. 26, W. 2nd Mer. This river has a large flat on it in Tp. 1, Rge. 26, W. 2nd Mer., which could be irrigated. The discharge of the river on August 23rd was 4.98 second-feet. The country between ranges 25 and 23 was so rough that we had to travel some distance south of the boundary line. No streams were passed until we reached Beaver Creek in Sec. 5, Tp. 1, Rge. 23, W. 2nd Mer., which had a flow of 0.539 second-feet. The country around Beaver Creek is very rolling and unsuitable for irrigation. We continued east until we reached Sec. 4, Tp. 1, Rge. 22, W. 2nd Mer., and, striking a good trail here leading to Plentywood, Montana, and being about out of oats and provisions, we decided to go there to replenish our supply.

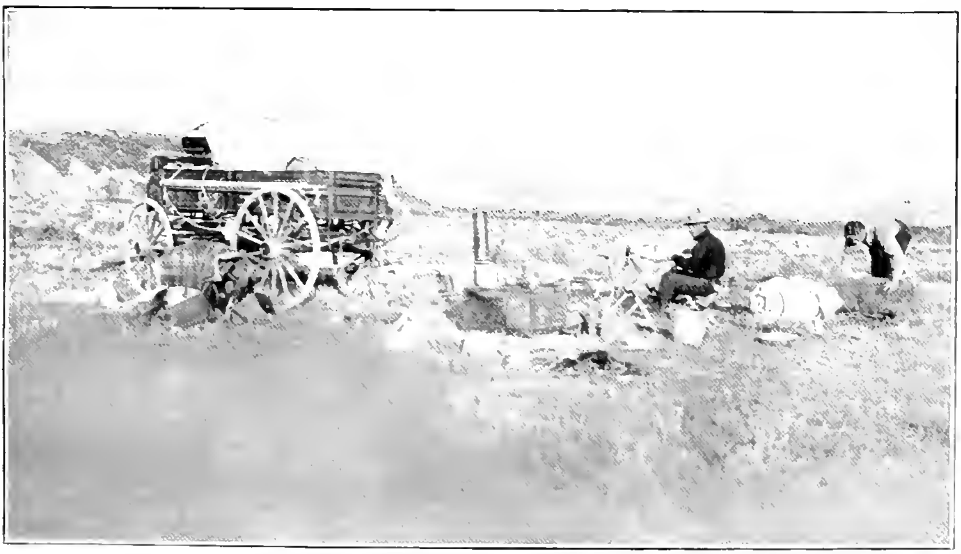
From Plentywood we travelled due north to the boundary line at Sec. 1, Tp. 1, Rge. 21, W. 2nd Mer., and from here to Bigmuddy police detachment, in Sec. 10, Tp. 1, Rge. 22, W. 2nd Mer.

PLATE No. 34.



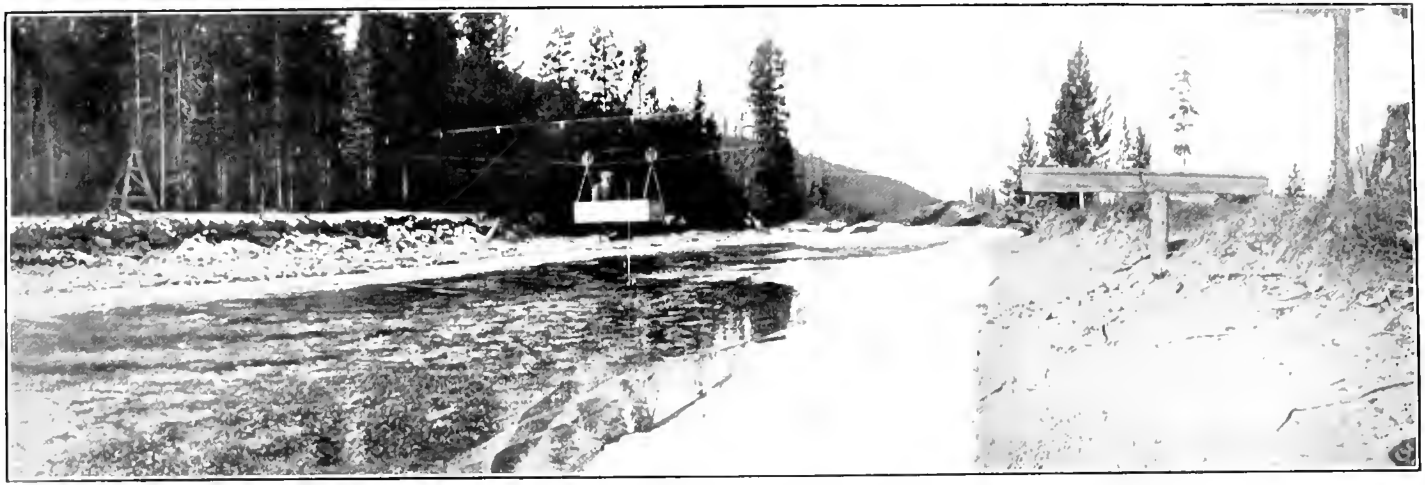
Wood Mountain Party Cooking Breakfast. Taken by P. M. Sauder.

PLATE No. 35.



Wood Mountain Party Breaking Camp. Taken by P. M. Sauder.

PLATE No. 36.



Gauging Station on Bow River at Laggan in early Fall. Taken by V. A. Newhall.

PLATE NO. 37.

Gauging Station on Bow River at Laggan in Winter. Taken by V. A. Newhall

Plate No. 38.

Gauging Station on Pipestone River near Laggan in early Fall. Taken by V. A. Newhall.

PLATE No. 39.

Gauging Station on Pipestone River near Laggan in Winter. Taken by V. A. Newhall.

There is a large flat here of heavy soil which leads from Bigmuddy Lake. We followed this flat until we came to the lake and found that there is a very great deal of alkali both at the lake and all along the valley. Leaving Bigmuddy Lake we travelled west crossing the head-waters of Beaver Creek in Tp. 2, Rge. 24, W. 2nd Mer. The country was very rolling and the creeks were either dry or had water standing in pools; none were flowing. On striking the trail to Willowbunch we followed it until we reached the town.

From Willowbunch we travelled southwest to Fife Lake and then to J. M. Knox's ranche in Sec. 28, Tp. 3, Rge. 3, W. 2nd Mer. We passed Hay Meadow Creek which has a very large flat along it, and had a discharge of 13.26 second-feet. This, however, was taken after a very heavy rain, and the normal discharge of the creek is very probably somewhat less. At J. M. Knox's place there is a large flat which covers the greater part of the N.W. and S.W. quarters of Sec. 28, Tp. 3, Rge. 30, W. 2nd Mer. In a coulee in Sec. 29, Tp. 3, Rge. 30, W. 2nd Mer., there is a large spring which could be used to irrigate the land owned by Mr. Knox. Owing to the porous nature of the soil, which is of a heavy sandy loam, the water from this spring disappears in the N.W. ¼ Sec. 28, Tp. 3, Rge. 30, W. 2nd Mer. Although the country is very hilly for some miles west and south of this point, and is probably more suitable for ranching purposes than for agricultural, there are numerous springs throughout the district which lead into small flats which could with small expense be irrigated. Many of the settlers in this district are from the western states and have used irrigation previous to the time of their coming to Canada to live. We made a short trip to a small creek in Sec. 2, Tp. 4, Rge. 1, W. 3rd Mer., which had a discharge of 0.994 second-feet; there are small flats of about ten acres each which could be irrigated. From J. M. Knox's place we travelled to Mr. Franks' place in Sec. 17, Tp. 4, Reg. 1, W. 3rd Mer. There is a fine large spring in the S.W. ¼ Sec. 17, Tp. 4, Rge. 1, W. 3rd Mer., which forms the head-waters of Hay Meadow Creek. The fall for several hundred feet from the spring is one foot in one hundred feet. Mr. Franks could use this spring to irrigate about ten acres in the quarter-section south of him. From this point we travelled to Wood Mountain and then followed the same route, as we did while Mr. Sauder was with us, as far as Lynthorp in Sec. 1, Tp. 7, Rge. 4, W. 3rd Mer., taking gaugings of Wood Creek in Sec. 20, Tp. 4, Reg. 3, W. 3rd Mer., and near its mouth at Twelve Mile Lake in Sec. 4, Tp. 6, Rge. 3, W. 3rd Mer. At the latter point the discharge was 4.36 second-feet. This rather large flow was caused by recent heavy rains.

From Lynthorp we travelled northwest to Gravelbourg, crossing Wood River in N.W. ¼ Sec. 18, Tp. 10, Rge. 4, W. 3rd Mer. There is a very good cross-section at this point, and it is the only good place to take gaugings which we met with along Wood River. The discharge here was 5.21 second-feet. Levels were run along Wood River in Sec. 31, Tp. 10, Rge. 4, W. 3rd Mer., which gave a fall of but 0.5 feet per mile. While at Gravelbourg we made a trip north, crossing Notukeu and Wiwa Creeks, and touched Wood River in Sec. 4, Tp. 13, Rge. 4, W. 3rd Mer. On account of the river being very low, the result obtained at the latter point was poor.

On leaving Gravelbourg we travelled west along the township line between Townships 10 and 11 as far as Notukeu creek in Sec. 5, Tp. 11, Rge. 10, W. 3rd Mer. The discharge here was 11.76 second-feet. Striking north, we crossed Russell Creek near its mouth at Sec. 17, Tp. 11, Rge. 10, W. 3rd Mer. (discharge 1.183 second-feet), and Mosquito Creek in Sec. 20, Tp. 11, Rge. 10, W. 3rd Mer. From this latter creek we travelled northwest to Swift Current. On September 18th, I took the transport and camp equipment to Maple Creek, disposing of it there as per instructions.

With regard to further work in the Wood Mountain district, there is little possibility of irrigation developments outside of the Frenchman River, Rocky Creek, and some very small schemes in the townships on the west side of Fife Lake, and I do not consider that further date in this district are of sufficient importance to warrant the expense of keeping an outfit in this district another year.

# APPENDIX No. 2.

## REPORT ON THE WINTER CONDITIONS IN THE BANFF DISTRICT DURING THE WINTER OF 1911–12, BY V. A. NEWHALL, B.A.Sc., DISTRICT HYDROGRAPHER.

In this district winter work was begun shortly after the severe cold spell in the early part of November. Prior to this, great trouble was experienced with floating slush, and anchor ice. In all the mountain streams anchor ice forms on the stones and boulders in the river-bottom before surface ice forms. The swiftly flowing water probably breaks any ice crystals forming on the surface, where the air is in contact with the water, while in the river-bottom crystals can adhere to the rough surfaces of the boulders and rock fragments. On many streams this floating mass was in such quantities that not only was the meter stopped but was even in danger of having stay-line and cable broken and carried away.

The severe cold weather created a surface ice at the stations having low velocities. This was the case on the Bow River at Morley.

Bow River at Morley had ice formed on it, then slush ice packed underneath, so that the meter could not revolve. This condition continued until the station was abandoned at the close of 1911.

Bow and Pipestone Rivers, at Laggan, were blocked by an ice-jam, so that the stations had to be temporarily abandoned. The cross-sections at these stations were later cut open in trenches three feet wide and down to the water, which was four to five feet below the top of ice. The difficulty experienced with such conditions as these is that the lowest ice surface—that in contact with the water—is composed of ice fragments, which deflect the water and disturb the stream-lines, so causing velocities that are the result of eddies and currents.

Bath Creek, at Laggan, flowed open during the entire winter season.

Bow River, at Banff, was ice-covered at the gauging section only once during the winter. At other times shore ice extended fifteen feet from each side, but this was cleared away to give open-water conditions.

On the Spray, Ghost and Kananaskis Rivers, ice formed at the sides, but owing to their high velocities these streams were kept open in the centre, until later in the season.

Devils Creek and Cascade River were both influenced by the construction of the dam controlled by the Calgary Power Company. The gauging station on Devils Creek had the ice cleared away by the huge flow that was continued for a day and a half, while the overflooding of the ice at the Cascade station, together with the ice cakes that jammed there, made it impossible to get a reliable gauging. If such an amount of water is released during a "hard" winter, when the snow is deep and the quantity of ice great, the Cascade station will be rendered useless again,

The foregoing give the conditions as they were in general, though at every visit some variation might be noted.

Gauge-height records under such conditions are practically valueless, as the water may be backed by a jam or raised by a thicker ice-formation. This latter should be explained by stating that in all swiftly flowing streams the ice forms in an arch, the greatest thickness being at the shores; hence ice formation crowds the water higher in the centre. Ice so formed influences gauge-heights when a thaw comes, the water melting the ice at the sides, thus making a greater flow, though an apparent drop or very small increase may be observed on the gauge. To obtain gauge-height records of winter flow where the section is poor would mean clearing away, by sawing or cutting, the rough ice that formed, for a width of about twenty-five feet across the entire section, to permit a new and better formation, but this is too expensive for records, which even then would not always be reliable.

A great trouble experienced in gauging when the temperature is more than twelve degrees below zero is the formation of ice on the meter, hindering the ready revolution of the cups and necessitating repeated warming. If the surface ice is covered with snow this seems to serve as a protective covering and reduces the escape of the heat in the water, by conduction, through the ice to the air. Much trouble lies in the bending of the electric cable when ice-coated. A break should usually be sought in this section before wasting time seeking elsewhere.

With regard to cutting tools three are necessary, namely ice-axe, ice-chisel and shovel, while a fourth, an ice-needle, is useful when breaking ice underneath water.

# APPENDIX No. 3.

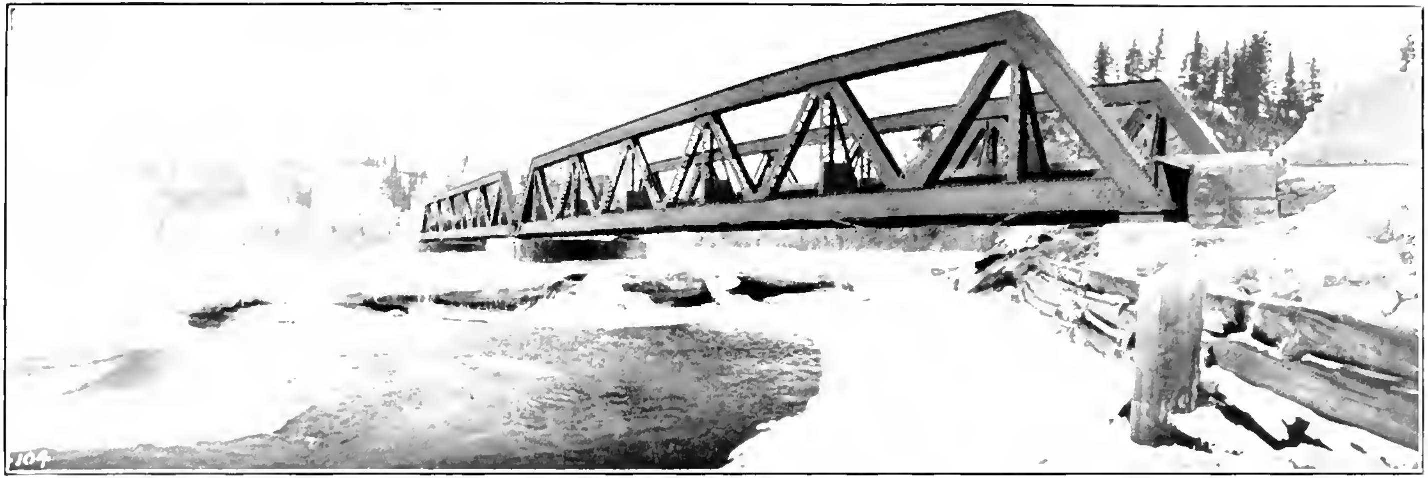
## DESCRIPTION OF AN APPARATUS FOR ADJUSTING THE LENGTH OF THE CREST OF A STEEL RECTANGULAR WEIR TO ANY DESIRED LENGTH, USED IN THE EASTERN CYPRESS HILLS DISTRICT, BY G. H. WHYTE, DISTRICT HYDROGRAPHER.

In the hydrographic work in the Maple Creek district, it has been found that the equipment must be reduced to a minimum, in so far as the accuracy of the results will permit. For this reason it was found that the carrying of two weirs would cause considerable inconvenience. At the same time there were a number of springs which it was necessary to measure. These small streams could not be measured with a 24-inch weir to a sufficient degree of accuracy. To overcome this difficulty, the attachment shown in Plates 46 and 47 was constructed and used with the 24-inch weir, to reduce the weir-crest to any desired length.

A plate of steel (see Plate 46) of the same thickness as the weir-face, was obtained and the bottom cut at the same angle as that of the weir plate (45°), resulting in a close joint. The left side was also bevelled to 45° so as to form a sharp edge upstream. This plate was attached to the weir by means of angles making it possible to adjust their lengths slightly.

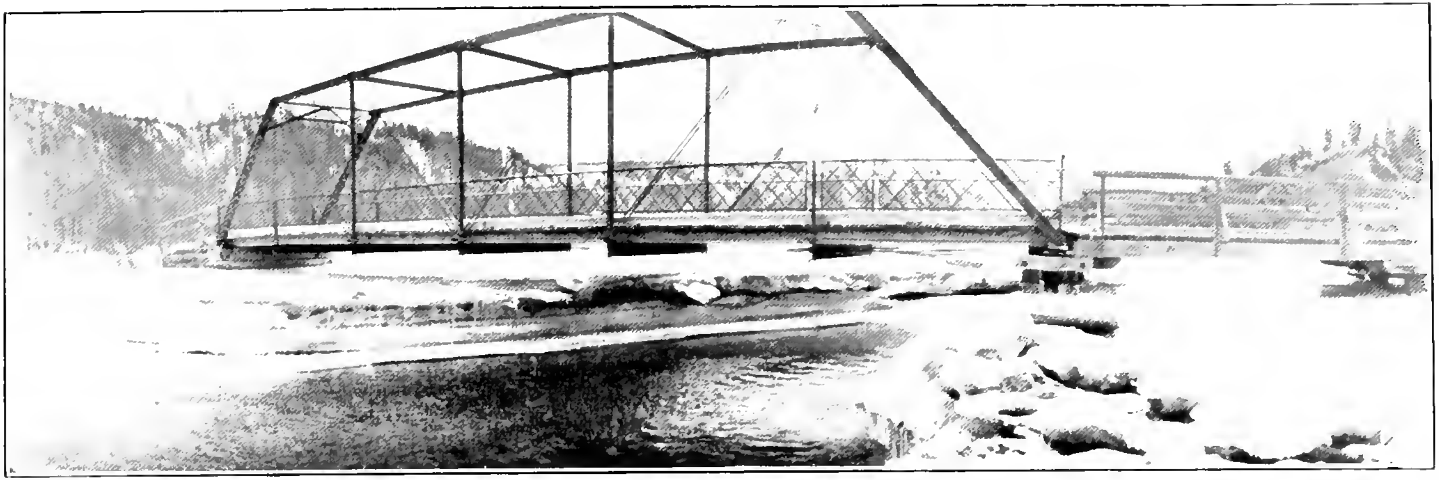
To use this attachment, the weir is set in the creek as for ordinary use, then the plate is put on and clamped at the desired point. The crest is graduated to feet and inches, making it possible to obtain at once the desired width of crest. The intervening space between the plate and the edge of the weir is filled with sod, allowing the water to pass through the other opening only (see Plates 48 and 49).

PLATE No. 40




Mass of Ice on Cascade River at C. P. R. Bridge, caused by turning water into the river from the reservoir during a very cold spell of weather.
Taken Feb. 27, 1912, by V. A. Newhall.

PLATE No. 41.



Mass of Ice on Cascade River at Traffic Bridge near Anthracite, caused by turning water into the river from the reservoir during a very cold spell of weather. Taken Feb. 27, 1912, by V. A. Newhall.

Gauging Station on Devil's Creek near Bankhead, Alta.



Gauging Cascade River on Feb 27th, 1912

PLATE No. 44.

Gauging Cascade River near Bankhead in Winter.

Plate No. 45.

Gauging Kananaskis River near Kananaskis in Winter.

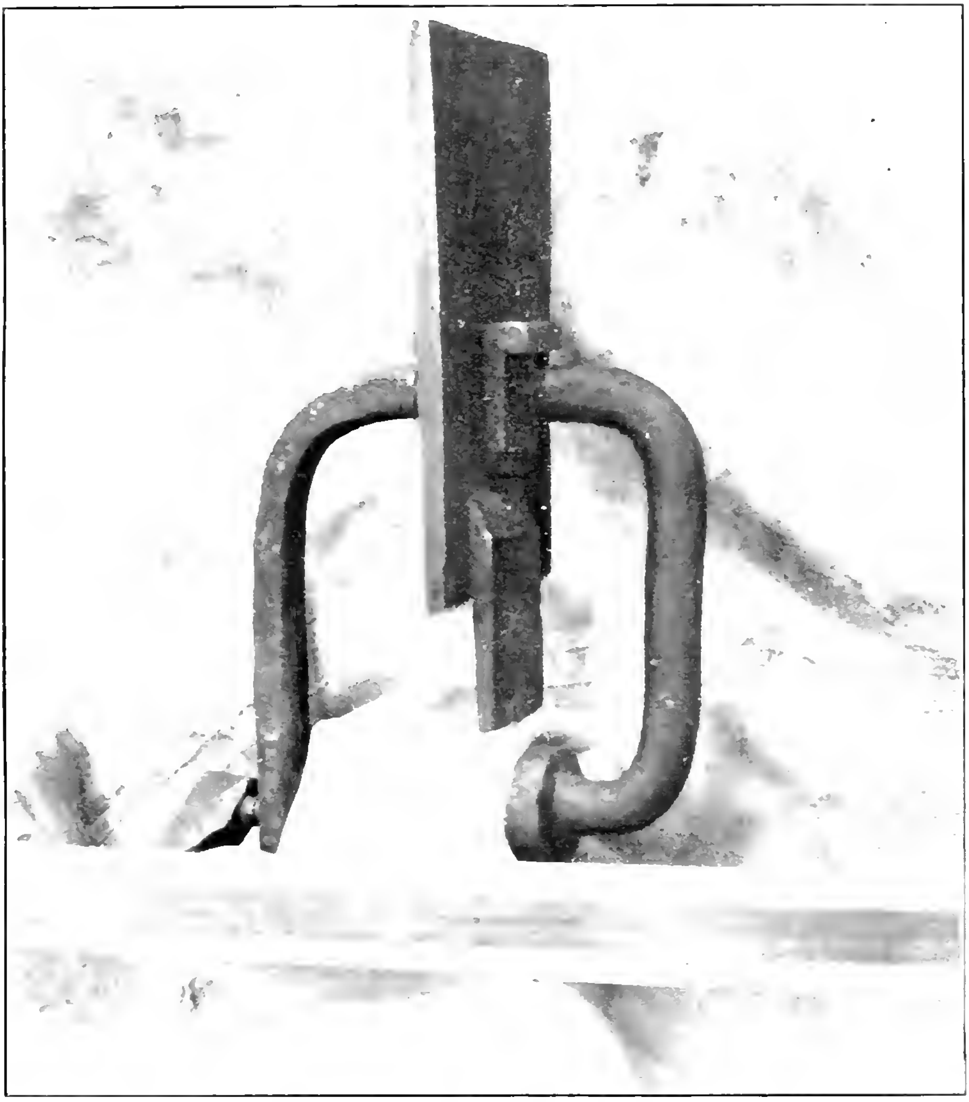


Plate and Angles for adjusting the Length of the Crest of a Steel Rectangular Weir.
Taken by G. H. Whyte.

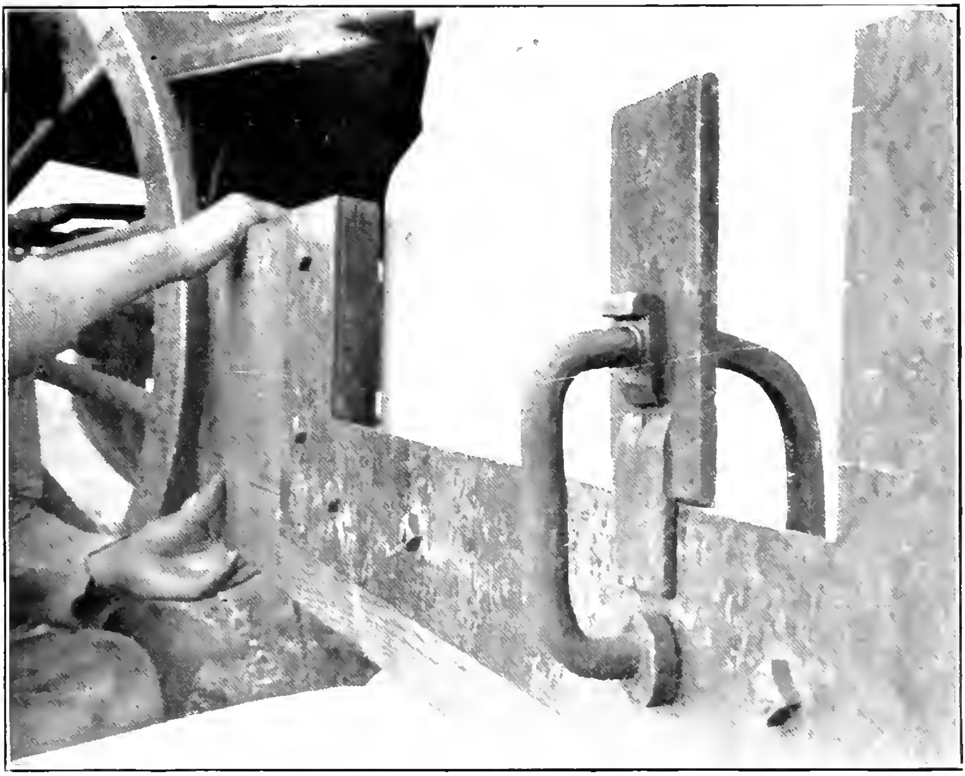


Plate attached to a 24-inch Weir. Taken by G. H. Whyte.

24-inch Weir reduced to 9-inch Crest in Use; Downstream Side. Taken by G. H. Whyte.

[illegible] to 0 inch Crest in Use: Upstream Side     Taken by G. H. Whyte.

# APPENDIX No. 4.

## REPORT ON THE CURRENT-METER RATING STATION ESTABLISHED BY THE IRRIGATION OFFICE, DEPARTMENT OF THE INTERIOR, AT CALGARY, ALBERTA, BY F. H. PETERS, C.E., COMMISSIONER OF IRRIGATION.

A description of this rating station was, by permission, submitted by the Commissioner of Irrigation in the form of a paper to the Canadian Society of Civil Engineers. The following report is practically a reproduction of that paper.

The work of stream measurements has been carried on by the Irrigation Office, Department of the Interior, for a long period of years in the two provinces of Alberta and Saskatchewan, but it was not until the early part of 1909 that the great importance of this work was recognized by the Department, and at that time a special hydrographic surveys branch was organized under Mr. P. M. Sauder, C.E., from which time the work of stream measurements has been carried on systematically and extensively.

Prior to this time a current-meter rating station had been established on a slack-water mill-pond on Bow river at Calgary, but its equipment was never very satisfactory, and it finally fell into bad repair and its use was discontinued. Along with the formation of the hydrographic surveys branch was considered the matter of establishing an up-to-date and efficient current-meter rating station, because it was realized that without this equipment, by which means all current-meters used could be frequently rated, that the current-meter records would be liable to serious errors.

No active steps were, however, taken in the matter until the winter of 1910, when the plans, specifications and estimate of cost for the station and equipment were prepared by the writer. The contract for the work was let to the firm of Jones, Blackshire and Lyttle of Calgary, on May 29th, 1911, and was completed by them on July 21st, 1911. In carrying out the construction the steel reinforcing, the steel rails, the cement and the car were supplied by the Department, and the City of Calgary laid the water-supply pipe to the edge of the rating-station property. Everything else was included in the contract except some small electrical fittings which were installed after the work was completed under the writer's supervision. The total cost for the station and equipment was $4475.39. The total estimated cost for the station was $4690.24.

In designing the work the aim was to obtain the most perfect apparatus possible for rating the current-meters and to create a permanent structure, so that it was early decided to use concrete in the construction of the necessary tank.

As no stretch of still water having a suitable length and depth was available, it was necessary to create a tank, and in studying its design two points had to be principally considered. First, as the water-supply had to be taken from the city mains, the tank had to be made proof against any leakage, as the city authorities were not willing to guarantee any large supply of water such as might be required if any serious leakage from cracks developed in the tank. Second, the cross-sectional water area was required as small as possible and yet of sufficient dimensions to guard against any following-on movement of the water, in running the meters through the tank. To overcome the first difficulty a heavily reinforced structure was designed, such that, being emptied and exposed to the weather in winter no temperature cracks could develop and the inside faces of the tank were waterproofed by Sylvesters' process. In deciding on the proper cross-section of the tank to overcome the second difficulty no data were obtainable, but with the tank as constructed no following-on movement or undue disturbance of the water has been observed, even with the largest meters tested at velocities as high as 10 feet per second. The length of the tank (250 feet) was adopted in order to bring the cost of the structure within the limits of the amount of money available, but provision has been made in locating the tank for its future extension to a length of 500 feet, which is desirable in order to attain the highest degree of accuracy.

A description of the station will be given, the various points of which will be made clear by referring to the several plates.

The main features of the station are a car, on which the current-meter is mounted, and it is then run through the water in the tank at different uniform rates of speed. The three elements,—the distance, the time, and the number of revolutions of the meter—are mechanically measured, and from these the velocity of travel of the current-meter through the water is related to the revolution per second of the meter, which relation of revolutions to velocity constitutes the rating of the meter.

The concrete tank is 250 feet long with an inside width and depth of 6 feet by 5 feet 6 inches, and the depth of water to be maintained is 5 feet. The floor and walls are 8 inches thick and are reinforced heavily longitudinally and transversely with half inch round mild steel rods—in order to absolutely preclude any temperature cracks in the concrete. The concrete was specified a mixture of one part Portland cement to seven parts clean river gravel, to have at least fifteen turns in a good machine, and to be placed wet and thoroughly tamped. All the interior faces were thoroughly spaded in order to create a smooth close-grained surface to which to apply the

Sylvesters' wash. All steel rods at joints were overlapped sixteen inches and it was specified that they were to be wired so as to have contact throughout the whole of this length. The tank floor was laid on an 8-inch foundation of large stones overlaid with smaller stones and gravel, in order to provide thorough drainage for any water which might leak through the tank, so that when the tank is emptied in winter, and exposed to the weather no heaving might result from any water being lodged under the tank bottom. The soil beneath is of sandy character, which is permeable to water. The water-supply is from a two-inch iron pipe laid from the city mains and a six-inch tile drain 224 feet long, fitted with an iron gate-valve at the tank, allows the tank to be emptied at any time into the Bow river. After the tank was completed, all the inside faces were treated with two coats of Sylvesters' wash. At the time of writing, the tank has been exposed, empty, to two cold snaps with the thermometer at —30° and no cracking of the concrete whatsoever has resulted, except a few hair-line cracks near the top of the walls. As regards the waterproofing, two observation shafts were left along the tank sides running down to the foundation and no leakage whatever was observed, during the summer when the tank was full, except a slight dampness at the bottom of the side walls. It should be noted that another reason why it was desired to make the tank leak-proof, is because it is intended to obtain evaporation records at the tank in future seasons.

The track laid along the side of the tank for the car is of 16-pound, and laid to a gauge of 32 3-8 inches on 4 x 6 inch ties, fish plates and bolts being used to every joint. In laying the track the greatest care was exercised to get it laid solid and as level as possible, with close rail joints, in order that the car would run on the track as smoothly as possible. The measured run of the car is 200 feet, 25 feet being left at each end of the track in which to speed up the car, and the track at one end runs into the car-house, where the car is kept under lock and key, when not in use.

The original idea was that the car should be mechanically driven by an electric motor working on one of the axles of the car. It is an essential that the rate of travel of the car over its measured course should be uniform, but after much consideration the writer was not able to devise any method of control by which the rate of travel of the car could be kept uniform (without acceleration) throughout its run, if driven by an electric motor or some other mechanical means. The car is, therefore, propelled by hand, but its design is such that an electric motor can be easily attached at any future date if any means can be devised of overcoming the difficulty mentioned above.

The main features in the design of the car have been copied from the car used by the Bureau of Standards, United States Government at their current-meter rating station at Washington, D.C., blue prints of the design of which were very kindly lent by an officer of the Bureau of Standards.

The main features of the car are that the axles run in roller bearings and the platform is attached to the front axle by a pinion joint which makes the level of the platform entirely dependent on the rear axle, and thus any tendency of the platform to be twisted due to uneven tracks is overcome. It is thought that this arrangement eliminates practically all the sharp vertical movements which might otherwise be transmitted to the current meter in its travel through the water. Two horizontal iron arms project from the car to the centre of the concrete tank. When the meter is being rated with the rod suspension, the meter rods are clamped in these horizontal arms. When the meter is being rated with a cord suspension and weights, the vertical cord is run down through the sockets used for clamping the meter rods, and a removable iron arm is used for attaching a wire stay-line to the meter. The car wheels have solid flanges and all the iron in the car is of heavy section, the idea being that with a heavy car running in easy bearings it would be easier to maintain a uniform rate of travel than with a light car.

In making the run with the meter, the count of the revolutions of the meter and of the time interval are both automatically registered in the car-house by electric apparatus. The electric circuits from the car into the car-house are made by two trolley wires above the car and one wire laid along the ties between the tracks. The circuit from the meter for the count of the revolutions is made by the two trolley wires, while the circuit for the time interval is made by the ground wire with one auxiliary wire, and one of the trolley wires used for the return. The diagram submitted will show the layout of the electric circuits clearly. The distance over which each run is made is 200 feet, and this distance is marked by two rods set up vertically on the ties at the side of the car. On the car platform are two electric switches with long arms projecting over the edge of the car platform, and these, engaging with the two rods at 200 feet interval, close the electric circuit for this interval, running through the commutator box on the meter and thus the revolutions of the meter over the interval of 200 feet are transmitted to the car-house where they are registered by two electric registers set in series in order to check each other on the count. Some difficulty was experienced at first in getting the electric registers to count accurately when running the meters at high velocities, but this difficulty was overcome by always overhauling the commutator box on the meters and making a fine adjustment of the make—and—break apparatus therein. It will be seen that this method of counting the revolutions is liable to be slightly in error owing to the fact that the registers do not take any count of the fractional revolution of the meter at either end of the run. This error however, would be reduced to a minimum by increasing the length of the run.

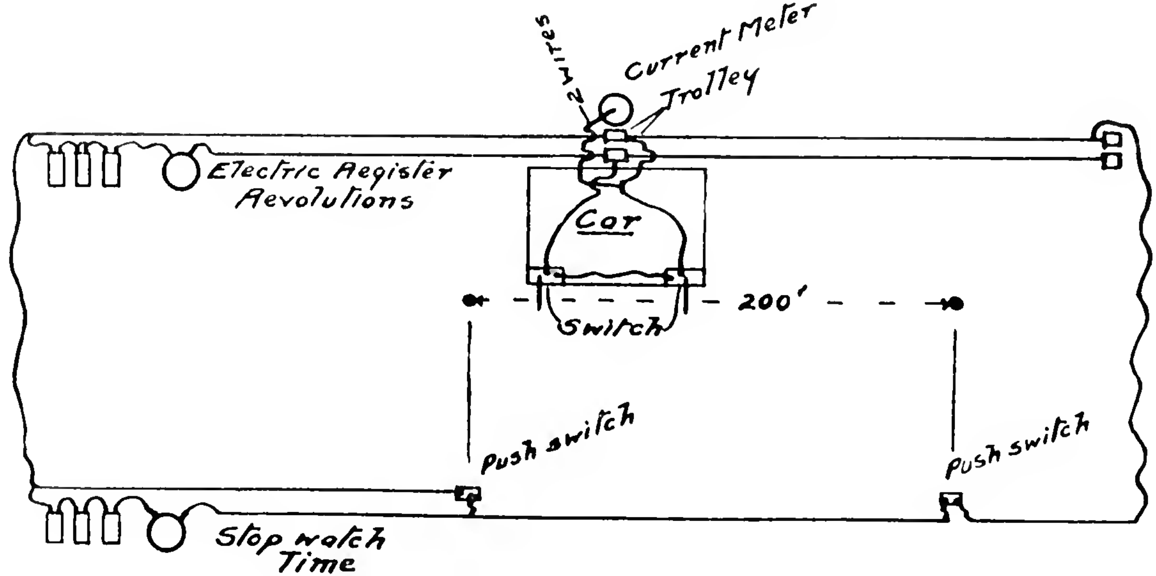
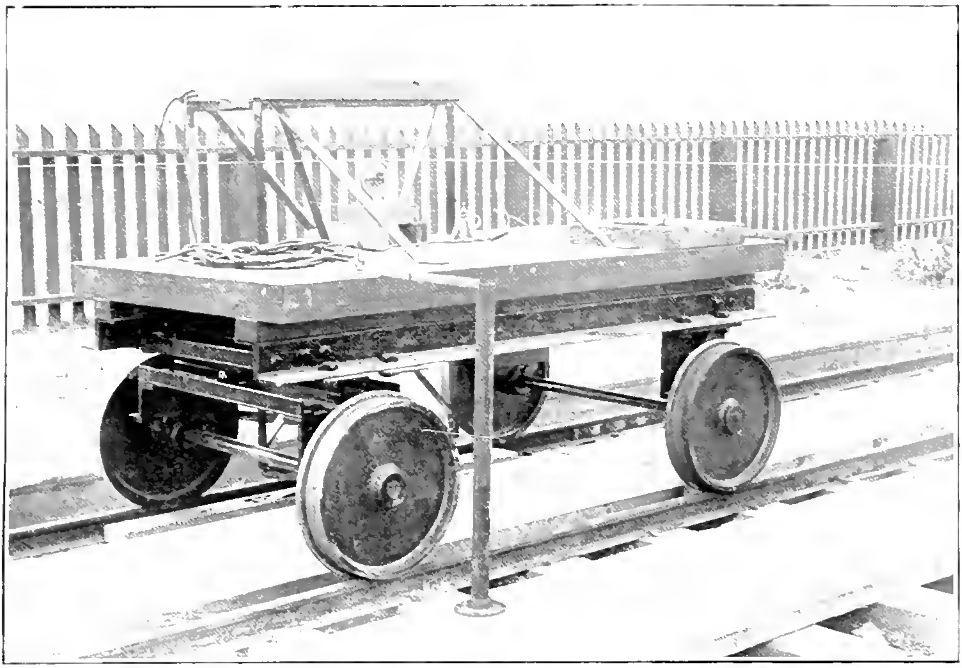
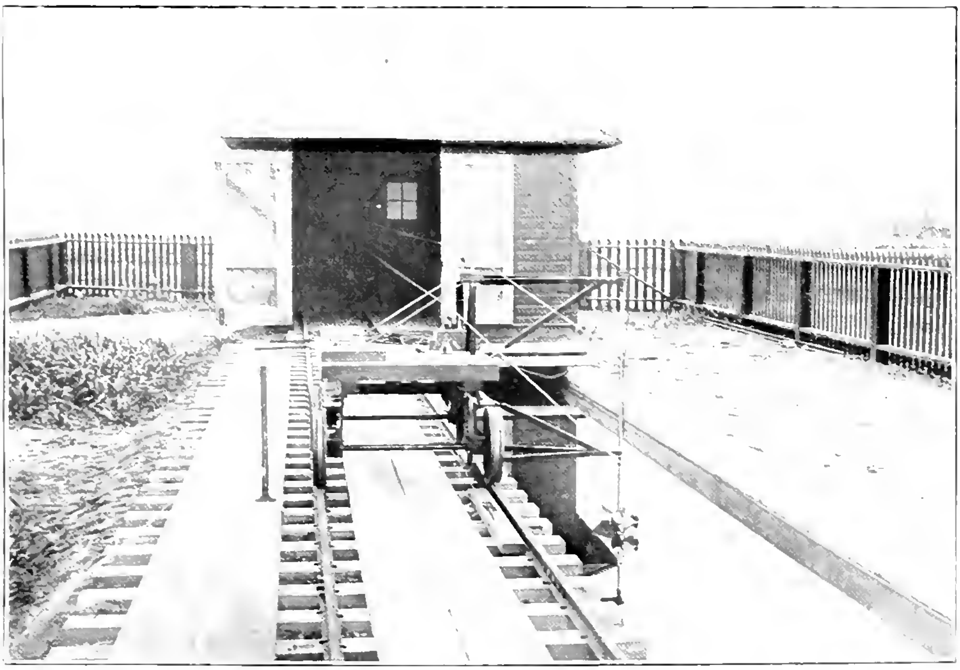



Diagram of Electric Connections



View of Current-meter Rating Car, showing Trolleys and Switches.





End View of Current-meter Rating Car, showing Car House behind

Plate No 53

General View of the Current-meter Rating Car at rest.

Plate No. 54.

The Current-meter Rating Car in motion.

The time interval is counted by a stop-watch, which is operated by a simple electro-magnet, with a padded lever attachment, designed by the writer, in exactly the same manner that a stop-watch is operated by hand. At each rod, marking the 200 foot interval, the circuit running through the stop-watch via the ground wires has inset a one-nipple push-switch, and lugs underneath the car make and break the circuit as the car passes these two points, thus starting and stopping the watch at the respective ends of the 200-foot run and thereby counting the time taken by the car in making the run of 200 feet.

The procedure adopted in rating the meter is to make 20 runs for each meter with velocities varying from 0.5 feet per second to 10 feet per second, the increments in velocity for each run from the low speed to the high being as uniformly distributed between the limits as possible. From the data thus gained the revolutions per second with their corresponding velocities per second are computed, the points plotted and among them the most probable curve is drawn. From the rating curve thus constructed the rating table is prepared for use in the field and the office, showing in convenient tabular form the velocities corresponding to the various revolutions per second of the meter, from zero velocity up to 10 feet per second. It should here be noted that the rule in the service is not to measure any stream at a section where the average velocity falls below 0.5 feet per second, and a velocity of 10 feet per second is about the highest met with in practive.

Mathematically, the most probable curve is that drawn from values found from normal equations by the method of least squares. It is considered, however, that the method adopted of taking the values off a curve carefully plotted as noted above is quite accurate enough to meet all practical requirements, and the saving of time and labour by using this method is very great.

For purposes of keeping a graphical office record of the succeeding ratings of the meters a separate sheet is prepared for each meter. On this is first plotted, for purposes of comparison, the standard curve for the meter (Gurleys' standard curve for all Price electric meters) and all succeeding ratings of the meter will be plotted on the sheet in different-coloured inks, with notes as to the date of ratings, conditions of the meter, etc., until the confusion of many curves will require the preparation of a new curve sheet. Revolutions per second are plotted as ordinates to a sca of 4 inches to one revolution per second, and velocities in feet per second are plotted as abscissæ to a scale of 4 inches to 2 feet per second. For velocities up to 3 feet per second, an auxiliary curve is drawn with the velocity scale increased to 4 inches to 1 foot per second, to allow for greater precision in taking the quantities off the curve.

It is the intention to carry on extensive experimental work in order to determine the various condit ns that affect the rating of the current-meter. Especially is it desirable to rate every large meter using the two methods of suspension, that is, by meter rods and by cable with stay line. With the limited time available during the past season it was possible to rate the meters only with the rod suspension. Some of the results obtained, however, are surprising and worthy of note. The writer has had a lengthy experience with the use of the Gurley No. 600, large Electric Meter, and his idea has always been (and he knows that it was shared by other men of experience) that with continued use on account of the pivot bearings constantly wearing, that the friction was increased, and that the revolution of the meter was thereby retarded. The experience of the past summer in rating nine of these meters has indicated that after considerable use the meters run fast instead of slow. The evidence points to the conclusion that with considerable use the bearing-points in the meter wear themselves smoother than they come new from the makers, and hence have less friction than when they are new. The experiments, however, have not been exhaustive enough to prove anything conclusively beyond the fact that, except when they are perfectly new, no current-meter can be relied upon unless it is carefully and frequently rated. The new medium-size type of electric meter (Gurleys' No. 623) had been adopted by this office for the first time this year, and therefore no experiments could be made on worn meters of this type. Five meters of this type were tested, of which two had been in light use for one season and three were perfectly new. All of these gave a rating curve practically the same as the standard curve issued by W. & L. E. Gurley, but in every case showing the meter running a little faster than Gurleys' standard.

Of the small electric meters (Gurleys' No. 618) nine were tested and all showed nearly the same results, although four of them had been in use for two seasons and five of them were new. At low velocities the new curve coincided with Gurleys' standard curve, but as the velocities increased the new curve dipped below the standard, which means that the meter was running slower than the standard. This may have been due to the bending, at high velocities, of the small meter-rods by which the meter was suspended from the car. This bending from the vertical of the meter rods was actually noticed to take place, but no opportunity was obtained to use a stay-line to keep the rods vertical, and thereby test the effect of the bending on the rating of the meter. As indicated above, it is the intention to carry on extensive experiments in the future to determine the effect of the method of suspension of the meter on the rating. In practice, all of the large streams are measured by suspending the meter in the stream with a cord and employing a stay-line to hold the meter up against the current. Under these conditions, especially with high velocities, there is a tendency for the meter to sway continually from side to side at right angles to the current, and it will be interesting and important to determine what effect this has on the revolutions of the meter. Identical conditions will not be obtainable at the rating station, as the length of the cord suspension will of necessity be much shorter than that used either from a cable-car station or from a highway-bridge station, and this factor will no doubt, enter largely into the amount of sway that the meter will have. Four rating curves are submitted with this paper in order to show graphically, actual results obtained in rating meters of different types during the past summer. Explanatory notes have been added, (which do not appear on the original office copies) and the curves were selected to show typical cases.

Mr. V. A. Newhall had charge of all the meter ratings during the past season, and under his direction, the working parts of the station were finally tuned up, and the electric switches and recording apparatus were finally adjusted and improved to overcome difficulties met with in operation. To him, also, the writer is indebted for the notes on the behaviour of the several types of meters on being rated.

In conclusion, the writer would note, for the information of the engineering profession, that the Irrigation Office is prepared to rate any meters that may be sent in by any engineers or others, desirous of having their current-meters tested, and a certified rating table will be prepared and returned with the meters. A small fee will be charged to cover only the actual time of the engineer and his assistant, employed in making the rating and preparing the table, based on the salaries paid to the men of the Department.

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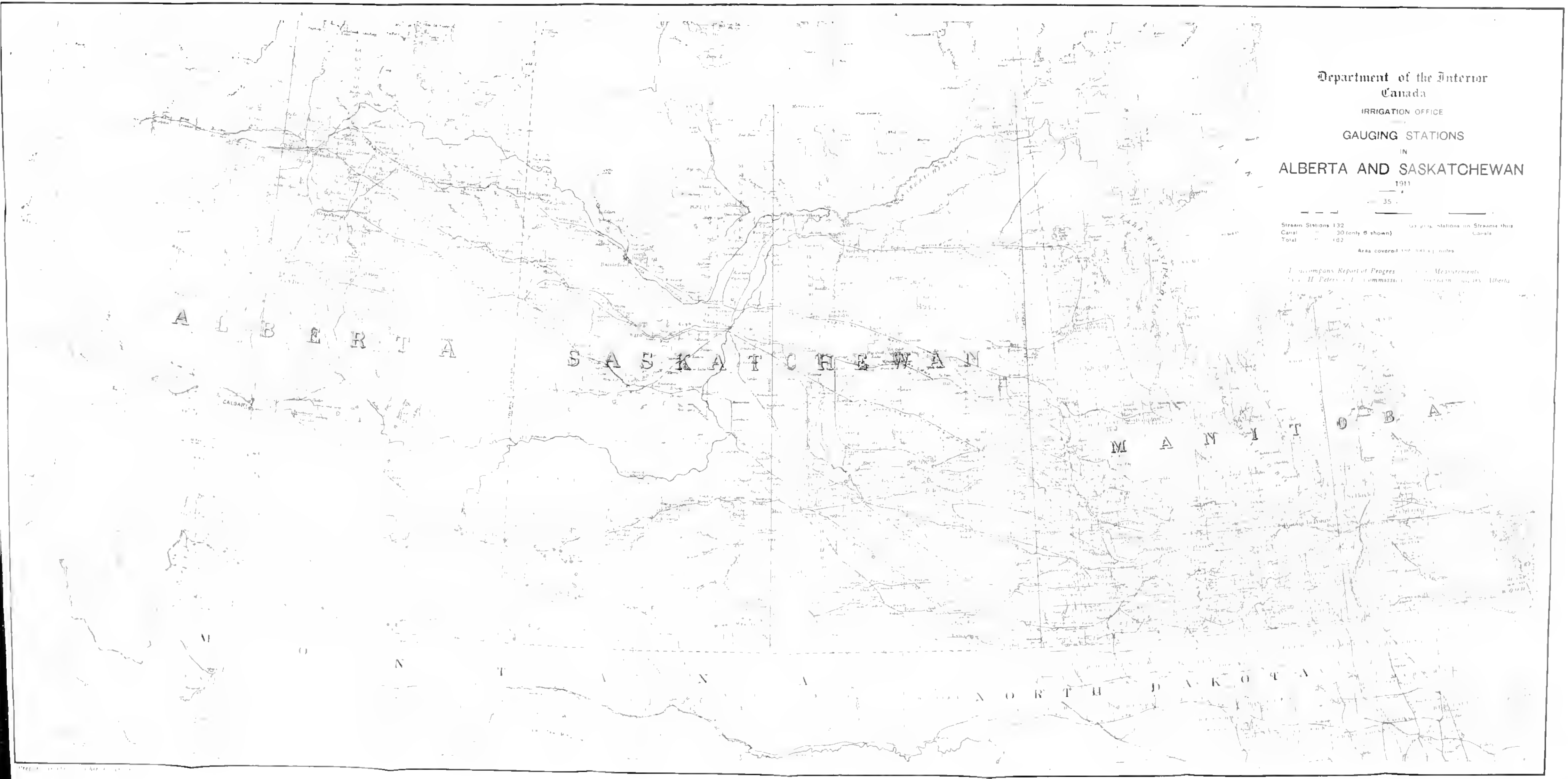
Department of the Interior
Canada
IRRIGATION OFFICE
GAUGING STATIONS
IN
ALBERTA AND SASKATCHEWAN
1911
Stream Stations 132
Canal " 30 (only 8 shown)
Canals
ALBERTA
SASKATCHEWAN
MANITOBA
NORTH DAKOTA

# SUMMARY REPORT

OF THE

# GEOLOGICAL SURVEY BRANCH

OF THE

# DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

1911

*PRINTED BY ORDER OF PARLIAMENT*

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1912

*To His Royal Highness the Duke of Connaught and Strathearn, K.G., &c., &c., &c., Governor General of Canada.*

MAY IT PLEASE YOUR ROYAL HIGHNESS,—

The undersigned has the honour to lay before Your Royal Highness—in compliance with 6-7 Edward VII, chapter 29, section 18—the Summary Report of the operations of the Geological Survey during the calendar year 1911.

(Signed) ROBERT ROGERS,
*Minister of Mines.*

To the Hon. ROBERT ROGERS, M.P.,
Minister of Mines,
Ottawa.

SIR,—I have the honour to transmit, herewith, my summary report of the operations of the Geological Survey for the calendar year 1911: which includes the reports of the various officials on the work accomplished by them.

I have the honour to be, Sir,
Your obedient servant,
(Signed) R. W. BROCK,
*Director Geological Survey.*

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STAFF FIELD WORK—*Continued.* PAGE.

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# SUMMARY REPORT

OF THE

# GEOLOGICAL SURVEY BRANCH

OF THE

# DEPARTMENT OF MINES

## FOR THE CALENDAR YEAR 1911.

To the Hon. ROBERT ROGERS, M.P.,
Minister of Mines.

SIR,—I have the honour to submit herewith, a summary report on the operations of the Geological Survey for the calendar year 1911.

The present organization of the Survey is as under:—

*Director.*

*Administrative and General:—*

Correspondence—Secretary, 3 stenographers.

Distribution—Chief, publication clerk, correspondence clerk.

Stationery—1 clerk.

Instruments—1 custodian.

Cabinetmaker—1.

Messengers, etc.—1 mail clerk, 4 messengers.

*Geological Division:—*

Palæontology—1 vertebrate palæontologist, 1 invertebrate palæontologist.

Geology—11 geologists, 9 assistant geologists, 1 compiler.

Mineralogy—1 mineralogist and curator, 1 assistant curator, 1 collector and distributer, 1 stenographer.

*Topographical Division:—*

Chief topographer, 3 assistant topographers, 1 model-maker, 1 triangulator and computer.

*Draughting Division:—*

Geographer and chief draughtsman, 13 draughtsmen, 1 clerk.

*Photographic Division:—*

Photographer in charge, 1 assistant.

*Natural History Division:—*

1 botanist and naturalist, 1 assistant botanist and naturalist, 1 assistant naturalist and custodian, 1 preparator and taxidermist, 1 taxidermist, 1 stenographer.

*Anthropological Division:—*

1 ethnologist, 1 assistant ethnologist, 1 archæologist, 1 stenographer.

*Library:—*

1 librarian, 2 assistants.

In the geological and anthropological division, officers were commissioned in addition to those of the regular staff, to take charge of field parties. Such officers are usually obtained from the staffs of technical universities. Field and student assistants were temporarily engaged for field work in the divisions of geology, topography, and natural history.

During the year the Survey lost through death the services of Dr. R. W. Ells and Mr. R. L. Broadbent. Dr. H. M. Ami was granted superannuation on account of ill-health, and Messrs. J. A. Dresser, F. H. MacLaren, and Hugh Matheson resigned.

Appointments to the staff were made as under:—

Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, and formerly Director of the United States Geological Survey, accepted the honorary position of Collaborator in Geology with special reference to the Cambrian.

Dr. H. I. Smith was appointed archæologist; C. M. Barbeau, assistant ethnologist; Robert Harvie, S. J. Schofield, and L. Reinecke, assistant geologists; W. E. Lawson, A. C. T. Sheppard, and K. G. Chipman, assistant topographers; S. C. McLean, triangulator and computer; S. N. Graham, assistant curator mineralogy and geology; P. A. Taverner, assistant naturalist and curator; G. D. Barrowman, custodian of instruments; Geo. P. Clarke, photographer; Alice B. Wilson, assistant in palæontology; A. F. Clarke, and Adam McGregor, draughtsmen; and Eilleen Bleakney, stenographer.

The death of Dr. R. W. Ells deprived the Survey of one of its oldest and most highly respected members. He entered the Survey in 1872 and was in active service up to the time of his death. The greater part of his work was in the Maritime Provinces, Quebec, and eastern Ontario, but he also carried on investigations in the northwest and in British Columbia. The results of his extended labours in these fields are to be found in the voluminous reports and maps that have appeared under his name.

To Mr. R. L. Broadbent were due more, perhaps, than to any one else, the fine mineralogical exhibits for the Museum. His untimely death, at the moment the collections were to be installed in the new Museum, has been a blow which will long affect the work of the Museum.

The resignation of Mr. Dresser emphasizes the urgency pointed out in recent summary reports, for securing more rapid promotion and higher salaries for the scientific staff, especially the field officials. The loss of an experienced officer is irreparable; for he has in his work, secured a mass of detailed information concerning the districts in which he has been engaged that can never be embodied in a report, but that is of constant value to the Department and the public in answering inquiries concerning particular areas or special problems. When such an official leaves the service this fund of information is lost to the Department and to the public.

As a partial off-set to such losses the Survey now has a corps of well-trained young geologists and topographers to draw upon. Four years ago when the Survey was able to announce that it had been removed entirely from politics and outside influences, and that appointments and promotions would hereafter be based strictly on merit, the most promising students in the colleges began to train for positions on the staff. By restricting the appointments as student assistants on field parties to students of at least two years standing in approved universities or technical colleges, who were studying for the professions of geology, mining, or topography, the Survey has been enabled to try out each year about sixty prospective technical men especially selected by their respective professors. The more promising of these are encouraged to proceed with their training, the geologists to take doctorate degrees in geology in post graduate universities, the topographers to train in the Survey. During the past year a number of such men had finished these courses and received appointments to the staff. Next year a further number of such specially qualified men will be available.

Such additions to the field forces render it possible to make much needed staff appointments, for general supervision of and consultation regarding the work. Until now, no experienced official could be taken from regular field work, since the field force was not strong enough numerically to cope with even the most pressing demands for field work, and the routine and other duties of the Director left him without the requisite time to devote to this branch of the work. Consequently, the individual officer did not receive the assistance in the field or in the office, in the way of friendly criticisms and suggestions, that is necessary to bring about the best results. It is now proposed to place experienced geologists in charge of office work and field work.

## COMMITTEES.

The Geological, Map, and Library Committees have continued to render valuable service. The work devolving upon these bodies is arduous and makes heavy inroads upon the time of the members of the respective committees. Since the results of their labours do not appear in a form which admits of individual credit being given, I take this opportunity of emphasizing the valuable results of their work.

As it becomes possible to allot staff duties to special officers, the demands upon these committees will be lessened, as only general questions need then be referred to them.

## PUBLICATIONS.

The results of the investigations of the various divisions of the Survey are recorded in maps and reports. Since, however, the information acquired by the Survey is of value for very different purposes by various classes and individuals, it is impossible in a given report to record every fact that may have a value to somebody or to treat the matter in a manner that is suitable for all purposes. Information that is not of general value has, as a rule, to be omitted from a report. But much of such information is furnished interested individuals in the field, and this is perhaps the most valuable service that the Survey renders. A great deal is supplied by correspondence. Information that is of immediate value to the public is supplied by means of Press Bulletins, which are furnished to any newspaper desiring such information, and to all individuals who have asked to be placed on the 'Notice list' of the Survey.

Any one who applies will have his name placed on this list, and will receive the Press Bulletins and a notice of reports as issued. No general distribution list is maintained.

The number of letters received during the year asking for publications was 5,616. The number of publications sent out in response was 20,506, distributed as follows: 17,945 to Canada, 2,029 to the United States, 202 to Great Britain and Ireland, and 330 to foreign countries. The sale of publications amounted to $286.24.

A list of maps and reports published during the year will be found near the end of this volume.

Attention may be called to the fact that maps now published by the Survey may be obtained printed on linen for field use. An extra charge of ten cents is made for maps on linen.

## FIELD WORK.

The geological and topographical work undertaken during the past season has, as usual, been almost exclusively economic and confined to districts in which such work gave promise of being of greatest or most immediate value.

Arrangements are made with the mining departments of the Provinces of Ontario and Quebec to avoid duplication of geological work. Consequently the districts in which these provinces have field parties are not examined and reported on by the Geological Survey. Such districts are usually those which, in any year, are receiving marked attention from prospectors and mining men.

The distribution of field parties was as follows:—

### GEOLOGICAL.

Mr. D. D. Cairnes was engaged on the Yukon-Alaska boundary line between the Yukon and Porcupine rivers.

For the geological work in both the Yukon and Alaska, a geological section to the Arctic ocean is needed, and the geological surveys of the United States and Canada are co-operating in this work, Canada becoming responsible for the section along the boundary line from the Yukon to the Porcupine river, and the United States for the section from Porcupine river to the Arctic ocean. The total length of the combined section will be about 340 miles.

Returning from the field, Mr. Cairnes examined a number of quartz properties in the neighbourhood of Dawson.

Mr. R. G. McConnell spent the field season in the Portland Canal district examining the mineral deposits of Goose bay and Alice arm on Observatory inlet, as well as continuing his investigations on Bear and Salmon rivers. He also made a reconnaissance trip across to the Nass river. The most important event in mining in this region during the season has been the advent of the Granby Company, whose vigorous development of their newly acquired Hidden Creek mine at Goose bay has proven the existence of large bodies of copper ore.

Mr. G. S. Malloch examined a portion of the Groundhog coal basin at the head of the Skeena river, north of Hazelton, a district which has attracted a good deal of attention during the past season. The basin is a large one, containing several seams of coal, anthracitic in character. Most of the seams are high in ash, but samples taken from one workable seam by competent men have had a low ash content.

Mr. C. H. Clapp spent the summer in a detailed investigation of the Nanaimo coal field, Vancouver island.

Mr. Charles Camsell spent a short time testing the Tulameen River gravels for diamonds, on the chance of finding stones of commercial size. Only minute diamonds were found. Minute rubies were also obtained. He made a geological survey of the Steamboat Mountain district which had received considerable notice during the preceding winter. His investigations tended to show that with the exception of one or two localities the district is economically unimportant. Some time was also spent on the Fraser river about Yale and northward up the Fraser canyon, where no work has been done by the Survey since the reconnaissance in 1872.

Mr. L. Reinecke concluded his investigations in the Beaverdell Mining district, West Fork of the Kettle river, through which a branch of the Canadian Pacific railway is being built.

Mr. C. W. Drysdale made a detailed geological examination of Franklin Camp, North Fork of the Kettle river.

Mr. O. E. LeRoy devoted a considerable portion of his time to visiting various mining centres in southern British Columbia and in superintending the work of several of the field parties. Among other districts, he visited the Slocan where very encouraging and important results have attended the development work that has been carried on. He made a detailed survey of an area of about 100 square miles covering the mining district about Nelson, where general mining conditions are improving.

Mr. S. J. Schofield continued his geological mapping in the East Kootenay district, paying special attention to the mineral deposits of the area, of which silver-lead is the most important.

Mr. R. A. Daly commenced work on the geological section across the mountains along the line of the Canadian Pacific railway. Work was begun near Kamloops and carried eastward to beyond Albert Canyon. For the detailed investigation of the mining districts, it is necessary to know the structure and general geology of the Cordilleran belt. To supply this information a number of geological sections across this belt are required. Mr. Daly has completed such a section along the 49th parallel (the International Boundary). This year he has begun a similar section along the Canadian Pacific railway. As soon as practicable a third section along the Grand Trunk Pacific will be undertaken.

Mr. J. A. Allen continued his examination of the area adjacent to the Canadian Pacific railway in the Rockies west of Field.

Mr. C. D. Walcott devoted the summer to a study of the Cambrian of the Rockies in the vicinity of Field from which he has obtained remarkable fossils.

Mr. W. W. Leach began a detailed examination of the Blairmore-Frank coal-field. Not only is this a heavy producer (over 1,600,000 tons in 1910), but it is being further developed.

Messrs. W. G. Miller, R. A. Daly, and George S. Rice examined and reported on the condition of Turtle mountain.

Mr. D. B. Dowling continued his investigation of the coal basins in the vicinity of The Grand Trunk Pacific railway near Yellowhead pass. One colliery is already in operation and the opening of three others is in contemplation. The Canadian Northern railway will also pass close to these collieries. A month was spent in examining coal occurrences in other parts of Alberta and in Saskatchewan, several of which, it is now reported, are being developed into mines.

Mr. A. C. Lawson was engaged in the Lake of the Woods and Rainy Lake district, where in his reconnaissance work in the '80's he had obtained most important geological results. His more detailed work the past season has supplemented these with an equally valuable contribution to the knowledge of Pre-Cambrian geology. Amongst other things, he has found fossils in a Pre-Cambrian horizon believed to be far below any hitherto known to be fossiliferous.

Mr. W. H. Collins continued his geological mapping of the country north of the Sudbury district. Since 1908, occurrences of silver-cobalt minerals similar to those at Cobalt have been found at various points within this district, and last August gold-bearing quartz veins were discovered near West Shiningtree lake.

Mr. W. A. Johnston continued his topographical and geological mapping in the Lake Simcoe district, important from the information it affords regarding the Ordovician rocks, and the superficial geology of Ontario.

Mr. F. B. Taylor continued his work on the superficial geology of Ontario. In New York, Ohio, and Michigan this has been carefully worked out; Mr. Taylor is connecting and correlating this work through southwestern Ontario.

Mr. C. Stauffer continued his study of the Devonian rocks of southwestern Ontario. Every Devonian formation is here of some economic value; the most important, however, is as a reservoir of oil.

Mr. A. F. Foerst made a study of the lower Palæozoic rocks of Manitoulin island.

Mr. M. E. Wilson continued his explorations in northwestern Quebec from Lake Abitibi eastward. The mineral bearing formations of northern Ontario extend into this portion of Quebec, and with approaching railway facilities it affords an attractive field for prospectors. There are also large areas of agricultural land.

Mr. J. Stansfield made detailed plans of typical apatite, mica, and graphite mines north of Ottawa river.

Mr. R. Harvie was assigned to the work previously carried on by Mr. Dresser, on the economically important Serpentine belt of the Eastern Townships, Quebec. No important asbestos deposits were noted in the area examined this season, but copper has been a product and may be again.

Mr. J. J. O'Neill made an examination of Belœil and Rougemont mountains, to complete the study of the Monteregian hills, a group of interesting old volcanoes that extend from Montreal eastward.

Mr. J. W. Goldthwaite continued his investigations of the raised beaches of eastern Quebec, extending the work into the Maritime Provinces. The determination of the amount and character of the post-glacial changes of level of the coast may lead to important deductions. This work is being correlated with similar investigations in progress along the Atlantic coast of the United States.

Mr. P. E. Raymond carried on field work in eastern Ontario and western Quebec, and also in the neighbourhood of Quebec city. New and important facts of palæontological value were obtained.

Mr. G. A. Young made a geological examination of the oil, gas, and gypsum district near Moncton, N.B. The gas field promises to become an important factor in the commercial development of this region.

Mr. H. E. Kramm paid special attention to the extensive gypsum deposits of the district as well as to several related deposits of the same mineral in other parts of New Brunswick and Nova Scotia.

Mr. W. A. Bell made a preliminary examination of the very important Joggins carboniferous section of Nova Scotia.

Mr. E. R. Faribault continued his mapping of the gold-bearing series in Queens and Lunenburg counties, N.S. In the area examined are several gold-bearing districts, at one of which, Fifteenmile Brook, a discovery of the tungsten ore, scheelite, was made.

Mr. W. J. Wright began a study of special problems relating to the gold-bearing rocks in Lunenburg county, N.S.

Mr. H. Ries continued the examination of the clay resources of the western provinces. The valuable results obtained from these investigations in past seasons have aroused keen interest in this important branch of the mineral industry.

Mr. J. Keele also contributed to the examination of the clay resources of the western provinces, and began the study of the clays of Quebec. He also visited the placer gold field of Beauce county, Quebec, where placer mining is being resumed.

TOPOGRAPHICAL.

Mr. K. Chipman mapped the northern half of the Cowichan-Alberni map area, Vancouver island.

Mr. R. H. Chapman surveyed the southern half of the same area.

Mr. A. T. Sheppard completed the Slocan map area and assisted Mr. Boyd at Blairmore.

Mr. S. C. McLean was engaged in triangulation in the Windermere district, East Kootenay, B.C.

Mr. W. H. Boyd supervised the mapping of the Blairmore area, and made a detailed map of Turtle mountain, Alta.

Mr. W. Lawson had charge of the topographical work in the Moncton map area.

Field work in natural history and anthropology will be mentioned later under the headings of these divisions.

## PROGRESS OF DIVISIONS.

### TOPOGRAPHICAL DIVISION.

The topographical division under Mr. W. H. Boyd has been strengthened during the year by the appointment of three topographers, and a triangulator. A number of other men now in training will soon be ready to undertake independent work. It is the intention to strengthen this division until it is able to furnish the base maps required by the geological division, so that the geologist entering the field will be provided with an accurate topographic base map on which to lay down in the field the results of his geological observations. This will result in a saving of time and in marked increase in the accuracy and usefulness of the geological work.

Our standard topographical maps now being produced by this division are accurate to scale and are in themselves of great value to mining and other engineers, and for all purposes for which such scale maps are suitable. The scales vary from 400 feet to 1 inch, as in the engineering maps, to 4 miles to an inch in areal maps; the contour interval varies from 10 to 500 feet according to the scale of the map and the nature of the district represented.

On account of the various classes of maps produced by the Survey, ranging from absolutely accurate contoured topographical maps to rough illustrative diagrams, it has been decided to classify them so that they may show on their face, for the information of the user, the degree of accuracy that may be expected to be found in them. The following is the classification adopted:—

| Grades. | A<br>Topographical Maps. | B<br>Geographical Maps. | C<br>Route Maps. | D<br>Plans. | E<br>Diagrams. |
|---|---|---|---|---|---|
| 1. Standard ..... | Unless mentioned as of lower grade assume standard quality. | | | | |
| 2. Graded ........ | Grade 2......<br>" 3......<br>" 4...... | Grade 2......<br>" 3......<br>" 4...... | | | |
| 3. Inferior........ | Inferior........ | Inferior........ | Track Survey... | Inferior........ | Inferior. |

The topographical maps are contoured, and show the relief, water, and cultural features.

The geographical maps show the water, and locations of places, etc., but are not contoured.

The route maps show the lines of exploration but do not represent the geographical features of the district as a whole.

The Standard maps are accurate to scale. Maps are to be regarded as Standard maps unless otherwise stated under the title. The Graded maps are graded according to the degree of accuracy obtaining throughout. The grade will be given under the title. Inferior maps are rough sketchy maps with insufficient instrument control, that should not be relied on as accurate, since they are intended solely to furnish a general idea of the geography or geology of the country, or to illustrate certain features.

Any of these maps or diagrams may be used as bases for geology.

## DRAUGHTING DIVISION.

This division has been strengthened during the year by the addition of several draughtsmen, rendered necessary by the increased mapping being carried on by the Survey.

PHOTOGRAPHIC DIVISION.

This division has also been strengthened during the past year, and its work extended to include wet-plate photography.

The work consists of the developing and printing of photographs taken by officers in the field, enlarging of photographs taken in photographic mapping, photographing specimens for reproduction and making prints to illustrate reports, enlarging and reducing for map-making, blue printing, and making lantern slides. During the year the work turned out in this division comprised 396 dry-plate negatives, 1,533 dry-plate exposures developed, 8,537 contact prints, 647 topographic enlargements, 272 lantern slides, and 25 wet-plate negatives.

The work has been considerably hampered on account of the new laboratories not yet being fitted up, necessitating shift arrangements. Considerable progress has been made in cataloguing the extensive and valuable collection of negatives.

NATURAL HISTORY DIVISION.

Only a limited amount of field work was undertaken by this division during the past season, confined principally to the Ottawa district, New Brunswick, and Vancouver island. The major portion of the time was devoted to the collections intended for public exhibition and for scientific reference. Mr. P. A. Taverner was appointed to this division as assistant naturalist and curator. Now that facilities are being provided for its work, the natural history staff requires to be augmented to properly cover the wide field allotted to it.

ANTHROPOLOGICAL DIVISION.

The anthropological division during the year has been organized and its work is now well under way. In addition to overhauling and preparing the collections for museum purposes, systematic field work has been undertaken. In the ethnological subdivision the field work carried on was as follows:—

Mr. E. Sapir made a reconnaissance of the Iroquois and Algonkin of Ontario and Quebec.

Mr. C. M. Barbeau conducted an ethnographical research among the Hurons of Lorette, Amherstburg, and Wyandotte.

Mr. A. A. Goldenweiser was engaged in a study of the social organization of the Iroquois of the Grand River reserve.

Mr. W. H. Mechling spent the summer in research among the Micmac and Malecite Indians of New Brunswick.

Mr. C. MacMillan spent the season among the Micmac of Nova Scotia and Prince Edward Island.

Mr. V. Stefansson is still working among the Eskimo of the Arctic east of the Mackenzie river, near Coronation gulf.

In the archæological subdivision, Mr. H. I. Smith, assisted by Mr. W. J. Wintemberg, studied a number of typical village sites in southern Ontario.

## LIBRARY.

On moving into the new quarters, the library was rearranged and the work of cataloguing undertaken. In this work the assistance of Miss Houston of the McGill library was secured.

## MUSEUM.

The Victoria Memorial Museum is a Natural History Museum, including biology, geology, and mineralogy, ethnology and archæology. As the National Museum of Canada it is hoped that it will become the repository of all objects of scientific value found within the Dominion. To fulfil its mission, it is necessary to secure the interest and co-operation of the Canadian scientists and of the public generally. An effort will be made to have the leading scientists of the country accept honorary positions on the staff of the Museum and to actively co-operate in the various branches of Museum activity. For the present, at least, the Museum is confined to Canadian material, the object being to specialize in this until it becomes in all branches thoroughly representative of the whole Dominion, a place where the entire natural history of Canada may be studied. Each division of the Survey is in charge of its section of the Museum. The task of moving into the new building was completed during the year. With the increased space considerable progress could be made in selecting and preparing material for public display and for the scientific collections. Little progress, however, could be made toward installing collections owing to lack of furnishings.

The scientific reference collections are to be housed in the halls on the top story, while the lower halls and rotunda will be used as exhibition halls.

The work of installation has been seriously hindered by the death of Mr. Ralph Broadbent, whose intimate knowledge of the collections, long experience in exhibiting, and artistic taste would have been of the greatest service.

The needs of the Museum in the matter of staff, facilities, cases, and specimens, are pressing. While the collections at present are very valuable, and thoroughly representative of portions of the country, from other parts only scattering material has been as yet secured.

Vermin-proof storage cases are required, especially for the biological and ethnological collections.

Help is required in all branches, but particularly necessary are preparators skilled in modern museum methods.

It is hoped that these pressing needs may be met in the near future so that the Museum may speedily become worthy of its national character.

## INTERNATIONAL GEOLOGICAL CONGRESS.

Preparations are being made for the Twelfth International Geological Congress which, on the invitation of the Canadian Government, the Geological Survey, and the Canadian Mining Institute will meet in Canada during the summer of 1913. It is expected that over one thousand of the leading geologists and mining engineers of the world will attend. Dr. Frank D. Adams has been elected president, and R. W. Brock, secretary-treasurer. An Executive Committee—consisting of F. D. Adams, R. W. Brock, W. G. Miller, T. Denis, O. E. LeRoy, W. McInnes, A. P. Coleman, W. Parks, J. B. Tyrrell, G. G. S. Lindsay, and A. E. Barlow—has been formed to superintend the arrangements for the Congress. Excursions will be made to points of geological and mining interest in the Maritime Provinces, Quebec, and eastern Ontario before the meeting. During the meeting, which will be held in Toronto, short excursions will be made to points of local interest, and after the meeting, excursions will be made through the west as far as Vancouver island and the Klondike.

The main topic for discussion will be the coal resources of the world. As a basis for this discussion, a monograph on the subject is to be issued before the meeting. The proper authorities in each country have been asked to supply the information concerning coal in their respective countries. From these reports the monograph is being compiled and edited in the Geological Survey. Guide books and maps covering the excursions will be prepared. It is the intention to make the excursions the chief feature of the Congress, affording the visitors, from all parts of the world, an opportunity to become acquainted with the geology and natural resources of the whole of the accessible portions of the Dominion.

## TURTLE MOUNTAIN COMMISSION.

In the Summary Report of last year attention was drawn to the instability of Turtle mountain, Alberta. On its publication a deputation, representing the coal company operating on the seam at the base of the mountain and the citizens of Frank, waited on the government urging the appointment of a commission to examine the mountain and to delimit the area likely to be affected in case of further rockslip. It was thereupon decided to appoint a commission for this purpose, and the following gentlemen, approved of by the Geological Survey, and by the representatives of the Alberta Government, the citizens of Frank, and the coal company, were named to act on this commission: W. G. Miller, Provincial Geologist of Ontario; R. A.

Daly, Research Professor of Geology, Massachusetts Institute of Technology; George S. Rice, Coal Mining Engineer, of the United States Bureau of Mines.

Mr. Rice at the time was absent in Europe studying the effect of mining upon the stability of the ground, but on his return, the commission proceeded with their examination of conditions at Frank.

Mr. W. H. Boyd, and staff, of the Geological Survey, had meanwhile prepared a detailed topographical map of Turtle mountain and Frank for the use of the commission. The report of the commission already published,[1] confirms the opinions expressed by the Geological Survey from time to time since the great rockslip of 1903.

## MINING LAW.

The Canadian Mining Institute for some years has been urging a Federal mining law to govern the acquisition of mining rights on lands under the control of the Dominion Government, on the grounds that the industry has now attained an importance deserving this recognition, and that a law would greatly stimulate the development of the mineral resources on Crown lands. It is also believed that the provinces having control of mining lands will make their mining laws conform closely to the Federal law, and thus secure, throughout the Dominion, uniformity in the mode of dealing with mining rights. At the suggestion of the Government, the Institute formulated the principles upon which it desired the law to be based. Mr. J. M. Clarke was engaged to draft an Act based on these principles. Subsequently, Mr. F. T. Congdon and the Director of the Survey were requested by the Committee on Mining Law of the Institute to revise this draft. After spending several months on the work they submitted a new draft which, with a few minor changes, has been accepted and recommended to the Government by the Canadian Mining Institute.

## WORK OF THE DIRECTOR.

In addition to attending to the routine work of the Survey, various scientific meetings were attended, including meetings of the Council of the Canadian Mining Institute and of the Executive of the Twelfth International Geological Congress.

### Tin and Topaz in New Brunswick.

In July, a visit was paid to the molybdenite-wolframite locality near Burnthill brook, southwest branch of the Miramichi river, to ascertain the mode of occurrence

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[1] Report of the Commission appointed to investigate the conditions of Turtle Mountain, Alta., Geological Survey, Memoir No. 27.

of topaz (recognized by Mr. R. A. A. Johnston in specimens of ore received from there during the winter), and in the hope that tinstone might be found to occur with such an association of minerals. Dykes of greisen, a rock which often carries tin, were found at a number of points, and a little cassiterite (tinstone) was discovered in some of it. In order to inform the public without delay, a description of the occurrence was published in the *Canadian Mining Journal*, No. 17, September 1, 1911.

"The rocks are argillites, considered by Bailey and Ells to be of Cambro-Silurian age, that have been invaded by a granite batholite. Along the contact of the granite the argillites are metamorphosed to spotted schists and hornfels.

"Granite porphyry and aplitic dykes from the granite cut the country rock. A few basic lamprophyres were also seen, but, at least, some of the latter are older than the granite, as the quartz veins run uninterruptedly through the basic dykes.

"Within the highly metamorphosed zone of the sedimentaries, which forms a border, roughly half a mile or so wide, along the granite contact, the mineral-bearing quartz veins are developed.

"About Burnthill brook the veins appear to be best developed and most highly mineralized on the side-hill facing and opposite the mouth of the brook. Near the granite contact, which crosses the brook about a fourth of a mile from its mouth, veins do not seem so numerous nor so well mineralized.

"The strike of the country rock varies somewhat, but is about N. 67° E.,[1] dip 55° N. Both the sedimentaries and the granite are heavily jointed, the joint planes having a direction of from N. 20° to N. 40° W.

"Quartz is developed parallel to the strike of the schistosity of the sedimentaries and parallel to the joint planes. Parallel to the strike, the quartz is irregular, forming lenses and sending irregular stringers into the country rock. Between such stringers the country rock is often silicified. Parallel to the joint planes the quartz occurs in well defined, regular veins which can be traced in some cases for several hundred feet but some can be seen to pinch out. Some inclusions of country rock occur in the veins and the wall rock is occasionally silicified, thus there has been replacement as well as vein filling. The majority of the veins are under a foot in width, but at the point where the specimens were obtained last winter (they were mostly float), I found the vein for about 50 feet to average at least 2 feet.

"On the east side of Burnthill brook, at its mouth, a mineral-bearing quartz vein is bordered by greisen, a rock consisting of silvery mica and quartz. The mica of the greisen, which is muscovite, is often segregated in bands. A little farther north is another vein in which greisen predominates. North of this, near the granite contact, is a 4 foot dyke of greisen, parallel to the joint planes and the quartz veins. In it were a few quartz stringers and druses of quartz. It was in this greisen that I found tinstone. There is, therefore, evidently a gradation from the greisen to the normal quartz veins, and the veins are clearly contact phenomena of the intruded granite. The following minerals were observed in these veins: quartz, muscovite, brown mica, feldspar, topaz, fluorite, wolframite, molybdenite, pyrrhotite, chalcopyrite, and cassiterite.

"The quartz, which is milky and vitreous, is the chief gangue mineral. It occurs massive and crystallized in vugs and druses. Muscovite is most plentiful in the greisen, but is also found in the typical quartz veins. The brown mica was seen in one of the quartz veins.

"Feldspar was found in one of the banded quartz-greisen veins.

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[1] Directions are magnetic.

"The topaz occurs in a great many if not most of the quartz veins, and in considerable quantity. It is most frequently found as crystals lining vugs and druses, but it also occurs massive. The crystals are microscopic to thumb-large in size. Little unweathered material could be obtained, and the topaz seen was mostly cloudy, or stained with iron oxide. Some crystals were almost milk white, but some small clear yellow crystals of gem quality were found. In one small vein a druse with a surface area of about 8 square feet was completely coated with topaz crystals. The dark purple fluorite also occurs in druses, but sparingly.

"The brownish-black wolframite occurs in considerable amount, usually more or less segregated into bunches which are commonly near the centre or along the edges of a vein. Although bunchy, it is sufficiently plentiful to warrant some prospecting. The molybdenite is less abundant. Its occurrence is similar to that of the wolframite.

"Pyrrhotite and chalcopyrite are only sparingly present. The iron sulphide is later than and veins the wolframite. The brown cassiterite or tinstone was found in the greisen in small amount only, but it may occur also in the quartz veins.

"The granite in the neighbourhood of Burnthill brook is for the most part drift-covered, but some is exposed in the brook itself. Some small quartz veins and pegmatite dykes were observed in it. The quartz veins were similar to those in the sedimentaries, but only molybdenite was observed in them. There is no reason, however, why tin-bearing greisen, or wolframite-topaz veins should not be found in the granite, especially in fractures near its contact with the sedimentaries, where pneumatolitic action would be as apt to occur as in the sedimentaries near the contact.

"The district is one that is worth some prospecting. While one cannot yet state that it is present in commercial quantity, the wolframite is in sufficient amount to warrant prospecting, and there is a chance that prospecting might reveal larger and richer veins. There is also a possibility of finding more tin. Greisen is notably a tin-bearing rock, and the association of minerals is also suggestive of tin. Some topaz of gem quality is likely to occur. The stone in the rough is not worth much but it has some value.

"While there are no roads, if a workable deposit were found, transportation would not be difficult. In winter supplies might be brought on the ice or a road would not be difficult of construction; in summer they might be floated in scows down the river from the National Transcontinental railway and the products floated on down to Boiestown. The chief difficulty in prospecting is the paucity of rock exposures, the wooded nature of the country, and the depth of wash and drift over much of it.

"To prospect, the contact of the granite should be sought and followed, and prospecting carried on both in the granite and in the metamorphosed zone of the argillites. In the latter the strike of the rocks should be followed, as the promising mineral-bearing veins are parallel to the joint planes at right angles to the strike. Where float is found in quantity the source is usually close at hand."

The locality is reached from Boiestown, on the Fredericton branch of the International railway, by driving about 9 miles to Campbell Settlement, and a day's poling up the southwest Miramichi in a canoe.

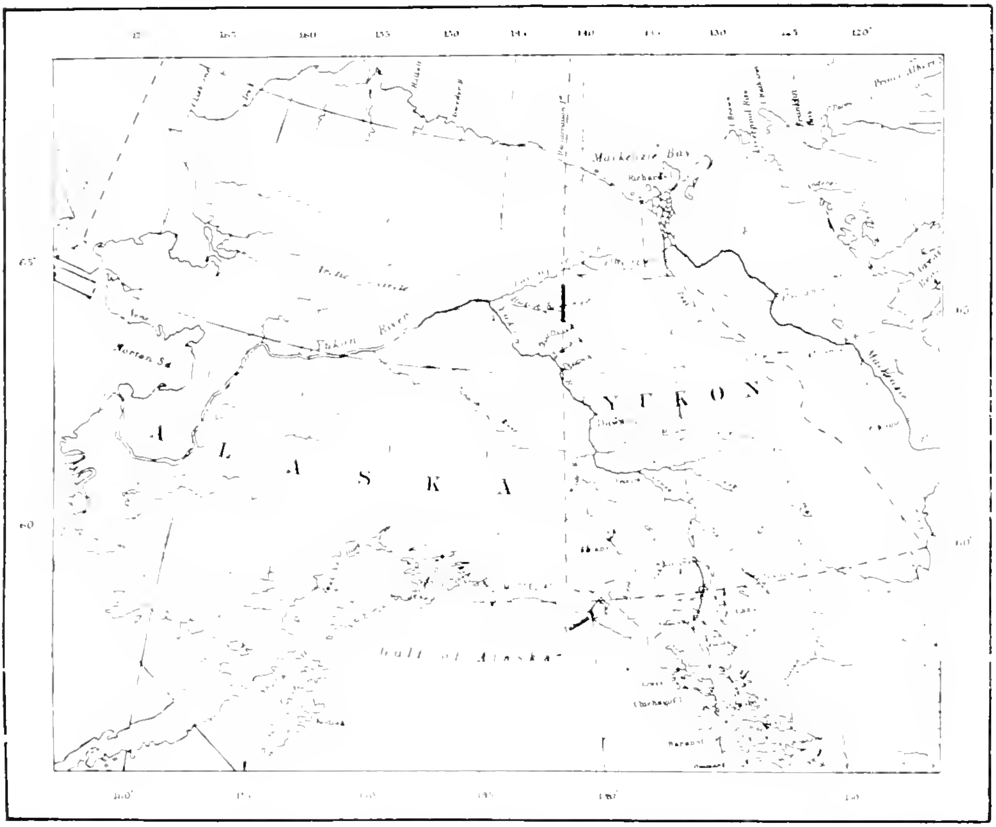
## Western Canada.

On August 11, I left Ottawa for Edmonton to discuss with the Provincial government the arrangements for the Turtle Mountain Commission. From Edmonton I went to Prince Rupert, and up the Skeena river to Hazelton, visiting some of the prospects in the vicinity. These have already been described by Mr. W. W. Leach.[1]

[1] Summary Reports: 1909, pp. 65-66; 1910, pp. 97-98.

Returning to Prince Rupert, a few days were spent with Mr. McConnell on Bear river, Portland canal, visiting prospects in this district.

My main work in the west was to have been a reconnaissance survey of the Iskut river, a tributary of the Stikine, and all arrangements had been made for carrying out this project which, however, had to be abandoned on account of an attack of typhoid fever. I returned to Ottawa, November 10.




DIAG. 1. Yukon and Alaska, showing the area along the International Boundary that was geologically mapped by the Canadian Geological Survey during the season of 1911.

# I

## GEOLOGY OF A PORTION OF THE YUKON-ALASKA BOUNDARY BETWEEN PORCUPINE AND YUKON RIVERS.

*(D. D. Cairnes.)*

### INTRODUCTION.

#### GENERAL STATEMENT.

With the exception of a few days in October, which were spent examining certain quartz claims in the vicinity of Dawson,[1] the field season of 1911 was devoted to studying and mapping the geology along a portion of the 141st meridian (the Yukon-Alaska boundary) between Yukon and Porcupine rivers (see Diag. 1). For a number of years the desirability of obtaining a geological section along the International Boundary between Alaska and Yukon has been recognized by both United States and Canadian workers in these territories; and accordingly the Geological Surveys of the United States and Canada decided to unite in performing this work. A commencement was made during the past summer, this time being considered particularly opportune as a number of International Boundary Survey parties were to be engaged in work along the portion of the 141st meridian under cousideration, and it was possible to make arrangements for those engaged in the geological work to become attached to these parties from time to time, thus obviating the necessity of procuring separate outfits for the geological work—and effecting in this way a considerable economy.

The Geological Surveys undertook to perform the geological work along that portion of the boundary lying between Yukon river and the Arctic ocean, a distance of about 340 miles, the investigations to the south and north of Porcupine river to be conducted respectively by the Canadian and United States departments. Mr. A. G. Maddren commenced at the Porcupine and continued northward for the United States Geological Survey, and the writer, in accordance with instructions from the Director of the Canadian Geological Survey, undertook the geological work south of this river.

I desire to express my indebtedness to the various members of the International Boundary Survey parties with whom I came in contact, all of whom were most courteous and obliging. Particular thanks are due Messrs. J. D. Craig and Thos. Riggs, Jr., who had charge respectively of the Canadian and United States parties; these gentlemen rendered numerous favours, and facilitated the geological work in every possible way.

The topographic work was performed by the International Boundary Surveys, and either copies of the finished map or tracings of the plane-table sheets were supplied me, thus enabling the geology to be much more readily and accurately plotted than would otherwise have been possible. The topography was mapped for 2 to 2½ miles on each side of the boundary, giving a map 4 to 5 miles wide; the work was plotted in the field to the scale of 1: 45,000 and is to be published on a scale of 1:62,500 or about one mile to the inch, the contour interval being 100 feet.

Geological work was commenced during the past season, at the Orange fork of Black river, at latitude 66°09′, and continued northward to latitude 67°00′—a

[1] For descriptions of these properties, see pages 33 of this Summary Report.

distance of about 60 miles—the geological formations being investigated and mapped for 2 to 2½ miles on each side of the boundary line to cover the International Boundary Survey's topographic map. My assistant during the summer was Mr. M. Y. Williams.

### ACCESSIBILITY.

To reach the district the usual route was followed as far as Whitehorse, *i.e.* the parties travelled to Skagway, Alaska, by steamer from either Seattle or Vancouver, distances respectively of 1,000 and 867 miles, and thence proceeded to Whitehorse, 101 miles distant, over the White Pass and Yukon railway. To get from Whitehorse to Dawson during the season of open navigation, it is customary to take passage on one of the steamers that ply regularly up and down Lewes and Yukon rivers between these points, a distance by river of about 460 miles: from the time of the 'freeze-up' in the autumn to the opening of navigation in spring, stages make regular trips over the Dawson-Whitehorse wagon road. Slack water stretches generally freeze over about the middle of October, but during some seasons the rivers remain open until well into November: the rivers generally open early in May, but the ice remains longer on the lakes. Lake Laberge, which is only a widened portion of Lewes river, having almost no perceptible current, generally blocks navigation until the first week in June.

During the past season the Boundary Survey parties arrived in Whitehorse early in May and were desirous of reaching Dawson with as little delay as possible. As the wagon-road at this time in the spring was in an almost impassable condition for stages, due to mud caused by rains and melting snow, the majority of the men walked to Carmacks, a point on Lewes river about midway between Whitehorse and Dawson, and at a distance of 131 miles measured along the wagon-road from Whitehorse; at Carmacks a steamer was waiting to convey them to Dawson. Others took small boats to the head of Lake Laberge, and then either walked or rode in sleds pulled by dogs, over the ice to the foot of the lake which is about 31 miles long: thence they went by boats to Carmacks and joined those who had come over the wagon-road.

From Dawson, the writer went by steamer down Yukon river to the mouth of Sheep creek and thence by trail to the point where the 141st meridian intersects the Orange fork of Black river, at which point the actual field work commenced. The horses to be used by the line-cutting party to which the writer and his assistant were attached were driven from the mouth of Sheep creek to the point where the International Boundary crosses Charlie creek, over a trail which for the greater part of the distance traverses muskeg and tundra with occasional snow-capped summits—the trip being made in 11 days. The provisions, outfit, etc., for the first half of the season, were poled up Charlie creek to the boundary, and thence were packed by the horses along the line as required. The intention was to send the supplies for the remainder of the season up Black river by means of a gasoline launch, but low water prevented this, with the result that the necessary provisions and horse feed had to be packed by horses south along the boundary from New Rampart House on Porcupine river. At the close of the season the writer accompanied the pack-team north to Porcupine river, and thence went down stream in small boats to Fort Yukon on Yukon river, where passage was taken on one of the lower Yukon River steamers to Dawson. Arriving at Dawson in September, the journey to Whitehorse was made all the way by steamer. The trip from Ottawa to the Orange fork of Black river, where the geological work was commenced, consumed 51 days—from May 1 to June 20 inclusive—but the journey from camp to Ottawa was made in 29 days, the return trip being much the quicker, as navigation was open on Lewes river, and the unavoidable delays contingent upon travelling with a large party, as in the spring, were obviated.

## Summary and Conclusions.

Topographically the district under consideration is included in what is generally known as the Yukon plateau, and in certain localities where the prevailing bed-rock is limestone or dolomite, the plateau characteristics are still well preserved, and extensive upland tracts occur over 3,000 feet above sea-level that are strikingly even and plain-like in contour. Outside these areas and where the bed-rock consists dominantly of other sediments such as slates, phyllites, quartzites, and related rocks, the plateau surface has been almost or entirely destroyed, and the topography is characterized by generally well-rounded hills and ridges irregularly distributed and dependent for their form and position, largely or entirely, upon the geological formations composing them.

The geological formations outcropping throughout the district consist dominantly of Quaternary, Mesozoic, and Palæozoic sediments, but a few small exposures of intrusive igneous rocks also occur. The Palæozoic sediments belong to the Ordovician-Silurian, and the Carboniferous periods. The Ordovician-Silurian beds are chiefly limestones, dolomitic limestones, and dolomites, and the Carboniferous members consist mainly of limestones, cherts, and cherty conglomerates. The Mesozoic beds are thought to be chiefly Cretaceous, and consist largely of sandstones, shales, phyllites, quartzites, dolomites, and magnesites. The Quaternary formations embrace the superficial deposits, mainly gravels, sands, clays, muck, peat, soil, and ground-ice. The specimens of the intrusives that have been examined, prove to be syenites, diorites, diabases, and andesites.

Marble, lithographic limestones, and magnesite occur extensively in parts of the district, and would be of considerable value if found in more accessible localities. Situated as they are, however, they have no present economic importance.

## General Character of the District.

### TOPOGRAPHY.

The district under consideration lies within and toward the northern edge of what is generally known as the Yukon Plateau physiographic province. This terrane is a portion of the great Central Plateau region that trends northward through central British Columbia and continues northwesterly through Yukon, and northwesterly and westerly through Alaska to Bering sea, following in a general way, the direction of the Pacific coast. In Yukon and Alaska, this plateau province is bordered on one side by the Rocky Mountain system and on the other by the Pacific Mountain system, and throughout its length has its centre approximately marked by Yukon river.

Within the area mapped during the past summer (1911) two distinct types of topography are represented, one of which possesses marked plateau features, while the other is almost entirely lacking in these characteristics. From the Orange fork of Black river northward along the 141st meridian for over 40 miles, the exposed rock formations are composed largely of Mesozoic slates, phyllites, quartzites, and also to a less extent of Carboniferous cherts, cherty conglomerates, and limestones, and there the topography is characterized by irregularly distributed, generally well rounded hills and ridges, that are dependent largely or entirely for their form and position upon the rocks composing them. The higher summits invariably consist of some resistant, indurated material, generally quartzite, and the valleys are everywhere underlain by slates, phyllites, or related beds that are readily susceptible to weathering and eroding agencies.

To the north of this irregular topography the bed-rock is dominantly limestone and dolomite, and there an even, but gently undulating upland over 3,000 feet above sea-level, is presented which truncates the limestone and dolomite beds wherever these are unconformable with the almost horizontal plateau surface. The upland is dissected by gorge-like valleys having precipitous and, in places, nearly perpendicular walls, at the junction of which with the upland surface, decided shoulders marking topographic unconformities are always in evidence.

Standing on the upland, well back from the valley walls, a plain-like surface is presented with only occasional small rounded summits rising above the general level. Such a nearly base-levelled or peneplanated and typically old topography was apparently produced when the region stood much nearer sea-level than at present. In accordance with this assumption the planating process must have been interrupted by a regional uplift while occasional hills still remained to relieve the monotony of the landscape, and these now constitute monadnocks rising above the general plateau surface. The uplift rejuvenated the streams which quickly trenched their valleys in the upland. The Ordovician and Silurian limestones have proved to be much more resistant to ordinary sub-aerial erosive processes than the Mesozoic and Carboniferous rocks to the south, as there the old plateau surface has been almost entirely destroyed and is now only indicated by occasional straight-topped ridges, and by a certain rather indefinite general summit level which may be noted in some localities.

As to the date of the uplift, the evidence in the district only shows that it was subsequent to the deposition of the most recent of the exposed Mesozoic rocks.

In addition to the agencies at work tending to destroy the upland and reduce the region again to sea-level, other forces are engaged in grading the district within itself. The results of this process are most marked on the surfaces of the remaining plateau fragments, where the features of the already plain-like areas are being smoothed over or equalized, thus producing a topography more and more uniform in contour. The forces included in this process are mainly nivation, frost, and chemical action. These tend to remove the materials from the upper levels and deposit them in the adjoining lower places, thus filling the hollows with the material derived from the adjoining hills. Especially in the Ordovician-Silurian areas this equalizing process is facilitated by the massive character of the rocks themselves, and is aided by the existing condition of almost perpetual frost in the soil, which obstructs the drainage everywhere except along the main waterways. The products of decomposition of the exposed beds thus remain near their parent source, and constitute the soil or muck that goes to form the tundra which blankets the greater part of the even upland tracts, and fills many of the existing bed-rock depressions, resulting in a strikingly uniform surface being produced.

The area under consideration is drained largely or entirely by Black river and its numerous tributaries which flow into Porcupine river. The main streams all have a westerly trend and consequently are transverse to the area mapped. The valley of the main Black river is about 5 miles in width, but those of its tributaries rarely if ever exceed 2 miles. The depressions occupied by the smaller streams are generally typically V-shaped and range from gorge-shaped incisions in the northern part of the area to those having much less steeply inclined walls. The form of the valley of the main Black, as well as of some of its tributaries in places, depends on the structure of the underlying beds, the valley walls on one side of the stream being steep and on the other gently inclined. The Mesozoic beds to the south of Black river dip at low angles in a northerly direction, causing the land-surface to slope gradually down to the valley bottom throughout a distance of over 4 miles, while to the north the river is bounded by precipitous walls due to the easy and abrupt breaking of the brittle slaty beds across the bedding planes.

The valley bottoms of the larger streams contain considerable amounts of gravel, sand, etc., largely of local origin, that have been deposited during wet seasons; and the main streams all possess wide flood channels showing that they are subject to seasons of extremely high water.

## Summary and Conclusions.

Topographically the district under consideration is included in what is generally known as the Yukon plateau, and in certain localities where the prevailing bed-rock is limestone or dolomite, the plateau characteristics are still well preserved, and extensive upland tracts occur over 3,000 feet above sea-level that are strikingly even and plain-like in contour. Outside these areas and where the bed-rock consists dominantly of other sediments such as slates, phyllites, quartzites, and related rocks, the plateau surface has been almost or entirely destroyed, and the topography is characterized by generally well-rounded hills and ridges irregularly distributed and dependent for their form and position, largely or entirely, upon the geological formations composing them.

The geological formations outcropping throughout the district consist dominantly of Quaternary, Mesozoic, and Palæozoic sediments, but a few small exposures of intrusive igneous rocks also occur. The Palæozoic sediments belong to the Ordovician-Silurian, and the Carboniferous periods. The Ordovician-Silurian beds are chiefly limestones, dolomitic limestones, and dolomites, and the Carboniferous members consist mainly of limestones, cherts, and cherty conglomerates. The Mesozoic beds are thought to be chiefly Cretaceous, and consist largely of sandstones, shales, phyllites, quartzites, dolomites, and magnesites. The Quaternary formations embrace the superficial deposits, mainly gravels, sands, clays, muck, peat, soil, and ground-ice. The specimens of the intrusives that have been examined, prove to be syenites, diorites, diabases, and andesites.

Marble, lithographic limestones, and magnesite occur extensively in parts of the district, and would be of considerable value if found in more accessible localities. Situated as they are, however, they have no present economic importance.

## General Character of the District.

### TOPOGRAPHY.

The district under consideration lies within and toward the northern edge of what is generally known as the Yukon Plateau physiographic province. This terrane is a portion of the great Central Plateau region that trends northward through central British Columbia and continues northwesterly through Yukon, and northwesterly and westerly through Alaska to Bering sea, following in a general way, the direction of the Pacific coast. In Yukon and Alaska, this plateau province is bordered on one side by the Rocky Mountain system and on the other by the Pacific Mountain system, and throughout its length has its centre approximately marked by Yukon river.

Within the area mapped during the past summer (1911) two distinct types of topography are represented, one of which possesses marked plateau features, while the other is almost entirely lacking in these characteristics. From the Orange fork of Black river northward along the 141st meridian for over 40 miles, the exposed rock formations are composed largely of Mesozoic slates, phyllites, quartzites, and also to a less extent of Carboniferous cherts, cherty conglomerates, and limestones, and there the topography is characterized by irregularly distributed, generally well rounded hills and ridges, that are dependent largely or entirely for their form and position upon the rocks composing them. The higher summits invariably consist of some resistant, indurated material, generally quartzite, and the valleys are everywhere underlain by slates, phyllites, or related beds that are readily susceptible to weathering and eroding agencies.

To the north of this irregular topography the bed-rock is dominantly limestone and dolomite, and there an even, but gently undulating upland over 3,000 feet above sea-level, is presented which truncates the limestone and dolomite beds wherever these are unconformable with the almost horizontal plateau surface. The upland is dissected by gorge-like valleys having precipitous and, in places, nearly perpendicular walls, at the junction of which with the upland surface, decided shoulders marking topographic unconformities are always in evidence.

Standing on the upland, well back from the valley walls, a plain-like surface is presented with only occasional small rounded summits rising above the general level. Such a nearly base-levelled or peneplanated and typically old topography was apparently produced when the region stood much nearer sea-level than at present. In accordance with this assumption the planating process must have been interrupted by a regional uplift while occasional hills still remained to relieve the monotony of the landscape, and these now constitute monadnocks rising above the general plateau surface. The uplift rejuvenated the streams which quickly trenched their valleys in the upland. The Ordovician and Silurian limestones have proved to be much more resistant to ordinary sub-aerial erosive processes than the Mesozoic and Carboniferous rocks to the south, as there the old plateau surface has been almost entirely destroyed and is now only indicated by occasional straight-topped ridges, and by a certain rather indefinite general summit level which may be noted in some localities.

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The valley bottoms of the larger streams contain considerable amounts of gravel, sand, etc., largely of local origin, that have been deposited during wet seasons; and the main streams all possess wide flood channels showing that they are subject to seasons of extremely high water.

CLIMATE.

The climate of the district appears to vary greatly from year to year. 'Old-timers' in the country report that some summers are exceptionally wet and cold, and that rain or snow falls during more than half the days. Last season (1911) however, was quite the reverse of this, being warm, frequently uncomfortably so, from June 1, to September 15, during which time but few showers occurred and these were generally light and seldom of more than 3 or 4 hours duration. In fact the climate was almost ideal, although the mosquitoes were very troublesome, and were most active and persistent throughout the entire summer.

The rivers and creeks generally open about May 1, but on some of the lakes the ice remains until the first week in June. Slack water stretches freeze over any time after October 1, but occasionally the rivers remain open until near the end of November.

FLORA AND FAUNA.

The valleys are generally well timbered and about one-third of the entire country is forest clad, the northern and eastern slopes being considerably more open than the southern and western hillsides; timber line extends to about 2,900 feet above sea-level. Five principal forest members occur that attain the dimensions of trees and ten varieties of shrubs were noted. Specimens were collected during the season of all the plants, including trees and shrubs, that were noted in the district, and these were delivered to Mr. J. M. Macoun of this department, from whose report the names here used are taken. The five main varieties of trees are, white spruce, aspen poplar, balsam poplar, northern canoe birch, and tamarack or American larch, and the more important shrubs include juniper, five species of willow, two species of alder, dwarf birch, and 'soapollali.' The spruce is the most important of the trees and constitutes about one-half of the forest growth of the district, extending on timbered hillsides in most places to an elevation of 2,400 feet, and in occasional draws, 400 or even 500 feet higher; specimens having 21 inch stumps were noted in some of the valley-bottoms, but the larger individuals generally range from 12 to 16 inches, and a tree 18 inches in diameter 3 feet from the ground is somewhat exceptional. The two varieties of poplar are very plentiful both on the valley floors and on the hillsides; these have stumps, generally less, and rarely more than 10 inches in diameter. Northern canoe birch occurs in occasional small groves both in the valleys and on the mountain sides, but it rarely has stumps exceeding 10 inches in diameter. Larch was only found in one locality, and only a few small specimens of this tree were noted. Willows, alders, and dwarf birch are very plentiful, reaching to timber line, and in places constituting quite dense thickets; the dwarf birch extends probably the highest and grows prevailingly near timber line, forming in places a dense undergrowth on the upland surfaces; the soapollali and juniper are not nearly so plentiful.

Eleven principal varieties of wild fruits were noted, some of which grow in great abundance; these are, bilberry, alpine bearberry, crowberry, bog apple or yellow berry, northern comandra, red currant, black currant, arctic raspberry, 'soapollali,' foxberry or northern cranberry, and high-bush cranberry. Of these the bilberry, bog apple, crowberry, northern cranberry, and bearberry are particularly abundant, and in places extend over entire hillsides and ridge tops. The high-bush cranberries, red and black currants, and raspberries occur only in occasional patches; the comandra and soapollali berries are fairly abundant but are not pleasant to taste.

The following is from Mr. Macoun's report on the plant specimens, including trees and shrubs, collected in this district:—

'Several species are quite unknown to either my father or myself, and these, with a few others about which we are uncertain, have been sent to specialists. Your collection is valuable in the first place as being the only one that has been brought from that region, and even did it contain nothing new either to Canada or science it would constitute a valuable addition to our knowledge of the flora of northern Canada. However, there are at least ten species that had not before been collected in Canada, and there are at least five new species of which one will, I believe, constitute a new genus. I am keeping a duplicate list on which I shall make corrections as I hear from specialists, and when this has been done the corrected list will be given you. As I have already told you, the specimens, though sometimes few in number, are all excellent in quality.

*Polypodiaceae*—

*Aspidium fragrans*, Sw.

*Equisetaceae*—

*Equisetum sylvaticum*, L.
" *pratense*, L.
" *fluviatile*, L.

*Lycopodiaceae*—

*Lycopodium Selago*, Desc.
" ***annotinum***, L., *var. bungens*, Desv.
" *alpinum*, L.
" *clavatum*, L.

*Pinaceae*—

*Juniperus nana*, Willd.
*Picea canadensis*, (Mill.) BSP.
*Larix laricina*, (DuRoi) Koch.

*Gramineae*—

*Hierachloa alpina*, R. and S.
*Arctogrostis latifolia*, Griseb.
*Calamagrostis Langsdorfii*, Trin.

*Cyperaceae*—

*Carex microchaeta*, Holm.
" *rigida*, Good?
" *rariflora*, Smith.

*Juncaceae*—

*Luzula glabrata*, Hoppe.

*Liliaceae*—

*Zygadenus elegans*, Pursh.

*Orchidaceae*—

*Cypripedium guttatum*, Sw.

*Salicaceae*—

*Populus tremuloides*, Mx.
" *balsamifera*, L.
*Salix anglorum*, Cham.
" *orbicularis*, Andr.
" *phyllicifolia*, Andr.
" *Richardsoni*, Hook.
" *Seemanii*, Rydb.

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*Betulaceae*—

*Betula glandulosa*, Mx.
" *resinifera*, (Regel.) Britton.
*Alnus tenuifolia*, Nutt.
" *sinuata*, (Regel.) Rydb.

*Polygonaceae*—

*Polygonum alpinum var. alaskanum*. Small.

*Santalaceae*—

*Comandra livida*, Rich.

*Caryophyllaceae*—

*Silene acaulis*, L.
" *repens*, Patrin.
*Stellaria longipes*, Goldie var. *laeta*, T. and G.
*Arenaria lateriflora*, L.
*Merckia physodes*, Fisch.

*Ranunculaceae*—

*Anemone Richardsoni*, Hook.
*Anemone* (?).
*Anemone narcissiflora*, L.
*Pulsatilla* (?).
*Ranunculus Lapponicus*, L.
" *Eschscholtzii*, Schlecht.
" *affinis*, R. Br.
*Delphinium glaucum*, S. Wats.
*Aconitum delphinifolium*, DC.

*Papaveraceae*—

*Papaver radicatum*, Rottb.

*Cruciferae*—

*Cardamine purpurea*, Cham. and Schl.
*Parrya macrocarpa*, R. Br.
*Lesquerella arctica*, (Rich) Watson.
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*Crassulaceae*—

*Sedum Rhodiola*, DC.

*Saxifragaceae*—

*Saxifraga tricuspidata*, Retz.
*Therophron Richardsoni*, (Hook.) Wheelock.
*Parnassea palustris*, L.
*Ribes rubrum*, L.
" *Hudsonianum*, Rich.

*Rosaceae*—

*Spiraea betulifolia*, Pallas.
*Potentilla nivea*, L.
" *fruticosa*, L.
*Rubus Chamaemorus*, L.
" *arcticus*, L.
" *stellatus*, Smith.
*Dryas integrifolia*, Ch. and Sch.
*Rosa acicularis*, Lindl.

*Leguminoseae*—

*Lupinus arcticus*, Wats.
*Oxytropis podocarpa*, Gray.
*Hedysarum boreale*, Nutt.

*Empetraceae*—

*Empetrum nigrum*, L.

*Violaceae*—

*Viola palustris*, L.

*Elaeagnaceae*—

*Shepherdia canadensis*, Nutt.

*Onagraceae*—

*Epilobium angustifolium*, (L.) Scop.
" *latifolium*, L.

*Cornaceae*—

*Cornus canadensis*, L.

*Ericaceae*—

*Ledum palustre*, L.
*Rhododendron Lapponicum*, Wahl.
*Loiseleuria procumbens*, Desv.
*Andromeda Polifolia*, L.
*Cassiope Mertensiana*, (Bong.) Don.
*Arctostaphylos alpina*, Spreng.
*Vaccinium uliginosum*, L.
" *Vitis-Idaea*, L.

*Diapensaceae*—

*Diapensia Lapponica*, L.

*Gentianaceae*—

*Gentiana glauca*, Pall.

*Polemoniaceae*—

*Phlox Sibirica*, L.

*Borraginaceae*—

*Mertensia alaskana*, Britton.
*Myosotis sylvatica*, *Hoffm. var. alpestris*, Koch.
*Eritrichium nanum*, *Schrad. var.*

*Selaginaceae*—

*Gymnandra stelleri*, Cham. and Schlecht.

*Scrophulariaceae*—

*Castilleja pallida*, *Kunth. var. septentrionalis*, Gray.
*Pedicularis flammea*, L.
" *Langsdorfii*, *Fisch. var. lanata*, Gray.

*Lentibulariaceae*—

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*Rubiaceae*—

*Galium boreale*, L.

*Caprifoliaceae*—

*Viburnum pauciflorum*, Pylaie.
*Linnaea borealis*, *Gronov. var americana* (Forbes) Rehder.

*Valerianaceae*—

*Valeriana bracteosa*, Britton.

*Campanulaceae*—

*Campanula lasiocarpa*, Cham.

*Compositae*—

*Crepis elegans*, Hook.
*Solidago multeradiata*, Ait.
*Aster sibiricus*, L.
*Antennaria.*
*Chrysanthemum integrifolium*, Rich.
*Artemisia.*
*Petasites frigida* (L.) Fries
*Arnica angustifolia*, Vahl.
" *alpina*, Olin.
*Arnica.*
*Saussurea remotiflora* (Hook.) Rydb.

'The characteristic mosses are: Sphagnum acutifolium. Sphagnum acutifolium var. rubrum. Sphagnum acutifolium var. versicolor. Sphagnum compactum. Dicranum fuscescens. Dicranum Bergeri. Polystichum strictum. Splachnum luteum.

'Among the lichens are: Nephroma arctica. Cladonia sylvatica. Cladonia rangiferina. Cladonia Cornuti.'

A few plants from this collection were sent to Dr. Edward L. Greene. Associate in Botany, United States National Museum, Washington, D.C. Among these specimens is a plant considered by Dr. Greene to belong to a new genus which he has named *Melanidion.* This was collected north of Runt creek. at long. 141°, lat. 66° 18′, and at an elevation of 2,300 feet above sea-level, and is described by Dr. Greene as follows:—

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'*Melanidion boreale.*—Leaves unknown. as also the root and the absolutely basal part of the plant. The branches, the rather long pedicels of the fruits, and the middle of each sepal are all whitened by a villous pubescence. The calyx is wholly of a very dark purple, yet quite herbaceous as to texture. The specimen is very mature. only a few of the corollas remaining at the summits of two of the racemose branches. Most of the silicles had shed their seeds. The valves are straw-coloured, also reticulate-veiny both without and within. The type is of so strange appearance and character that I am unable to name any genus to which I should say that it is nearly allied.'

Dr. Greene has also described a new species of *Anemone* from among the specimens sent him, as follows:—

'*Anemone Cairnesiana.*—Leaves at time of flowering, small: barely half-inch long and not much broader, ternately cut into many oblong acutish lobes and glabrous, but the petioles loosely villous; scapes stoutish, only two or three inches high, leafless, but with a conspicuous invelucre of three leaves at about the middle, each divided into about three narrowly oblong or oblong-linear segments each somewhat callous at tip, all glabrous above, beneath clothed loosely with long, somewhat appressed silky hairs; peduncle of the solitary flower whitened with a villous woolliness at and near the summit; perianth very large for the plant, measuring 1½ to 1¾ inches across in expansion, the sepals oblong, seven or eight in number, and of a deep slightly purplish blue; filaments still more deeply purple, the anthers elliptical and blackish; styles in the flower rather prominent, pubescent; fruit unknown.

'This very beautiful new anemone Dr. Cairnes obtained from two localities in the region; the first specimens are from somewhere north of the Orange fork of the Black river, long. 141°, lat. 66° 10′, the land having an altitude of some 2,000 feet. These were taken on June 21, 1911. Other specimens, and these the best, are from between Teecat and Runt creeks, the altitude 3,000 feet, and were gathered June 26. This is, perhaps, the most beautiful of American species of the genus, and the blue colour of the flowers is remarkable. I gladly dedicate the species to Dr. Cairnes. Viewed as a whole the plant bears some suggestion of *Pulsatilla*; but the perianth is rotate, and from what I see in the pistils as they exist in the flower, I am confident the fruit when known will be shown to be that of genuine *Anemone*.'

Moose, caribou, and sheep are somewhat plentiful in many localities. The moose are the large giant moose, *Alces gigas*; the caribou are also the giant variety, Osborn's caribou, *Rangifer osborni*; and the sheep are Dall's mountain sheep, *Ovis dalli*. Black, brown, and grizzly bears are also plentiful, and with wolves, wolverine, martin, lynx, ermine, and fox constitute the chief fur-bearing animals of the district. Rabbits are also quite plentiful.

The chief game birds noted are: rock ptarmigan, *Lagopus rupestris rupestrus*, (Gmelin); willow ptarmigan, *Lagopus lagopus*; Alaska spruce partridge, *Canachites canadensis osgoodi* (Bishop); Hutchin geese, *Branta canadensis hutchinsi* (Rich), and several varieties of ducks. The ptarmigan are very plentiful and are to be found on nearly every hill. The partridge are also quite abundant, as also are the ducks and geese in certain seasons. A considerable variety of other birds was noted in the district, but only a few specimens were obtained; these have been examined by Mr. P. A. Taverner of this department, who has supplied the above identification as well as the following list: the Alaska jay, *Periospcus canadensis fumifrons* (Ridg.); Swainson hawk, *Butec swainsoni* (Bonaparte); hawk owl, *Surnia ulula coparoch* (Muller); northern varied thrush, *Ixoreus naevius meruloides* (Swain); townsend solitaire, *Myadestes townsendi* (Aud.); grey-checked thrush, *Hylocicicla alicie aticiae*. (Baird)?; fox sparrow, *Passerella iliaca iliaca* (Merriam), Vole (Sp.?).

The streams are generally well supplied with fish, mainly a variety of grayling.

## General Geology.

### GENERAL STATEMENT.

The geological formations of the area under consideration are mainly of sedimentary origin, but a few small exposures of intrusives were also noted. The sedimentary beds consist of Quaternary gravels, sands, clays, muck, peat, soil, and ground-ice, and Mesozoic, Carboniferous, and Ordovician-Silurian, sandstones, shales, slates, phyllites, quartzites, cherts, cherty conglomerates, limestones, dolomitic limestones, *Rubiaceae*—

*Galium boreale*, L.

*Caprifoliaceae*—

*Viburnum pauciflorum*, Pylaie.
*Linnaea borealis, Gronov. var americana* (Forbes) Rehder.

*Valerianaceae*—

*Valeriana bracteosa*, Britton.

*Campanulaceae*—

*Campanula lasiocarpa*, Cham.

*Compositae*—

*Crepis elegans*, Hook.
*Solidago multeradiata*, Ait.
*Aster sibiricus*, L.
*Antennaria.*
*Chrysanthemum integrifolium*, Rich.
*Artemisia.*
*Petasites frigida* (L.) Fries
*Arnica angustifolia*, Vahl.
" *alpina*, Olin.
*Arnica.*
*Saussurea remotiflora* (Hook.) Rydb.

'The characteristic mosses are: Sphagnum acutifolium, Sphagnum acutifolium var. rubrum, Sphagnum acutifolium var. versicolor. Sphagnum compactum, Dicranum fuscescens, Dicranum Bergeri, Polystichum strictum, Splachnum luteum.

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TABLE OF FORMATIONS.[1]

*Sedimentary.*

| | | |
|---|---|---|
| Quaternary | Superficial deposits | Chiefly gravel, sand, clay, muck, peat, soil, and ground-ice. |
| Mesozoic (Probably largely Cretaceous) | Orange group | Chiefly sandstone, shale, slate, phyllites, quartzite, dolomite, and magnesite. |
| Carboniferous | Racquet series | Chiefly limestone, chert, and cherty conglomerate. |
| Ordovician-Silurian | Porcupine group | Limestone, dolomitic limestone, and dolomite. |

*Igneous.*

| | | |
|---|---|---|
| Mesozoic or Post Mesozoic | Small isolated exposures of syenite, diabase, diorite, and andesite. | |

DESCRIPTIONS OF FORMATIONS.

*Porcupine Group.*[2]

The rocks belonging to the Porcupine group constitute the bed-rock of the northern 20 miles, approximately, of the area mapped. These beds have an aggregate thickness of at least 5,000 feet and consist of limestones, dolomitic limestones, and dolomites, that range from white through various shades of grey to almost black, and are even occasionally decidedly reddish or pink in colour. Structurally, these rocks are characteristically massive and crystalline, but, especially in some of the darker members, the bedding planes in places are still well preserved. Some heavy beds of beautifully white marble were noted, and in places extensive deposits of lithographic limestone also occur. The members of this group underlie the area in which they occur in gently undulating fashion, the folding being only of local significance.

A number of fossils were collected from different beds of the Porcupine group and all are either of Ordovician or Silurian age. Of these, Dr. E. M. Kindle, of the United States Geological Survey, says:—

'Lot VII j 5.[3]—This lot contains in addition to an undetermined sponge and a poorly preserved *Cladopora*-like coral two well marked species which strongly suggest the Silurian age of the faunule. One of these is a *Meristella* sp. undet. which, so far as can be judged by external characters, is identical with a species in the Wright collection from Glacier bay, Alaska, which has been referred to a late Silurian horizon.

The other is a large ostracode valve belonging to an undetermined species of *Leperditia*. This ostracode represents a form distinct from any of the very large

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species of this group in the Glacier Bay fauna. The evidence afforded by these two species is not, of course, entirely conclusive, but it is sufficient to suggest provisional reference of this fauna to a late Silurian horizon.

'Lot VI l 48.—The collection from this locality includes a small number of species, which are listed as follows:—

*Favosites* cf. *niagarensis*.
*Camarotoechia* cf. *neglecta*.
*Conchidium* cf. *greenei*.
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In addition to the species listed above, two or three species of undetermined bryozoa are present. The *Conchidium*, which is comparable with *C. greenei*, outranks all of the others combined as regards number of individuals represented. This dominant species of the fauna has, however, more numerous and finer striæ as well as other features which distinguish it from *C. greenei*, and doubtless characterize a new species. Although none of the species have been definitely identified with described species, the assemblage is of such a character as to leave no doubt as to its Silurian age. It probably represents a Middle Silurian horizon and may belong to the Silurian fauna which the writer listed from the Porcupine River valley.[1] A larger collection of fossils would be required to determine the latter point.

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With the exception of *H. catenulatus* none of the species has thus far been recognized in the Alaskan faunas. I consider the fauna to be probably of early Silurian age. It appears to be somewhat older than the fauna which has been listed from the Porcupine River locality.[2]

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of the material representing this coral does not indicate whether or not it can be discriminated from the Silurian species of *Favosites*. The genera *Favosites, Striatapora*, and *Diphphyllum* have not previously been found associated together in a pre-Silurian fauna so far as the writer is aware. The presence in the fauna, however, of such characteristic Ordovician fossils as *Calapoecia canadensis, Maclurina manitobensis*, and *Dinorthis proavita* seems clearly to place the fauna in the Ordovician. The last named species resembles somewhat the Silurian shell *Orthis flabellites*, but Mr. E. O. Ulrich who has examined the specimens considers them identical with the Minnesota representatives of *D. proavita*. *M. manitobensis* is a characteristic and widely distributed species in the Ordovician of Alaska, occurring in both the extreme eastern and western parts of the territory. *Calapoecia canadensis* is another Ordovician species which has a wide distribution in the northern part of the continent. It is one of the abundant corals in the Ordovician of the Seward peninsula.'[1]

In addition, Mr. Lawrence Lambe, of this department, states:—

'Three limestone fragments of fossil coralla, from Dr. Cairnes' Yukon-Alaska boundary collection of 1911, are determined by me as follows:—

From locality VI, C. 22:—

1 specimen of *Favosites gothlandica*, Lamarck.

The corallites in this specimen average about 3 mm. in diameter, there are numerous flat tabulae, and pores can be obscurely seen in sides of the walls, but neither in transverse nor in longitudinal sections of the coral can spiniform septa be detected. The species represented is with little doubt *F. gothlandica*.

1 specimen which probably is referable to Favosites but in which the absence of clearly defined structure renders a definite determination impossible.

From locality VI, U. 11:—

1 specimen which apparently belongs to the genus Boreaster, Lambe.

'This genus has hitherto been known only from the Silurian of Beechey island, Lancaster sound, where it occurs with *Favosites gothlandica* (vide "Notes on the fossil corals collected by Mr. A. P. Low at Beechey island, Southampton island, and Cape Chidley, in 1904," by Lawrence M. Lambe, appendix IV, The Cruise of the Neptune, by A. P. Low).

'Dr. Cairnes' specimen reveals the presence of septa apparently of the nature of those found in Boreaster, and of mural pores arranged in vertical series. Flat tabulae are numerous and the walls of the corallites are thick, with their line of junction in contiguous corallites distinctly shown in longitudinal sections. In consequence of a decided thickening of the walls the connecting pores are conspicuously lengthened and they appear in longitudinal sections as mural passages whose length is four or five times their diameter. The corallites are generally five or six sided, and their calicular edges are ornamented with a single series of tubercles in which each tubercle represents the union of the upper ends of two septa of contiguous corallites.

'This specimen differs from *Boreaster lowi*, Lambe, the type species of the genus from Beechey island, in the following particulars—the corallites have twice the diameter, the walls of the corallites are much thicker, the tabulae appear to be more numerous as do also the mural pores which are, however, relatively smaller. Dr. Cairnes' specimen may represent a species distinct from *B. lowi* and should be further studied with this possibility in view.

'The horizon indicated by the above fossils is probably a Silurian one. *Favosites gothlandica* is a common Silurian form and the genus Boreaster is typically Silurian.

[1] Kindle, E. M.: —— Amer. Jour. Sci., Vol. XXXII, 1911, pp. 344, 345.

As already mentioned *Favosites gothlandica* and *Boreaster lowi* form part of the Silurian fauna of Beechey island. The discovery of *B. lowi* (or a nearly allied species of the genus) in northern Yukon is of interest as it implies that similar conditions affecting marine life prevailed in the north over a very extensive area during Silurian times.'

## *Racquet Series.*[1]

The rocks belonging to the Racquet series extend over an area 6 miles long measured in a northerly direction, by 1 to 3 miles wide, the southern boundary of which is about 11 miles north of the Orange fork of Black river. The beds have an aggregate thickness of at least 1,500 feet and consist mainly of limestones, cherts, and cherty conglomerates, all three of which occur in places intimately associated.

The limestones are generally quite crystalline and range from nearly white through various shades of grey to almost black in colour, occasional reddish members being also noted; on fresh fractures, however, these beds are typically dark grey to nearly black. The upper limestone beds nearly everywhere contain chert pebbles which in places constitute the cherty conglomerates of this series, and all gradations occur from a limestone including only occasional chert pebbles to a cherty conglomerate with a siliceous matrix and containing no perceptible lime. The chert pebbles are well rounded and usually about the size of marbles, but some were noted as large as 1½ to 2 inches in diameter. In colour, most of the pebbles are some shade of grey, but occasional quite black individuals were noticed. Beds of pure massive chert similar in appearance to that composing the conglomerate pebbles occur in places, but are not nearly so extensive as the limestone or conglomerate members.

A number of fossils were found in the limestone beds of this series concerning which Dr. Raymond, after a preliminary examination, reports:—

'Specimens obtained from lower beds—

*Productus,* sp. ind.
*Aviculopecten cf. A. affinis,* Walcott.
*A. cf. A. hagnei,* Walcott.
*Aviculopecten,* 2 species.

'These Aviculopectens suggest the fauna of the White Pine shale of the Mississippian of Nevada.

'Specimens obtained from upper beds—

*Productus,* sp. ind.
*Spirifer cf. S. alatus,* Schlotheim.
*Productus, aff. P. aagardi,* Toula.
*P. cf. P. inflatus,* McChesney.
*Canarophoria margaritovi,* Tschernyschew (?)
*Spiriferella arctica,* Haughton.
*Productus aff. P. gruenewaldti,* Stuck.
*Derbya,* sp. ind.
*Costellirostra,* sp. ind.
*Dielasma bovidens,* Morton.
*Eumetria,* sp. ind.

'Nearly all the above specimens from the upper beds were sent to Dr. George H. Girty of the United States Geological Survey, who very kindly determined them.

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of the material representing this coral does not indicate whether or not it can be discriminated from the Silurian species of *Favosites*. The genera *Favosites*, *Striatoporo*, and *Diphphyllum* have not previously been found associated together in a pre-Silurian fauna so far as the writer is aware. The presence in the fauna, however, of such characteristic Ordovician fossils as *Calapoecia canadensis*, *Maclurina manitobensis*, and *Dinorthis proavita* seems clearly to place the fauna in the Ordovician. The last named species resembles somewhat the Silurian shell *Orthis flabellites*, but Mr. E. O. Ulrich who has examined the specimens considers them identical with the Minnesota representatives of *D. proavita*. *M. manitobensis* is a characteristic and widely distributed species in the Ordovician of Alaska, occurring in both the extreme eastern and western parts of the territory. *Calapoecia canadensis* is another Ordovician species which has a wide distribution in the northern part of the continent. It is one of the abundant corals in the Ordovician of the Seward peninsula.'[1]

In addition, Mr. Lawrence Lambe, of this department, states:—

'Three limestone fragments of fossil coralla, from Dr. Cairnes' Yukon-Alaska boundary collection of 1911, are determined by me as follows:—

From locality VI, C. 22:—

1 specimen of *Favosites gothlandica*, Lamarck.

The corallites in this specimen average about 3 mm. in diameter, there are numerous flat tabulae, and pores can be obscurely seen in sides of the walls, but neither in transverse nor in longitudinal sections of the coral can spiniform septa be detected. The species represented is with little doubt *F. gothlandica*.

1 specimen which probably is referable to Favosites but in which the absence of clearly defined structure renders a definite determination impossible.

From locality VI, U. 11:—

1 specimen which apparently belongs to the genus Boreaster, Lambe.

'This genus has hitherto been known only from the Silurian of Beechey island, Lancaster sound, where it occurs with *Favosites gothlandica* (vide "Notes on the fossil corals collected by Mr. A. P. Low at Beechey island, Southampton island, and Cape Chidley, in 1904," by Lawrence M. Lambe, appendix IV, The Cruise of the Neptune, by A. P. Low).

'Dr. Cairnes' specimen reveals the presence of septa apparently of the nature of those found in Boreaster, and of mural pores arranged in vertical series. Flat tabulae are numerous and the walls of the corallites are thick, with their line of junction in contiguous corallites distinctly shown in longitudinal sections. In consequence of a decided thickening of the walls the connecting pores are conspicuously lengthened and they appear in longitudinal sections as mural passages whose length is four or five times their diameter. The corallites are generally five or six sided, and their calicular edges are ornamented with a single series of tubercles in which each tubercle represents the union of the upper ends of two septa of contiguous corallites.

'This specimen differs from *Boreaster lowi*, Lambe, the type species of the genus from Beechey island, in the following particulars—the corallites have twice the diameter, the walls of the corallites are much thicker, the tabulae appear to be more numerous as do also the mural pores which are, however, relatively smaller. Dr. Cairnes' specimen may represent a species distinct from *B. lowi* and should be further studied with this possibility in view.

'The horizon indicated by the above fossils is probably a Silurian one. *Favosites gothlandica* is a common Silurian form and the genus Boreaster is typically Silurian.

[1] Kindle, E. M.: —— Amer. Jour. Sci., Vol. XXXII, 1911, pp. 344, 345.

As already mentioned *Favosites gothlandica* and *Boreaster lowi* form part of the Silurian fauna of Beechey island. The discovery of *B. lowi* (or a nearly allied species of the genus) in northern Yukon is of interest as it implies that similar conditions affecting marine life prevailed in the north over a very extensive area during Silurian times.'

### *Racquet Series.*[1]

The rocks belonging to the Racquet series extend over an area 6 miles long measured in a northerly direction, by 1 to 3 miles wide, the southern boundary of which is about 11 miles north of the Orange fork of Black river. The beds have an aggregate thickness of at least 1,500 feet and consist mainly of limestones, cherts, and cherty conglomerates, all three of which occur in places intimately associated.

The limestones are generally quite crystalline and range from nearly white through various shades of grey to almost black in colour, occasional reddish members being also noted; on fresh fractures, however, these beds are typically dark grey to nearly black. The upper limestone beds nearly everywhere contain chert pebbles which in places constitute the cherty conglomerates of this series, and all gradations occur from a limestone including only occasional chert pebbles to a cherty conglomerate with a siliceous matrix and containing no perceptible lime. The chert pebbles are well rounded and usually about the size of marbles, but some were noted as large as 1½ to 2 inches in diameter. In colour, most of the pebbles are some shade of grey, but occasional quite black individuals were noticed. Beds of pure massive chert similar in appearance to that composing the conglomerate pebbles occur in places, but are not nearly so extensive as the limestone or conglomerate members.

A number of fossils were found in the limestone beds of this series concerning which Dr. Raymond, after a preliminary examination, reports:—

'Specimens obtained from lower beds—

*Productus*, sp. ind.
*Aviculopecten cf. A. affinis*, Walcott.
*A. cf. A. hagnei*, Walcott.
*Aviculopecten*, 2 species.

'These Aviculopectens suggest the fauna of the White Pine shale of the Mississippian of Nevada.

'Specimens obtained from upper beds—

*Productus*, sp. ind.
*Spirifer cf. S. alatus*, Schlotheim.
*Productus, aff. P. aagardi*, Toula.
*P. cf. P. inflatus*, McChesney.
*Canarophoria margaritovi*, Tschernyscheu (?)
*Spiriferella arctica*, Houghton.
*Productus aff. P. grueneraldti*, Stuck.
*Derbya*, sp. ind.
*Cystodictya*, sp. ind.
*Dielasma boridens*, Morton.
*Eumetria*, sp. ind.

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He states that the fauna is that which occurs in the highest Carboniferous limestone in the Calico Bluff section of the Yukon.'

This series corresponds lithologically with the lower Cache Creek group[1] of British Columbia and Yukon, which, however, has not been very definitely defined, palæontologically, but from the fossils that have been reported it would appear that probably the lower Cache Creek group includes the Racquet series. Chert, cherty conglomerates and breccias, and limestones that lithologically also closely resemble the members of the Racquet series occur extensively on Macmillan river.[2]

### *The Orange Group.*[3]

The Orange group is the most extensive geological terrane encountered, and extends over about two-thirds of the area mapped during the past season. These rocks outcrop south of the Orange fork of Black river and continue northward for a distance of over 40 miles, and with the exception of the 10 or 12 square miles throughout which the Carboniferous beds outcrop, and less than one square mile of igneous rocks, the Orange beds constitute the bed-rock throughout this 200 square miles of territory.

The group consists chiefly of slates, phyllites, quartzites, sandstones, shales, and occasional dolomite and magnesite beds. The quartzites range from nearly white to dark grey in colour, and are typically massive with a sugar-grained texture. Occasional beds, however, contain a certain amount of mica and chlorite, which in places are arranged in definite streaks between layers of purer quartzite, giving to the rocks a distinctly gneissoid habit.

The slates vary greatly in colour, being generally, however, black or various shades of grey, green, red, or brown. They have everywhere a decided secondarily induced cleavage and generally break readily into plates from one to several feet in diameter and as thin as $\frac{1}{16}$ of an inch or even less. Probably the most noticeable and persistent beds in the Orange group are certain beautifully banded red and green slates, the alternate bands of which are in places extremely thin and delicate and not more than $\frac{1}{4}$ to 2 inches in thickness, and frequently much less, presenting thus a decidedly ribbon-like appearance. The colours are apparently due to the various stages in the oxidation of the sediment before it settled from suspension, which is thought to be the result of changing climate. Writing on 'the colours of variegated shales,' Professor John Barrell, of Yale University, states[4]: 'This is mainly dependent upon the oxidation of the iron and the presence or absence of carbon: and in marine sediments I think it is generally due to the nature of the sediment before it comes to rest. I think it is typical of intermediate climatic states. Arid climates tend to give red shades, both marine and continental; semi-arid or seasonably arid tend to give uniform red or brown shades, more especially to continental river deposits; humid climates favour deoxidation and give uniform grey to black shades; climates oscillating about the mean will give variegated shades. Of course with any climate the physiographic factors are also fundamental.'

The phyllites[5] also vary considerably in colour, but are generally some shade of grey, although occasional greenish, brownish, or black members were noted. These

[1] Dawson, G. M. Ann. Rept., Geol. Surv., Can., Vol. VII, 37 B-48 B.
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[4] Private communication.

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rocks are distinguished from the slates by containing more mica, and in general being somewhat coarser textured. In places, the phyllites are much crinkled, folded, and distorted—monoclinal and even closed folds being exhibited in hand specimens; these rocks, also, wherever found, break readily along the cleavage planes and frequently large thin slabs are procurable.

The sandstones and shales were only rarely noted and are the less metamorphosed phases of the slates, phyllites, and quartzites.

The dolomites and magnesites almost invariably weather to a rough surface and red colour due to the considerable amount of iron they contain. The dolomite beds are 100 to 200 feet or even more in thickness in places, but the magnesite beds rarely exceed 10 feet, and in places occur interbanded with the slates and dolomites, in layers less than 2 feet in thickness.

No accurate estimate could be formed as to the aggregate thickness of this group, as nowhere was a section found where the uppermost beds are preserved, and only small portions of it could be observed at a place. Also, on account of the metamorphosed condition of the rocks it was difficult, in most places, to determine the dip and strike of the beds. The group is, however, at least 6,000 feet in thickness and may be considerably more.

These beds overlie the Racquet Creek rocks, but nowhere could it be determined whether or not an unconformity exists between the two series.

The only fossils found in the Orange beds occur within 100 feet of the underlying Carboniferous rocks, and of these Dr. T. W. Stanton, of the United States Geological Survey, reports that owing to their poor and peculiar state of preservation, they cannot be definitely determined. He says: 'The specimens labelled F 18, 56, 59, 119, and some others appear to be casts of a simple species of *Ostrea*. The larger specimen labelled F 10 is probably a *Pecten*. The specimens labelled F 36, 64, and some others are referred to *Astarte* or a related genus. My judgment is that these fossils are not older than Mesozoic and they may be Cretaceous, though there is no definitely distinctive Cretaceous fossil among them, and they do not seem to fall into any fauna known to be from that region.'

On account of the distinctive lithological appearance of certain members of this group, especially the green and red banded slates, these are thought, in all probability, to be the same as certain beds occurring on the Macmillan and Upper Stewart rivers, which have been described both by Mr. R. G. McConnell[1] and Mr. Joseph Keele.[2] Mr. Keele found Triassic fossils in or immediately below rocks apparently corresponding to the members of the Orange group.

*Igneous.*

The igneous rocks occurring in the district are all intrusives and pierce the Mesozoic, Orange group; they were found only at five points and their outcrops are of relatively slight extent. The largest exposure occurs about 2 miles west of the boundary line and 5 miles south of the Stony fork of Black river, and appears to represent a small boss about one-fourth of a mile in diameter. This rock has a typical granitic habit, greyish colour, somewhat coarsely holocrystalline texture, and under the microscope is seen to consist mainly of microcline, microperthite, and biotite with a few small particles of accessory iron-ore, and their alteration products muscovite and calcite. It is thus a mica syenite.

The next largest exposure occurs about 2 miles west of the boundary line and three-fourths of a mile north of the Stony fork of Black river, and is at least 40

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yards in width, but as bed-rock exposures are scarce at this point on account of the heavy covering of superficial material, the nature and extent of this outcrop was not determined. Megascopically the rock is finely-textured, holocrystalline, and dark-greenish in colour; a typical specimen examined under the microscope proved to be a quartz mica diorite, consisting chiefly of plagioclase, orthoclase, quartz, biotite, green hornblende, and accessory sphene and iron-ore.

The other three exposures of igneous rocks represented dykes less than 100 feet in width and traceable on the surface for less than 200 feet. These rocks are all finely textured, greenish materials. A typical sample from each locality was examined microscopically: of these, two specimens proved to be andesite and the other diabase.

### Economic Geology.

The only deposits that have been found in this district that are of interest from the standpoint of economic geology are marble, lithographic limestone, and magnesite. Numerous beds of magnesite up to 10 or even more feet in thickness occur intercalated in the dolomites and slates of the Orange group in various places. Beds of beautiful pure, white marble up to 15 feet in thickness, and other beds up to 50 feet in thickness of what appeared to be a fair grade of lithographic limestone were noted in places and are included in the Porcupine series.

However important these might be if found in other places, situated as they are, so far from transportation, they possess no present economic value.

# II

## QUARTZ MINING IN THE KLONDIKE DISTRICT.[1]

### Introduction.

After completing the regular season's work along the 141st meridian[2] (the Yukon-Alaska boundary) a few days in September were spent in the examination of a number of the more promising quartz properties in the Klondike district, mainly in that portion of Dawson Mining district which is situated along and between Indian and Klondike rivers and their tributaries.

Considerable interest has of late been displayed concerning the quartz veins of the Klondike, and special efforts are being made to develop the lode mining of this district, in the hope that a revenue may eventually be derived from this source that will continue to foster the mining industry of this portion of Yukon when the placer deposits have become exhausted, which it is thought, however, will not be for many years to come.

### Summary and Conclusions.

Quartz veins are very plentiful in the schistose rocks of the Klondike district, and although the greater number of these deposits are small and non-persistent, still the aggregate amount of quartz is very great. Occasional very encouraging assays have been obtained, but with rare exceptions it is not even approximately known what average amounts of gold the deposits in the different localities contain. The quartz is practically all free-milling and is but slightly mineralized, the only metallic constituents apparent being pyrite, and rarely magnetite, chalcopyrite, galena, and native gold.

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[1] Brock, R. W. Sum. Rep. Geol. Surv., Dept. of Mines, 1909, pp. 16-22.

[2] For the results of this work see pp. 17-33 of this Summary Report.

More systematic sampling and assaying should be conducted to obtain a fair general idea of the gold content of the quartz, and the various deposits should be more thoroughly prospected to ascertain their probably lateral and vertical extent. In case the results of these tests prove sufficiently encouraging, it would be particularly advantageous to have a stamp mill built at some convenient point capable of handling readily and quickly 5 or 10 tons samples from the various deposits of the district; in this manner claim owners could obtain sure and ready information concerning their properties. This is virtually the only way that reliable results can be obtained from these low-grade, free-milling deposits, as it is almost impossible to obtain perfectly satisfactory results from ordinary assay samples, and the expense of shipping small samples to outside points is practically prohibitive.

### The Quartz Deposits.

A great amount of quartz occurs in the old schistose rocks that are so extensively developed in the Klondike district, and in some localities it is in sufficient quantity to even constitute a considerable portion of the whole rock mass. The quartz occurs prevailingly in veins which exhibit considerable variety of form, and are as a rule small and non-persistent, but range in size from mere threads to masses several hundred feet in length but in most places less than 10 feet in thickness; one vein, however, on Yukon river below the mouth of Caribou creek, exceeds 30 feet in thickness.

The most common type of vein is lenticular in form, the individual lenticles measuring but a few inches in thickness and less than 50 feet in length; in places, however, individuals as much as 10 feet in thickness occur, but even these are rarely traceable for any considerable distances. The lenses in most places follow, in a general way at least, the strike of the schistosity of the containing rocks, but along their dips they frequently cut the wall rocks at various angles.

Typical bedded or sheeted veins are also characteristic of some localities; in this type of deposit the quartz occurs interleaved with the folia of the schists, the individual quartz bands being generally but a few inches in thickness; in places such deposits occur in zones up to 10 feet or more in width that consist entirely of alternate quartz and schist lamellæ exhibiting a wide range of relative proportions.

Typical fissure veins were also noted, but on account of the decidedly schistose and fractured character of the enclosing rocks, these veins readily pass into the lenticular or sheeted types, due to the fact that the solutions from which the quartz was deposited, were naturally frequently diverted in whole or in part from the particular channels along which they might at any time be travelling, on account of the multitude of cleavage and fracture cracks which intersect these rocks, affording thus numerous routes for percolating waters. All types of veins are thus liable to bifurcate or branch out, and smaller veins frequently unite to form larger deposits. In places along lines of previous excessive fracturiug, mineralized zones occur in which several of the vein types are represented; lenses, sheets, pockets, and various irregular deposits of quartz may be separated by and include varying amounts of wall rock, and the whole be intersected by, or associated with numerous stringers and fissure veins of quartz.

A notable feature of some of the veins is the presence in them of occasional feldspar crystals indicating their relation to certain pegmatites in the vicinity. In this connexion Mr. McConnell says[1]: "A few examples of typical pegmatite veins or dykes occur in the district, and in one case, a coarse-grained pegmatite vein was observed to pass along its strike into a purely siliceous rock. The aqueo-igneous origin of the pegmatites, and their close genetic connexion with certain classes of

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep., Geol. Surv., Can., Vol. XIV, p. 63 B.

quartz veins, maintained by various writers, is supported by the facts observed in the Klondike district.'

The quartz veins are in most places but slightly mineralized; pyrite and more rarely magnetite occur in places in sufficient quantity to produce a reddish coloration on the exposed and oxidized portions of the veins, and in a few places the quartz contains particles of galena, chalcopyrite, and native gold.

## The Economic Importance of Quartz.

Often fair and occasionally even high assays are obtained, and in places the quartz shows native gold, but, except in possibly a very few instances, it is not known even approximately what average amounts of gold the quartz contains. From the various properties that have been examined, however, the gold that does occur is always either associated with metallic sulphides or is at or near the contact between the quartz and schists; in the latter case the gold is generally found in both vein material and wall rock.

It would thus seem possible that some of the fractured zones that have become irregularly impregnated with quartz, may prove of greater value than the more clearly defined massive veins, since the former contain a greater area of contact-surfaces in the same volume or weight of material. However, the majority at least of the mineralized zones that have been examined, do not appear to be sufficiently persistent to allow of their containing sufficient quantities of pay-ore to make a mine; it is possible, nevertheless, that larger and more richly mineralized zones may yet be found. In a number of places several veins or mineralized zones which were noted in close proximity to each other could be worked conjointly. These would yield a considerable tonnage, and would become important producers if the bulk of the quartz will pay for milling. It is thought that, since the majority of the veins are non-persistent, the successful exploitation of the quartz of this district will largely depend on finding groups of veins or mineralized zones sufficiently close to allow of their being worked conjointly.

The deposits that have already been discovered in Klondike, in all probability represent but a small portion of the quartz that actually exists in the district, as bed-rock is covered by superficial deposits in most places, except along the summits of the hills and ridges, and along the sides of the secondary valleys, where the bulk of the quartz occurs that has so far been found; other discoveries have been largely accidental and due frequently to placer operations. It is, therefore, probable, that future prospecting and development will disclose numerous deposits that are at present unknown.

More development should be performed, however, in connexion with the quartz deposits of the district that have been already discovered, with a view to ascertaining their extent, and more systematic sampling and assaying should be performed in order to determine within reasonable limits, at least, the average values of the materials they contain. It seems probable that at least the upper weathered and decomposed portions of a number of the deposits could be profitably milled, due to the fact that the district has not been glaciated, and a certain surface concentration of gold is to be expected, and in places is known to occur.

Prospectors and others interested in lode mining frequently do not sufficiently realize the importance of assays, and when these are made, in probably the majority of instances in Klondike district, they are from samples that are not representative of the deposits from which they are taken. Two reasons seem mainly to account for this condition: one is that it is not as convenient to have assays made in Yukon as in most mining districts, and moreover it is frequently realized how difficult it is to obtain really representative assay samples from free-milling deposits.

The most reliable and satisfactory results for such ores are obtained from mill tests of at least 5 or 10 ton lots. A sampling mill capable of making tests of 10 ton samples of the different quartz deposits of this district would greatly facilitate the development of the industry, and would stimulate prospecting throughout the district. With such a mill situated somewhere in the vicinity of Dawson, sufficient information could be obtained in a short time, possibly in one or two seasons, to demonstrate whether the Klondike has or has not a future in quartz. If these deposits are not profitably workable, the sooner this is known the better it will be for those owning, holding, and developing such properties; also if a number of deposits are sufficiently rich to become producers, the earlier this fact is established the greater will be the benefits that will accrue to the territory in general and to those most interested. In the meantime, however, it is important that more definite information be obtained concerning the extent and average value of the various deposits throughout the district.

## Mining Properties.

### GENERAL STATEMENT.

Among the more promising quartz properties in the Klondike district, and those on which the most energy has been expended in development, are: the Lone Star group, near the head of Victoria gulch, a tributary of Bonanza creek; the Violet group, situated along the divide between Eldorado and Ophir creeks; the Mitchell group, on the divide between the heads of Hunker and Goldbottom creeks; the Lloyd group and neighbouring claims, situated along the divide between the heads of Green gulch and Caribou gulch, tributaries respectively of Sulphur and Dominion creeks; and several groups of claims on Bear creek near where joined by Lindow creek. Of these, the Lone Star was the only property on which any work, other than the necessary assessment duties, was being performed during the summer of 1911.

In addition to the above-mentioned properties, considerable enthusiasm has been aroused during the past two seasons over a number of claims staked on Dublin gulch, a tributary of Haggart creek which drains into the south fork of McQuesten river. This locality is not in the Dawson mining district, but is in the Duncan Creek mining district; it is, nevertheless, frequently spoken of as being in the general Klondike district and will be here so considered.

### *The Lone Star Group.*[1]

The Lone Star group is situated near the head of Victoria gulch, a tributary of Bonanza creek. This property is owned by a joint stock company with head office in Dawson and having a capitalization of $1,500,000; the president, Dr. Wm. Catto, as well as the secretary-treasurer, and the majority of the board of directors also reside in Dawson.

On these claims two main veins, or really one vein and a mineralized zone, have been discovered, which have been, by the owners, designated respectively the 'Corthay vein' and the 'Boulder lode'; these occur in much metamorphosed sericite and chloritic schists. The Boulder lode strikes N. 50° W.,[2] dips from 70° to 80° to the S.W., and is in most places at the surface from 3 to 10 feet in width, containing 1 to 7 feet of quartz. This 'lode' has been traced definitely along its outcrop for 400 feet, and quartz is exposed at various points in the same general line of strike for 600

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep., Geol. Surv., Can., Vol. XIV, pp. 64 B-65 B.

[2] All bearings given in this report are astronomic or true. The magnetic declination in the Klondike district is in most places 35° east.

feet farther, indicating that this zone may persist for this distance. The quartz occurs prevailingly in lenses, sheets, and irregular bodies ranging in size from those that are only microscopically observable to others 3 or 4 feet in thickness; these are interbanded or interfoliated with the schists, and generally agree with them in strike, but along their dips cut the planes of schistosity of the enclosing rock at various angles up to 90°. In places masses of practically solid quartz as much as 4 or 5 feet thick occur, but such a condition is rather exceptional. Numerous fissure veins or stringers less than 6 inches in thickness, intersect the main zone in various directions.

The Corthay vein strikes N. 14° W., has an almost perpendicular attitude, and where it has been explored is much more regular than the Boulder lode; this deposit also resembles more an ordinary compound fissure vein, and consists mainly of quartz which is in most places from 3 to 6 feet in thickness.

The quartz of both the Corthay vein and the Boulder lode is but slightly mineralized, the only metallic constituents that were noted being pyrite and native gold. The pyrite occurs as scattered particles or in small bunches, and is in sufficient amount in places to give the quartz a rusty appearance where weathered. The native gold occurs mainly as occasional grains and nuggets both in the quartz and wall-rock, but prevailingly near their contact, and is in places quite well crystallized.

An open-cut about 70 feet long, 10 feet wide, and having an average depth of approximately 15 feet, as well as 8 or 10 smaller surface cuts or pits have been dug at intervals along the strike of the Boulder lode. A cross-cut tunnel 310 feet long has also been driven, from which, when examined in September, 1911, about 40 feet of drifting had been run on the Boulder lode which at this depth of approximately 60 feet was much narrower than at the surface and contained in most places less than 2½ feet of quartz. A vertical shaft has been sunk through the schists and tapped the Corthay vein at a depth of 60 feet where the quartz was about 4 feet thick. Another shaft 40 feet deep has been sunk on the Corthay vein and was connected with a drift from the tunnel by a 30 foot upraise; a drift 70 feet long was also run from the bottom of this shaft.

A four-stamp Joshua Hendry mill has been erected on this property, and a gravity tramway 3,500 feet long has been constructed to convey the ore from the workings to the mill on the creek about 900 feet below. A power line 4 miles long was about completed in September, which was to convey power to the mill from the power line of the Northern Light and Power Company on Bonanza creek, the cost of the power to be at the rate of three cents per horse-power.

Miners working on this property and in the vicinity receive $4 per day (10 hours) and board.

The manager of the Lone Star group claims to be able to mine and mill the ore from this property for $3.50 per ton. It is not known what average amounts of gold the quartz and adjoining rock there contain, but a number of promising assay returns have been received and the tests that have been made indicate that at least the somewhat decomposed superficial portion of the Boulder lode and possibly of the Corthay vein as well should pay to mill. No definite information was obtained concerning the remaining portions of the deposits.

### *The Violet Group.*[1]

The Violet group is situated on the divide between Eldorado and Ophir creeks, about 5 miles from Grand Forks, and consists of four claims and a fraction, all of which are Crown granted. It is claimed that $60,000 have been spent in developing this property which, however, was sold by public auction in September, 1910, and acquired by the present owner, Mr. H. H. Honen.

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep. Geol. Surv., Can., Vol. XIV, p. 65 B.

Three veins are reported to have been discovered on this property, but the bulk of the work has been done on one of these which strikes in a southeasterly direction with the enclosing schists, but dips across them. This vein is in most places from 3 to 6 feet in thickness, and the quartz composing it is crystalline and contains considerable reddish feldspar giving it a pegmatitic appearance. The quartz contains considerable iron which near the surface weathers and gives the vein a rusty appearance; particles of galena were also noted. It is not known what amounts of gold this vein contains but it is stated to average $10 to $11 per ton.

Three shafts, respectively 55 feet, 35 feet, and 150 feet in depth have been sunk on the property, and 300 feet of drifts have been driven: in addition, one open-cut 50 by 12 by 15 feet approximately, and a number of smaller cuts have been dug.

### *The Mitchell Group.*

The Mitchell group is situated on the divide between the heads of Hunker and Goldbottom creeks, and consists of about 27 claims which are owned by Mrs. Margaret J. Mitchell.

A number of quartz veins occur on this property, but as the surface of the ridge on which these have mainly been discovered is in most places covered with superficial materials, it is not known either how many veins may be present, nor even how many veins the known occurrence of quartz represent, as considerable stretches of bed-rock are still covered between the different exposures. Quartz occurs in a number of small cuts or trenches more or less in alignment, that have been made on one part of the property at intervals throughout a distance of about 2,000 feet, yet this by no means proves that the quartz all belongs to the same vein; in places, trenches were sunk to bed-rock across the supposed line of strike of this vein, and no quartz was encountered; and further, the exposures themselves are, in places, decidedly lenticular in form. For 600 to 800 feet, however, quartz has been found along a N. 5° W. direction wherever bed-rock has been exposed to view, which is at frequent intervals; it would thus seem that for this distance either a fairly regular fissure vein or a nearly connected line of quartz lenses occurs. Other parallel lines of exposures were also noted, indicating that at least 3 or 4 veins and possibly many more than this number occur.

The quartz is all deposited in sericite schist, and whenever contacts between the quartz and wall-rock were noted the quartz cuts the schist folia along both dip and strike. The veins range from a few inches to 7 or 8 feet, but are in most places from 2 to 4 feet in thickness; the quartz generally contains almost no metallic constituents, but in places exhibits considerable disseminated pyrite which causes weathered surfaces to have a rusty appearance. A few particles of galena and native gold were also noted.

Only a few samples were taken from this property, but the results obtained from the analysis of these few, all indicate that the white unmineralized quartz rarely carries more than traces of gold, which mineral almost invariably occurs either associated with the metallic sulphides or near the contact of the quartz and schist, and in either material.

The development work performed on this property consists mainly of a number of open-cuts, shallow trenches, and pits, and also a shaft 80 feet deep, from which a 50-foot drift has been driven. The shaft was filled with water when visited, but a grab sample was taken from the dump, which assayed $5 in gold per ton[1]; this is the highest assay obtained from the various samples taken by the writer from the Mitchell group, although much higher returns are believed to have been received from other samples taken previously. It, therefore, appears that, although the aggregate amount

[1] All the samples that were taken by the writer from the various claims in the Klondike district during the past season, were assayed by the Mines Branch of the Department of Mines, Ottawa

of quartz on this group of claims is considerable, by no means all the material will pay for treatment. The various veins should thus all be systematically sampled, to obtain an estimate of their probable average values, and to determine approximately the veins and portions of these that will pay for mining and treatment.

### *The Lloyd Group.*

The Lloyd group is situated at the head of Green and Caribou gulches, tributaries respectively of Sulphur and Dominion creeks, and consists of 17 Crown-granted claims owned by Messrs James Lloyd, J. A. Seghers, and Wm. Nolan.

A number of exposures of quartz 2 to 6 feet in width occur on this property, but in only a few places could the thicknesses of the veins, and their relations to the wall-rocks be determined; the other known occurrences of quartz were either still more or less covered with superficial materials, or the various shafts, cuts, etc., that had at one time exposed the veins, contained considerable water or other materials that had drained or fallen in since the work was performed. One vein, however, was well exposed in a 25 foot shaft near the cabin: this deposit has an average thickness of about 3 feet, strikes N. 58° W., dips at angles of 60° to 70° to the N.E., and cuts across the foliation planes of the schist wall-rock with every appearance, in the shaft at least, of being a typical regular fissure vein. The wall-rocks everywhere observed are sericitic or chloritic schists.

The quartz outcrops on this property are in most places from 2 to 3 feet in thickness, and represent at least 3 or 4 veins and possibly more. In different portions of the claims exposures of quartz, approximately in alignment, were noted at various intervals extending throughout distances of several hundred feet, but until more development has been performed, it will be impossible to decide whether these lines of exposures each represent one continuous vein or several more or less connected lense-shaped deposits such as characterize the schistose rocks of that district.

The quartz is characteristically white and generally but slightly mineralized: however, in some places, the veins carry considerable disseminated pyrite which where oxidized gives the quartz a reddish iron-stained appearance; occasional particles of galena were also noted.

Concerning the average gold content of the quartz, but little is known. The writer took only three samples from the different veins of the Lloyd group, and all yielded merely traces of gold. However, one of the owners of these claims had what he considered to be an average sample of one of the veins tested during the time I was in Dawson, and this gave $10.60 in gold to the ton; and other still higher assays are believed to have been obtained at different times. In this connexion, however, it is to be remembered, as previously mentioned, how extremely difficult it is to get satisfactory results from assay samples of low grade free-milling ores; the samples taken by the writer may not be at all representative of the veins from which they were taken. To obtain reliable information concerning such ores, either a great number of assays must be taken, or mill tests must be made.

Considerable prospecting work has been performed upon this group of claims, mainly as follows: about 10 shafts having an average depth of approximately 30 feet have been sunk, the deepest of these being down 56 feet when visited in September; in addition a number of open-cuts and trenches have been dug.

### *Bear Creek.*

A number of quartz claims, probably 30 or 40 in all, owned by John Nicholas and others, have been located on the right limit of Bear creek near the junction of this stream with Lindow creek. The schistose bed-rock at different points on these claims, contains deposits of quartz impregnated with more or less pyrite, and in places showing particles of native gold that is occasionally quite crystalline. It is not known what average amounts of gold the veins in this vicinity contain, but it is claimed that a number of promising results have been received.

*Dublin Gulch and Vicinity.*

Dublin gulch is a tributary of Haggart creek which drains into the south fork of McQuesten river. A considerable number of claims have been located on Dublin gulch and in that vicinity, extending throughout a belt about 8 miles long. This locality has not been visited by the writer, but some quartz deposits near Dublin gulch were examined and reported upon by Mr. Joseph Keele[1] of this department in 1904.

During the past two seasons, especially, a number of discoveries that are reported to be very promising have been made in the Dublin Gulch locality, with the result that a considerable renewal of activities and enthusiasm has been evidenced; old claims have been relocated, new claims have been staked, and prospecting has received a decided stimulus. Some of the main claim holders in the district are Dr. Wm. Catto, Mr. Jack Stewart, and Messrs. Fisher and Sprague.

While in Dawson, the writer was shown a large number of specimens of the ores from Dublin gulch and the surrounding district; these all consisted mainly of quartz carrying varying quantities of mispickel (arsenopyrite or arsenical iron pyrite) and occasional particles of pyrite; the quartz in places was coated with a yellow ferric arsenate. A few typical samples were selected and an average assay has been made from these, which yields 3·98 ounces of gold, or $79.60 per ton.

[1] Keele, J. "The Duncan Creek mining district": Ann. Rep. Geol. Surv., Can., Vol. XVI, 1904, pp. 38 A-39 A.

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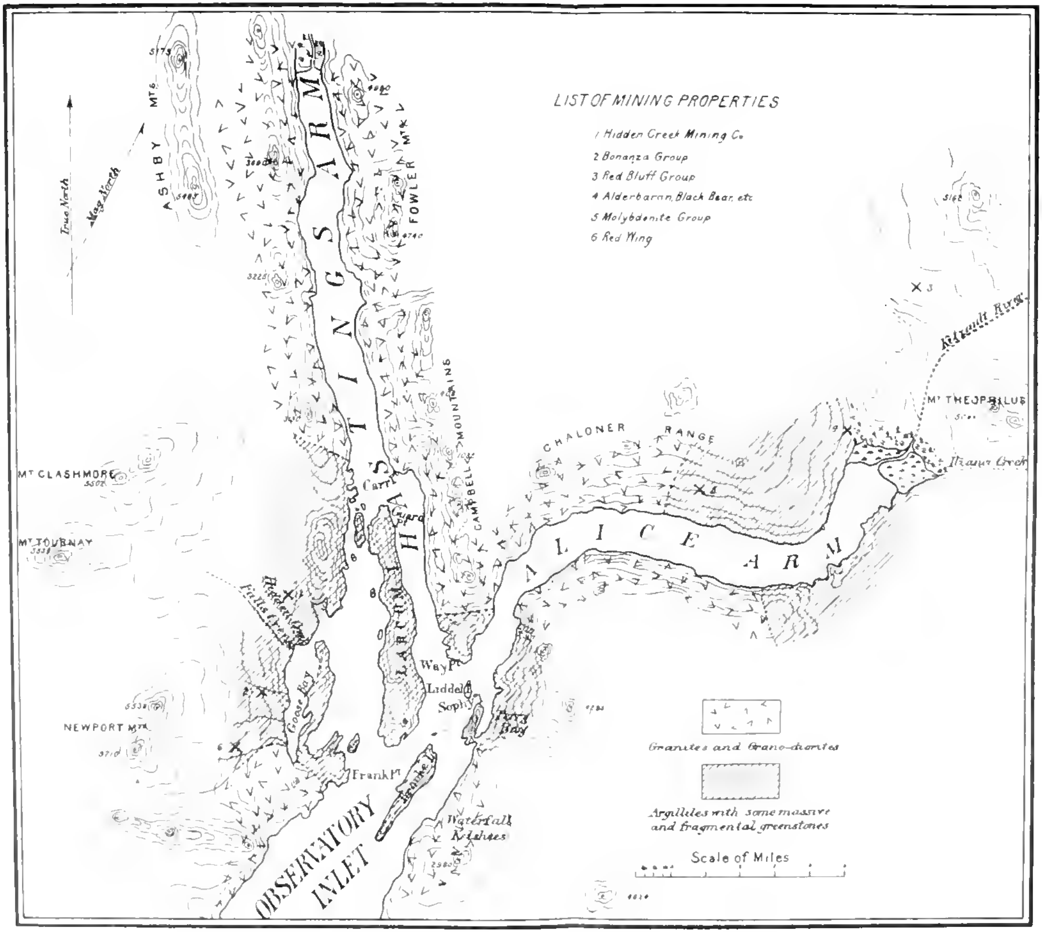



Diagram of portion of Observatory Inlet, B.C.; Geology by R. G. McConnell, 1911

# I

## OBSERVATORY INLET, BRITISH COLUMBIA.

(*R. G. McConnell.*)

### Introductory.

The work of the past season included a geological reconnaissance and an examination of the important mineral deposits around Goose bay and Alice arm, Observatory inlet; an examination of the Salmon River mineral district; the completion of a geological map of the Portland Canal mining area, and a reconnaissance trip across the Coast range to the Nass valley. I was assisted during the season by Mr. A. O. Hayes, and during August and September by Mr. G. G. Gibbins, both of whom efficiently performed all duties entrusted to them. The delineation of the geological boundaries in the Portland Canal district, as shown on the map, is largely the work of Mr. Hayes. A microscopical examination of a number of these sections was also made by him.

### Observatory Inlet.

Observatory inlet parallels the lower portion of Portland canal on the east, and is connected with it by a passage north of Pearce island. Its shore lines are more irregular than those of Portland canal and towards its head it divides into two branches known as Hastings arm and Alice arm. Hastings arm continues in the general northerly direction of the main inlet, while Alice arm bends to the east and like Portland canal cuts through the granitic batholith of the Coast range and penetrates for some distance the argillites and associated rocks which border it on the east.

At the junction of the two arms, the inlet expands in width and contains a number of islands, some of larger size. Larcom island has a length of 7 miles and Brooke island of 3 miles. West of Larcom island is the entrance to Goose bay, an irregular sheet of water 3½ miles in length and from half a mile to a mile in width. The principal known mineral deposits of the inlet are situated in its vicinity.

The inlet is bordered on both sides by mountains in groups and short ranges except near the head of Alice arm. From this point, a high rough plateau broken by basaltic cliffs extends eastward to the Nass valley. The mountains present, as a rule, steep glacier-worn sides towards the inlet, and range in height from 3,500 to nearly 6,000 feet. Glaciers occur in some of the valleys but are not so large and conspicuous as along Bear river.

The streams entering the inlet are all of moderate size. They include Falls creek, a short stream with numerous falls emptying into Goose bay, the Kitzault and Ilianci at the head of Alice arm, and a branching sediment-laden stream at the head of Hastings arm. Falls creek is utilized to operate the plant at the Hidden Creek mine. It is a steep stream and flows a large volume of water during the greater part of the year, but like all of the streams of the district, the supply becomes greatly diminished during the midwinter months.

#### GEOLOGY.

Observatory inlet has its whole course in the Coast range and the rock section along it consists mostly of granite. A large included mass of argillites associated with greenstones, mostly pyroclastic in origin, occur at the junction of the two arms, and argillites also occur along the upper part of Alice arm.

*Granites.*

Granites occur along Observatory inlet from Pt. Ramsden, opposite Pearce island, northward to a point near the southern end of Goose bay where they are replaced by argillites and greenstones. The latter are exposed along the shores of the inlet for a distance of 9 miles and are then followed by granites and allied rocks which continue to the head of Hastings arm and for some distance beyond.

Alice arm extends eastward beyond the eastern edge of the Coast Range batholith. The mountains along the lower portion consist of granite, and those bordering the upper portion of argillites interbanded in places with greenish felspathic beds.

The granites along Alice arm and the lower part of Hastings arm are medium grained, occasionally porphyritic, greyish rocks made up mostly of quartz orthoclase and plagioclase with sparingly distributed biotite. In the upper part of Hastings arm, the grey granite is replaced by a dark coloured, more basic and apparently older variety, feebly schistose in places, and cut near the contact by acid granitic dykes. This rock is very coarse grained in places, has hornblende as the principal dark mineral, and represents a transition phase between the granites and diorites.

*Argillites.*

An area of dark argillaceous rocks with some greenstones enclosed on all sides by granite occurs at the junction of Alice and Hastings arms. The area has a width along the west shore of Observatory inlet of 9 miles, but narrows to the east. On the east shore, it is barely 2 miles wide and the area appears to wedge out in the bordering mountains. Larcom, Brooke, and other smaller islands near the junction of the two arms, consist of argillites cut by granitic dykes. The area, while not traced through, probably extends westward to Portland canal, as similar rocks somewhat more highly altered occur in the same strike in the vicinity of Maple bay.

The argillites and associated beds are very similar to the rocks of the Bitter Creek series of Bear river, but cannot be definitely correlated with them until the intervening region is more closely examined. The principal variety is a fine-grained sedimentary rock, made up largely of quartz grains with some feldspar, darkened with carbonaceous material. Mica, mostly secondary, is usually present, and in places the argillite passes into a quartz mica schist. Secondary quartz, pyrite, calcite, and hornblende are also common constituents.

In texture, the argillites vary from a hard, fine-grained, compact rock to a granular one in which the grains are distinctly visible. The colour varies with the texture, becoming lighter with increasing coarseness, and in places, the fine-grained, dark and coarse, greyish more feldspathic varieties alternate in thin bands.

The argillites are seldom, and only over limited areas, cleaved into slates. Usually they occur in rather heavy beds from 1 inch to 6 or more in thickness, and in weathering form a talus of angular fragments.

The associated rocks are greyish limestones and beds and wide bands of greenstone. The limestones are not prominent, and only occur in small beds and bands seldom traceable for any distance. The greenstones largely replace the argillites towards the southern edge of the area. They are granular, mostly fragmental rocks.

The beds of what may be called the Goose Bay argillite area are folded into a greenish micaceous schist.

The beds of what may be called the Goose Bay argillite area, are folded into a number of anticlines and synclines, striking approximately east and west, or parallel to the long axis of the area. The dips as a rule are regular and comparatively low, although, in places, the strata are steeply tilted and strongly distorted. No faulting on a large scale was observed.

The Goose Bay sedimentary beds occupy a depression in the granitic rocks of the Coast Range batholith, and are cut by numerous acidic dykes genetically connected with it. Various types are represented, including pegmatite, aplite, quartz porphyry and granitic dykes. A second system of lamprophyric and basaltic dykes, younger and more basic in character than those connected with the granitic intrusion, is also prominent. The dykes of this system are later than the mineralization of the region.

Dark, sedimentary rocks very similar to those in the Goose Bay area occur along the upper part of Alice arm, east of the main granite area. They consist mostly of fine-grained, dark, slaty rocks often in heavy beds, with coarser feldspathic bands some of which hold small angular fragments. Farther north along the Kitzault valley, in the vicinity of the Red Bluff group of claims, the dark sedimentary rocks are largely replaced by fine and medium grained greenish fragmental rocks tufaceous in character. These rocks include dark argillaceous bands and are much less altered than those in the vicinity of the granite. Their relation to the latter was not ascertained, as in the course travelled along the valley the connecting section is concealed.

No fossils were collected and no evidence in regard to the age of the sedimentary rocks was obtained, other than that they are cut by and are, therefore, older than the Coast Range granitic batholith usually referred to late Jurassic or early Cretaceous. The argillites are often highly altered locally, in places, passing into mica schists, but this is attributed to the effects of the great granitic invasion and affords no proof of extreme age. It is probable that none of the sediments are older than the Carboniferous.

MINERAL DEPOSITS.

The mineral deposits of Observatory inlet consist of quartz veins carrying values in silver and lead and in one case in molybdenum, and of what can only be described as mineralized areas carrying low values in copper. The latter will be described first.

*Hidden Creek Copper Company.*

The claims controlled by this Company were staked about ten years ago and a considerable amount of surface and underground work was done on them by the Hidden Creek Copper Company under the direction of Mr. M. K. Rogers. Recently the claims were bonded to the Granby Consolidated Mining, Smelting, and Power Company operating at Phoenix, B.C., and a diamond drill test of the property by this Company proved so satisfactory that the bond was taken up and preparations are now being made to work it on an extensive scale.

The thanks of the writer are due to Mr. O. B. Smith, General Mines Superintendent of the Granby Company, and Mr. MacDonald, local manager of the Hidden Creek mine, for permission to examine the workings for information, and for other courtesies.

*Situation.*—The claims are staked on the summit and sides of a hill 920 feet high, enclosed between two branches of Hidden creek, and situated 8,500 feet north of Goose bay, near its outlet into Observatory inlet. A good wagon road, planked where necessary, about 2 miles in length, has been built from the portal of the main tunnel to a wharf at Anyoux on Goose bay, the shipping port of the mine, and a tramway, partly gravity and partly traction, to the same point, was commenced some years ago but never completed.

*Rocks.*—The rocks in the vicinity of the mine consist of dark and dark grey argillites with occasional light coloured, coarse-grained feldspathic beds and rarely some limestone. Beds and bands of greenstones, probably largely of pyroclastic origin, occur with the argillites but are not prominent in the vicinity of the mine. Both argillites and greenstones are always more or less altered, and in places pass into mica, quartz mica, and chloritic schists. The bedding is coarse, and while a strong cleavage is developed in spots, the bedding planes over most of the area constitute the principal partings. The beds have been compressed into several folds, and, in places, dip steeply, but are seldom, in the section examined, overturned, and no large faults were observed. The strike, while generally east and west, shows considerable variation in places.

The argillites and associated rocks are exposed over an area about 9 miles wide, where cut by Observatory inlet. They are surrounded by the granite rocks of the Coast range, and are considered to be an undestroyed and deeply sunken portion of the old roof of the Coast Range batholith. The basin they occupy is of great depth, as the sedimentary rocks of the inclusion are exposed from base to summit of mountains over 5,000 feet in height, and they must extend for a considerable depth below the present surface.

The argillites are cut by numerous dykes, one set being older than the mineralization of the region and genetically connected with the enclosing granitic rocks. These vary widely in character and include granitic, dioritic, quartz porphyry, aplitic and pegmatitic types. In addition to these, a second widely distributed set occurs, the members of which were intruded after the mineralization of the region. These are fine to medium grained basic dykes often of a lamprophyric character. Thin sections from examples cutting Mammoth bluff showed laths and occasional phenocrysts of feldspar, mostly plagioclase, with abundant brown hornblende in long prisms and occasional plates of mica. Rounded irregularly bounded quartz grains, possibly of foreign origin, are also present, and large calcite areas probably representing original olivine are of frequent occurrence. A second type obtained from a dyke crossing the main tunnel of the Hidden Creek mine between the two ore bodies, contained large olivine and augite phenocrysts in a fine-grained hornblende-feldspar base and is classed as an olivine basalt. A third type, represented by a dyke crossing the Redwing, consists mainly of hornblende and plagioclase and possesses a well marked ophitic structure.

The later dykes may be connected with a basaltic flow which caps the hills south of Alice arm. They do not appear to affect in any way the ore bodies they cut.

*Workings.*—A large amount of surface and underground work has been done on the Hidden Creek mine. The mineralized area is very large and was first outlined roughly by long trenches running in various directions. Subsequently a working tunnel was started below what is known as Cabin bluff at an elevation of 530 feet, and has been driven straight into the hill in a northwesterly direction for 950 feet. A drift to the left from the main tunnel, starting 85 feet from the face, has been carried in for a distance of 300 feet, and several shorter drifts from points along the main tunnel serve to explore the ground bordering it.

Besides the main working tunnel and its branches, a number of shorter tunnels have been driven at various heights into the iron-stained slopes of Cabin and Mammoth bluffs. One of these, commencing in a depression at the foot of Cabin bluff, is connected by an upraise with the main tunnel.

In addition to the numerous trenches and tunnels, the mineralized area has been further extensively explored with the diamond drill by the Granby Company, the present owners of the property. A number of long bore-holes, starting from various points along the main tunnel and from the surface, have been drilled and have yielded valuable information in regard to the general character of the deposit.

*Size and General Character of the Deposits.*—The mineralized area, as shown by the various surface and underground workings, is of great extent although it has not as yet been fully defined, both ends being still unknown. In shape it forms a right angle. The smaller arm, known as the first ore body, has a northeasterly strike and dips to the northwest. It has been traced from the main tunnel in a southwesterly direction for over 600 feet, the width averaging about 160 feet or including a siliceous band which borders it on the northwest, of nearly 200 feet. The longer arm holding the second ore body has been traced in a northwesterly direction for a distance of 1,500 feet with an average width of about 400 feet. The deposit has been proved by a bore-hole to a depth of 514 feet below the main tunnel or approximately 900 feet below the surface outcrops on the hill.

While only a portion of the large area described contains valuable minerals in sufficient quantities to constitute commercial ores, the original rocks are everywhere either completely altered into greenish or less commonly brownish micaceous schists or replaced by quartz and iron and copper sulphides. The transition from the dark, slightly altered argillites which constitute the country rocks, to ore is usually fairly abrupt, often occurring in a few inches.

A conspicuous feature of the deposit is the presence of a zone of whitish quartz schists, practically strongly silicified argillites, traceable part way around it. This siliceous zone forms the northwestern boundary of the southwestern or smaller arm, crosses the deposit, then bending at right angles continues to the northwest as the northwestern boundary of the larger arm. It was not observed on the southwest border of the larger arm or the southeastern border of the smaller one.

The rocks in the siliceous zone vary in the amount of silicification undergone. In most places they are nearly pure quartz schists, but occasionally the zone consists of alternating dark and white bands. The width of the zone ranges from 30 to 60 feet and more. The dip where it skirts the smaller arm and crosses the deposit is to the northwest, but after bending to the northwest the dip, as shown by the bore-holes, changes to the northeast. It thus forms the hanging wall of both arms.

*Mineralogy.*—The metallic minerals present consist mainly of iron pyrite, some of it cupriferous, pyrrhotite, and subordinate quantities of chalcopyrite. A little bornite, evidently secondary, was found at one point. The principal non-metallic constituents are quartz, some calcite, a greenish micaceous schist, probably largely chloritic, some brownish micaceous schists, and occasionally some hornblende.

Pyrite is the most abundant metallic mineral present. It usually occurs in a granular condition, and in places near the surface breaks down into an iron sand. It is always associated with more or less quartz and large areas consist of pyrite grains separated by a thin siliceous matrix. It also occurs in grains and small bunches distributed through the secondary schists. Its distribution through the mineralized area is irregular, some portions containing only a small percentage, while others consist almost entirely of sulphides and quartz. The main tunnel, started some distance down the slope from the mineralized area to gain depth, passes through 380 feet of argillites, all somewhat altered and containing occasional grains and small bunches of pyrite, then through a pyritic zone 200 feet wide, becoming very siliceous towards the northwest border, then through a greenish schistose zone with some quartz and pyrite 240 feet wide, beyond which is a second pyritic area which continues to the end of the tunnel 120 feet. A drift to the left from a point near the end of the tunnel running about north for 300 feet, shows the continuation of the pyritic area for that distance, the breast being in granular sulphides mostly pyrite, embedded in a siliceous matrix. A drift to the left passes through sulphides and quartz for 100 feet, then through greenish chloritic schists only slightly mineralized for 120 feet.

The comparatively barren interval separating the two pyritic areas in the tunnel is not apparent on the surface, some of the ground overlying the lean portion being well mineralized with sulphides.

Pyrrhotite, while much less abundant than pyrite, is common throughout the greater part of the mineralized area. It occurs intermingled with the pyrite and also forming comparatively large masses usually specked with chalcopyrite.

Chalcopyrite in grains, small aggregates of grains, and in thin layers usually accompanies the iron sulphides where the replacement is complete or nearly so, and also occurs in small quantities scattered through portions of the schistose areas. The proportion present, while variable, is always small and in certain areas seems to be absent altogether. The chalcopyrite is associated so intimately with the iron sulphides that there is little doubt that both are the products of the same period of deposition.

Bornite was found at one point, but only as a surface alteration mineral, and it does not occur so far as known as a primary mineral of the deposit.

Among the non-metallic minerals, quartz is the most prominent. A wide siliceous zone crosses and bounds portions of the mineralized area, and the large sulphide areas are all more or less siliceous. Calcite occurs occasionally but is not prominent. Portions of the area included in the mineralized zone on the accompanying map consist of greenish micaceous schists often highly siliceous. These carry significant quantities of sulphides in some places and are nearly barren in others.

*Ores.*—The iron sulphides in the Hidden Creek mine carry very low values in the precious metals. Out of a number of samples assayed in the laboratory of the Mines Department one showed 0·02 ounce gold to the ton, one 1·65 ounce silver, and the rest only traces. The commercial value of the deposit must, therefore, depend mainly on the copper content. Chalcopyrite usually accompanies the iron sulphides, but in variable amounts. Some areas are nearly barren, while others contain sufficient quantities to constitute a low grade copper ore, that is ore carrying up to 3 per cent copper and over limited areas an even higher percentage.

The most important body of commercial ore so far outlined in the boring operations of the Company, occurs southeast of the siliceous zone previously described as bordering the shorter arm of the deposit on the northwest and continuing along the larger arm. The siliceous zone is fringed by a band of ore usually from 20 to 25 feet in width and already traced for a distance of nearly 1,400 feet. A vertical bore-hole from the main tunnel apparently proves it to a depth of 514 feet below that level and it extends to the surface above, a variable distance, depending on the contours of the country but probably averaging about 200 feet. The huge tonnage expected from this ore body will undoubtedly be greatly supplemented from other portions of the mineralized area. Workable ores are known to occur at a number of points, but the definition of their extent and quality awaits further exploration.

*Origin.*—The mineralized area at the Hidden Creek mine occurs in a larger predominantly argillaceous area surrounded and doubtless underlaid, although at a considerable depth, by granitoid rocks, and cut by dykes and stocks belonging to the same period of igneous intrusion. The argillites were irregularly compressed and folded at the time of the invasion and the deposit probably occupies an area more than ordinarily crushed and fractured, although this has been masked by subsequent alteration and deposition and is not apparent. A wide, broken zone, rather than a single fissure, is conceived to have afforded the means by which heated siliceous waters carrying iron and copper sulphides in solution ascended from the underlying batholith, altering the argillites in their upward passage and replacing them with silica and sulphides as the pressure and temperature conditions became less severe.

An origin of this kind would ally the deposit genetically with the loosely defined contact metamorphic group, although the ordinary contact metamorphic minerals, including the iron oxides, were not observed, and are either absent altogether or present only in very small quantities.

Deposits of the contact metamorphic group, that is, deposits situated on or near the contact of igneous masses with sedimentaries and formed by ore-bearing solutions, either aqueous or gaseous, emanating from the cooling intrusive, vary widely in character. Ordinarily they are described as bunchy, irregular masses, made up mostly

## LEGEND

Goose Bay argillite

Mineralized area

Quartz and silicified argillite

Lamprophyric and olivine basalt dikes

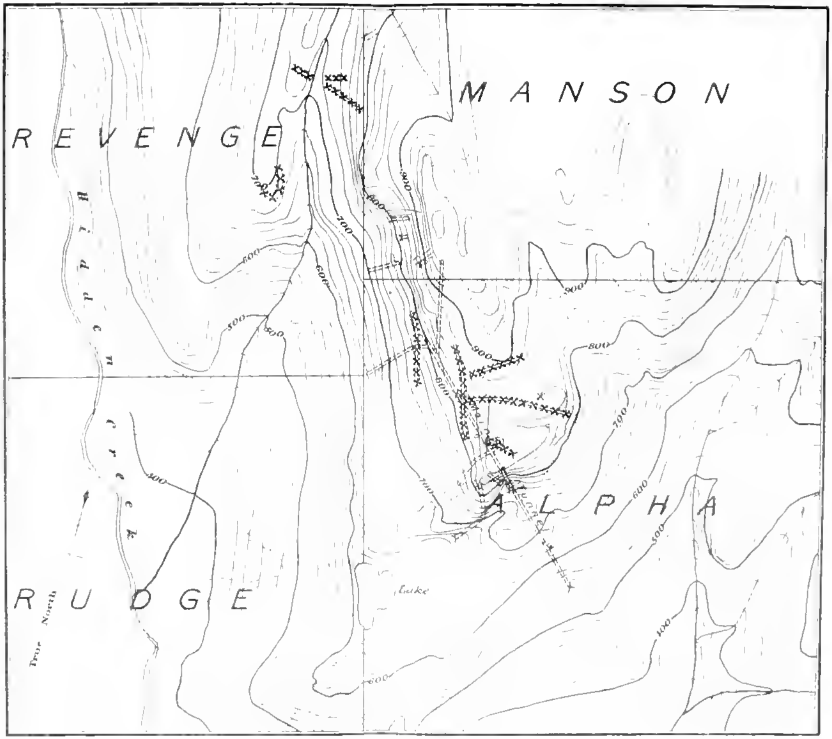
Surface deposit of Limonite

### Symbols

××××

Open cuts

Underground workings




Scale, 100 ft. to 1 inch
100 0 500 1000

Diagram showing mineral deposits and workings on Alpha and adjacent mining claims, Hidden Creek, Observatory Inlet, British Columbia; Geology by R. G. McConnell, 1911

*To accompany Summary Report, 1911*

of iron oxides, and iron, copper, lead, and zinc sulphides, in a gangue of secondary silicates, mostly garnet, epidote, augite, and tremolite. An eaxmination of numerous occurrences at various points along the west coast indicates, however, that neither shape nor the presence of any or the majority of the compounds mentioned are essential features. The shape is dependent on the channel followed, and in a broken region perfect vein forms produced by the complete replacement of the country between parallel fissure are not uncommon. The constituents are also dependent on the character of the parent intrusive, on conditions of deposit, and possibly on the aqueous or gaseous character of the emanations, and gradations occur from masses of pure or nearly pure magnetite to others made up largely of tremolite and iron and copper sulphides, and in some instances of quartz and sulphides. The present classification, based only on a broad genetic relationship, is far from satisfactory. The name of the group is also misleading, as it included deposits far removed from actual contacts.

*Equipment.*—Work on the Hidden Creek mine up to the present has been altogether of an exploratory character, but plans for working and equipping it on a scale commensurate with its importance and for transportation of the ores to the beach are now being formulated. A smelter will probably be erected to treat the ores, but the site of this was not decided on at the time of my examination, or at least was not announced. The present equipment includes a power plant situated on Falls creek and operated by water furnished by that stream, and a compressor and diamond drill plant.

### *Bonanza Group.*

This group is situated about three-fourths of a mile up Bonanza creek, a small stream emptying into Goose bay about 2 miles below its mouth. Bonanza creek is a rapid stream about 20 feet wide, confined in a deep, narrow valley terminating below in a rock canyon 20 to 30 feet deep, excavated since the glacial period.

The Bonanza group of claims, six in number, were the first claims staked in the district, and were explored to some extent by Mr. M. R. Rogers before the discovery of the Hidden Creek group. Very little work has been done on them in recent years.

The general character of the deposit on which the claims are staked is similar to that of the Hidden Creek group. The country rock is a dark, somewhat altered, argillite cut by pegmatite and dioritic dykes, before it was mineralized, and by a later set of basic dykes after it was mineralized. The argillites are altered over a wide area into biotite and chloritic schists, some of it quite coarse, holding variable quantities of pyrite, pyrrhotite, and in places chalcopyrite. The sulphides are accompanied by some quartz, but this mineral is much less abundant than in the Hidden Creek mine. The altered and mineralized area has a width of over 500 feet, and is opened up by short tunnels for a distance of 600 feet along its strike.

The workings consist of 3 tunnels, one over a hundred feet in length, north of Bonanza creek, near the creek level, and two tunnels and some surface work on the south side. The most westerly of the tunnels north of the creek cuts 10 feet of granular pyrite near its mouth, beyond which are micaceous schists holding only a small percentage of sulphides. Little copper is present. A sample of the granular pyrite gave on assay 0·48 per cent copper, 1·25 ounce silver to the ton, and traces of gold. Some pyrrhotite holding specks of copper occurs in the middle tunnel. The east tunnel passes through micaceous schists sparingly mineralized with pyrite.

The two tunnels south of the creek expose schists holding pyrite in scattered grains and bunches, and occasionally some chalcopyrite. Some good looking chalcopyrite ore is exposed in a cut near the creek, but further exploration is needed to determine whether it occurs in workable quantities or not.

The Bonanza ground looks favourable enough to warrant a diamond drill exploration such as that in progress with such favourable results in the Hidden Creek property. The area of altered schists carrying iron and occasionally copper sulphides is very large and the present workings cover only a small portion of it.

A large quartz vein, fully 10 feet wide in places, occurs on the North Star claim, one of the Bonanza group. It holds some pyrite and chalcopyrite. A sample assayed yielded only 0·48 per cent copper and 0·20 ounce silver to the ton. A number of large quartz veins occur around Goose bay, most of which seem to be barren or nearly so.

*Redwing.*

The Redwing, staked in 1909 by Joseph McGrath, is situated about 2 miles up Glacier creek at an elevation of 1,820 feet above sea-level. Glacier creek is a short rapid stream issuing from a glacier which fills the upper part of its valley, and emptying into Goose bay near its lower end.

The country rock in the vicinity of the claim is an altered silicified greenstone, passing in places into a schist, lying between the argillites and the granite. Granite occurs a short distance to the south, and a wide dyke or spur crosses the valley at one point.

The claim is staked on a conspicuous oxidized zone in the greenstone running up the northern wall of the valley. The zone has a width of over 50 feet in places, contains some quartz stringers, and is paralleled on the east for some distance by a strong quartz lead. A basic dyke, made up largely of hornblende and fresh plagioclase and showing a diabase texture, crosses it at one point.

The mineralization is similar to that of the other occurrences described, consisting of iron sulphides with some irregularly distributed chalcopyrite. The only development work done consists of a tunnel 25 feet long, driven into the face of the cliff near the centre of the oxidized zone. This passes through the basic dyke mentioned above, then through 6 feet of nearly solid iron with some copper sulphides, the latter in grains and fair sized bunches, then through micaceous schists sparingly mineralized. Chalcopyrite occurs both in the tunnel and at other points in sufficient quantities to constitute a good copper ore, but more development work is needed to prove quantity. Assays of the sulphides are stated to show some values in the precious metals.

*Red Bluff Group.*

Looking up the wide valley of the Kitzault river from the head of Alice arm, a red patch shows prominently on the face of a mountain north of the river, distant about 4½ miles. A number of claims have been staked on the red area and grouped together under the name of the Red Bluff group.

A short visit to the showing was made in company with Mr. Young, one of the owners, but as little development work has been done, observation was limited to the general surface features. A rough trail leading up the valley of the Kitzault for some distance, then up a tributary stream from the north, has been brushed out to the foot of the red bluff.

The rocks in the neighbourhood of the showing consist mostly of fine and medium-textured, greenish, tufaceous sandstones alternating in places with bands of finer grained, dark argillaceous rocks. The tufaceous sandstones occur in wide, practically massive bands, showing little stratification. They are not much altered and consist mainly of rounded and angular feldspar grains, some quartz, and fragments of glass and volcanic rocks.

The mineralized area is very large, fully a thousand feet in width, and traceable for a long distance up the steep slopes of the mountain. The rocks are fractured and the pyrite oxidized to a greater depth than usual, and no large mass of sulphides is exposed on the surface. Copper carbonates in small quantities occur at a number of points, and a specimen consisting mostly of white pyrite in a siliceous gangue contained small specks of bornite. Some pyrargyrite in small grains was also found with pyrite in one exposure. This mineral does not occur, or at least has not been found, in the other large iron croppings of the district. A crust deposited by a spring bubbling up near the centre of the deposit was determined by Mr. R. A. A. Johnston as allophane, a hydrous silicate of aluminium.

The economic importance of this large pyritized area is uncertain. It contains some copper, and while the small amount of surface work which has been done has not exposed it in commercial quantities, the prospects certainly warrant further exploration. The presence of the rich silver mineral pyrargyrite, even in small quantities, is important.

## Quartz Veins.

### *Aldebaran, Black Bear, Etc.*

Quartz veins rich in silver occur on a group of claims, including the Aldebaran and Black Bear, located three-fourths of a mile north of the head of Alice arm, on the lower slopes of the mountains bordering the valley on the west. They were located in 1906, and the controlling interest is owned by Mr. Frank Roundy.

The principal showing is on the Aldebaran and consists of stringers of quartz cutting the argillites for a width of about 6 feet. The central vein has a width of 6-8 inches and a drift has been started on it. It is well mineralized, while the bordering quartz stringers are nearly barren. The strike is northwesterly, and the dip to the southeast at an angle of 45°. The minerals present consist of pyrargyrite or ruby silver in noticeable quantities, argentiferous galena, pyrite, chalcopyrite, and sphalerite. The vein, where exposed in the short tunnel, runs very high in silver, but has only been followed for a short distance. A small cut 100 feet from the tunnel in the direction of the lead shows a quartz vein 3 feet thick, and quartz also occurs in cuts 250 and 350 feet distant. It is uncertain if the small quartz veins in these cuts represent a continuation of the rich vein at the tunnel or are different veins lying in the same fractured zone. They contain some values but are less highly mineralized, and no pyrargyrite was noted.

### *Molybdenite Group.*

These claims are situated north of Alice arm, about a mile east of the contact of the argillaceous series with the granite of the Coast range, and at an elevation of 1,100-1,400 feet above sea-level. The argillites are associated with some coarse feldspathic beds probably of tufaceous origin, and by pre-granite, altered, greenish dykes.

The showing consists of a series of quartz veins and stringers following a fractured zone striking in a northeasterly direction and traceable for over 1,000 feet. The strike of the veins is parallel to that of the zone as a rule, but occasionally they cross it diagonally. They vary in thickness from a few inches up to 4 feet.

The quartz veins contain molybdenite sometimes in considerable quantities, in scattered flakes, small bunches, and in lines parallel to the sides. Other minerals present in small quantities are iron pyrite, galena, and blende. A strong quartz porphyry dyke which crosses the trend of the lead is slightly mineralized with molybdenite and cut by small quartz stringers.

A specimen of the molybdenite-bearing quartz assayed in the laboratory of the Department of Mines, contained 2·60 per cent of molybdenum and traces of gold and silver. The owners state that fair gold values have been obtained from places along the lead.

*Waterfront Claim.*

This claim is situated on the north side of Alice arm, about half a mile from its head. It contains a strong quartz lead about 6 feet thick which outcrops near the water level and is said to be traceable in a northwest direction across the claim. It contains grains of iron pyrite, galena, and sphalerite, but is only lightly mineralized. Pyrargyrite is stated to have been obtained from it, but none was seen by the writer.

A galena showing on a branch of Lime creek in the mountains south of Alice arm, and a large iron showing high up, west of Goose bay, were not examined, as at the time of my visit (June 23-July 15) they were still buried in snow.

*Maple Bay.*

Maple bay is a small indentation in the coast of Portland canal, situated due west from the head of Goose bay on Observatory inlet. The argillaceous rocks of Goose bay extend westward across the mountain range separating Observatory inlet from Portland canal, and crop out along the shores of the latter in a wide band in the vicinity of Maple bay. They become more altered in their extension westward, and the dark argillites are represented by greyish and dark micaceous schists and the included greenstone bands, both clastic and massive, by chloritic schists.

The schists are cut in places by quartz veins, and one of these was mined on a considerable scale some years ago by the Brown Alaska Company. The vein worked is situated about a mile from the beach in a N.N.E. direction, and at an elevation of 980 feet above it. A road from the beach to the mine was constructed, a wharf built and a number of buildings, including bunkers, erected at the mine and wharf, and a compressor and boiler-house at the beach. All of these are now rapidly going to ruin.

The principal workings consist of a long tunnel measuring roughly 980 feet. The quartz vein was followed for 550 feet. It was then either lost or gave out, as little quartz was noticed in the last 430 feet. The vein strikes a few degrees east of north and dips to the east at an angle of 45°. It consists mostly of quartz with some enclosed schist, and ranges in width from 3 feet to about 12 feet. The principal metallic minerals noted are pyrrhotite, pyrite, and chalcopyrite. The percentage of chalcopyrite varies, and only in places is present in sufficient quantities to constitute an ore. Small values in the precious metals are reported.

Some stoping has been done and the ore shipped to a smelter on Prince of Wales island. The general tenor of the ore was not learned. The mine has been idle for several years.

# II

## SALMON RIVER DISTRICT.

### Introductory.

A short description of the Salmon River mineral district was given in the Summary Report for 1910. During the past season more time was spent in the district and the geology roughly outlined and laid down on a map compiled from the Boundary Survey maps and sketches made by ourselves. The district is still difficult of access as no proper trails have been constructed, and except along the lower portion of the river where horses can be used all supplies and outfit needed must be packed in by men.

TOPOGRAPHY.

Salmon river parallels Bear river on the north and is separated from it by the long Bear River ridge. It is a short stream issuing from a large glacier, and after a course of 13 miles measured along the valley, empties into Portland canal near its head. The main stream is entirely in Alaskan territory, the International Boundary line crossing its valley near the lower end of the glacier.

South of the Salmon glacier, between it and Bear River ridge, is a broken ridgy tract of country, about 2½ miles wide, drained by Cascade river, a tributary of the Salmon. Most of the mineral occurrences are situated along this belt.

Cascade river heads in Long lake, plunges down a series of cascades through a recent rockcut channel into Silver lake, then continuing southward, joins the Salmon after a course of about 5½ miles measured along its valley. Its grade is exceptionally steep, averaging over 500 feet to the mile. It has a width of from 20 to 50 feet, flows a large volume of water, and if the prospects now being investigated develop into mines, will doubtless be utilized at several points for power plants.

A branch to the northeast, separated from the main stream by Slate mountain, a long ridge rising to an elevation of 4,000 feet, skirts the base of Bear River ridge to a point close to Long lake and at about the same elevation. It is fed by streams descending from the snow and ice-covered slopes of Bear River ridge, and near its mouth is almost equal in size to the main stream.

Long lake, the source of Cascade river, is a narrow stretch of water about a mile and a half in length, occupying a depression in a north and south trending valley separating Mt. Dillsworth[1] from Bear River ridge. Its elevation is approximately 3,250 feet. The valley beyond it rises slowly northward to a flat summit, then descends towards the Nass slope.

The principal elevations of the district include: the long Bear River ridge, bounding it on the east; Slate mountain, 4,000 feet high, between the two branches of Cascade river; the Big Missouri ridge, 3,400 feet, between Cascade river and Salmon glacier, and Mt. Dillsworth, a round, dome-shaped, completely snow-covered elevation, rising to an altitude of 5,600 feet between Long Lake valley and Salmon glacier. Skirting the southern base of Mt. Dillsworth is a narrow, broken, and hummocky belt sloping towards the Salmon glacier. Mt. Miter, so called by the miners on account of its notched summit, is a conspicuous object in the view up Long Lake valley. It has a broad spreading base deeply buried in snow and ice from which a bare, seemingly almost perpendicular, mass of rock shoots up to a height of over 8,000 feet.

The glaciers of the district are a prominent feature. Salmon glacier, the source of Salmon river, has a length of nearly 8 miles and occupies the summit of a through valley connecting the Salmon with the Nass. It is fed mainly by two branches from the west, one joining it at the summit almost at right angles and from this the ice flows east and west down both slopes. Its elevation at the summit is approximately 3,000 feet and at its termination in the Salmon valley 480 feet, the lowest point reached by perennial ice in this portion of the Coast range. The Nass branch ends in a lake at a much higher elevation. A number of small glaciers descend from the large permanent snow field which crowns Mt. Dillsworth, and a line of ice tongues creep down the slopes of the Bear River ridge, none of them reaching the valley. The western slopes of this ridge are less steep than those fronting on Bear river and American creek and large snow fields are more prominent.

The general aspect of the Salmon River district above an elevation of 3,000 feet is exceedingly bleak and arctic looking. Long lake at the time of our visit, August 2, was still covered with ice, and except on projecting rocky knobs and sunny slopes the preceding winter's snow lay thick everywhere. Below an elevation of 3,000 feet,

[1]-Named after one of the pioneer prospectors of the district.

the valleys and mountain slopes are generally well wooded, principally with large hemlock and spruce of good quality.

## Geology.

The formations represented in the Salmon River district are the Bear River greenstones, the Nass argillites, and the granitic rocks of the Coast Range batholith.

The eastern edge of the Coast Range batholith on the western slope of Bear River ridge, and in the Salmon River valley, occurs on the Alaskan side of the International Boundary and was not traced out. Following the boundary line, small granitic areas, some of which may be spurs from the main batholith, and large dykes, are crossed at intervals, but the predominant rock is greenstone. On the western side of the Salmon valley the eastern edge of the batholith trends to the north and crosses the International Boundary near the lower end of Salmon glacier. It follows the glacier for 3 miles, to a point above the first feeder, then turns more to the west and passes beyond the district examined.

A band of granitic and porphyritic rocks, roughly paralleling the main batholith at a distance of from 4 to 6 miles, crosses into the Salmon valley from the head of Goose creek, and extends in a northwesterly direction across Long lake to the base of Mt. Dillsworth, then bending more to the west crosses Salmon glacier to a mountain south of the main feeder at the summit. The width of the band is variable, in places exceeding half a mile and in others diminishing to a few hundred feet. West of Long lake, it becomes very narrow and soon breaks up along its course into a series of large parallel dykes dipping to the southwest.

The rocks in this band are usually porphyritic and in places pass into typical quartz porphyries made up of quartz, and plagioclase feldspar phenocrysts, with some white mica embedded in a fine-grained, micro-crystalline base. In the main batholith west of the Salmon glacier the prevalent variety, as shown in a couple of sections, is a coarse grano-diorite with hornblende often in well formed crystals as the principal dark mineral. The other essential constituents are plagioclase feldspar, quartz, and a little orthoclase.

### *Bear River Formation.*

This is the most widely distributed formation in the Salmon River district. It occurs bordering the granite a little to the southwest of the International Boundary, on the western slope of Bear River ridge and in the Salmon valley, and except where overlain by occasional patches of the Nass argillites and cut by granitic dykes and areas, underlies the region east of the Salmon glacier as far north as examined.

The Bear River formation is predominantly a greenstone formation and represents the products of a long period of vulcanism. The rocks include fine, medium, and coarse volcanic breccias or agglomerates, tuffs, bands, and areas of massive porphyrites, and occasional argillaceous bands. The fragmental rocks are often difficult to separate from the massive rocks in the field and even in thin sections. They are seldom distinctly bedded or banded, and often appear massive through sections hundreds of feet in thickness. The fragments are angular or subangular, consist mainly of feldspathic porphyrites, and on fresh surfaces are often indistinguishable from the matrix, although plainly outlined where the rock is weathered.

In the Salmon valley, the greenstones are usually sheared and pass into coarse greenish and greyish schists, the lines of schistosity being roughly parallel to the eastern edge of the Coast Range granitic batholith and dipping towards it at a high angle. The shearing is irregular, some areas being only slightly affected, and usually, but not invariably, increases in intensity approaching the granite.

### *Nass Formation.*

The rocks of the Nass formation overlie the Bear River greenstone. They occur on the northern part of Slate mountain and extend northeasterly in a comparatively narrow band west of Long lake to the eastern shoulder of Mt. Dillsworth. A second area separated from the first by the erosion of the valley of the East Fork of Cascade river, is exposed east of Slate mountain in the western slopes of Bear River ridge. This area is largely buried in snow and ice and its upper contact with the greenstone was not seen. A third area, tentatively referred to the Nass formation, occurs bordering the Coast Range granitic rocks west of the Salmon glacier.

The rocks of the Nass formation are mainly dark argillites, always more or less altered and in places cleaved into slates. On Slate mountain they are fine-grained and very uniform in composition throughout. They rest on a massive-appearing, dark-coloured, volcanic breccia, below which are the greenish schistose fragmentals of the Bear River formation. On the western slope of Bear River ridge and north of Long lake, the argillites are associated with greenish and greyish beds and bands of tufaceous sandstone. The material in these consists mostly of angular quartz and feldspar grains with fragments of slate and calcite.

In the area west of the Salmon glacier they consist of hard, siliceous, dark and striped slaty rocks resembling quartzites in places.

The Nass argillites and associated granular and fragmental beds occupy the Long Lake depression, and rise to the south in Slate mountain and the western slope of Bear River ridge. They have been folded in the mountain-making movements, and in places crushed into the underlying Bear River greenstones. The dips and strikes, while irregular, indicate a double fold trending in a north-northwest direction. The formation extends northwards beyond the district examined and its thickness was not ascertained.

## MINERALIZATION.

The mineral occurrences of the Salmon River district occur altogether in the Bear River schistose greenstones, and consist mostly of silicified zones often of great width, carrying varying quantities of iron, lead, zinc, and copper sulphides. Fissuring occurs in connexion with some of the deposits, but few of them are bounded by sharp walls and in most cases the cessation of the mineralization is gradual. The mineralized zones are really bands of country rock sometimes 50 feet in width, partially and in limited areas wholly replaced by silica and various sulphides. A few quartz veins occur in addition to the replacement deposits, and in some instances carry high grade silver minerals.

A large number of claims have been staked on these mineralized zones, extending in an almost continuous line, often several tiers deep, from the International Boundary, up Cascade river, along the Big Missouri ridge, and the lower slopes of Mt. Dillsworth to near the summit of the Salmon glacier. While staking has been active the progress of development and exploration work has been very slow, this consisting only, with the exception of a couple of short tunnels, of small open-cuts and cross trenches. None of the showings have been advanced beyond the stage of surface prospects. This slow progress is due in large measure to the absence of transportation facilities and the consequent extravagant cost of supplies. The building of trails has been delayed by the fact that while the showings are mostly on the Canadian side of the International Boundary, the road to the coast passes through Alaskan territory.

## PROSPECTS.

The first camp reached ascending Cascade river is that of Bunting Bros. and Dillsworth, situated at an elevation of 1,050 feet on the eastern bank of the East Fork of Cascade river about a mile northeast of the International Boundary and 12 miles from Portland canal, following the Salmon valley. A joint stock company, under the name of the Cascade Falls Mining Company, has recently taken over the five claims owned by this syndicate.

The principal showing occurs on Cascade Falls No. 2 claim, and consists of a mineralized zone traversing the greenstone schists which form the country rock in an easterly direction. The schists for a width of over 30 feet are altered and strongly silicified and pyritized. In portions of the zone, galena is present in considerable quantities, associated with some zinc blende and occasional grains of chalcopyrite. A rough sample across 8 feet of the best mineralized portion of the lead assayed in the laboratory of the Department of Mines, yielded:—

| | |
|---|---|
| Gold | 0·14 oz. per ton. |
| Silver | 7·00 ozs. per ton. |
| Lead | 7·60 per cent. |

Ore of this grade could doubtless be mined at a profit in the district if present in quantity, but the extent to which it persists either in depth or along the strike of the lead has not been demonstrated. The mineralization is irregular both across the lead and along its strike, portions of the zone containing little or no galena, the principal silver-bearing mineral; and the present workings are limited to a shallow cut in the steep hillside across the lead and some surface stripping. The prospects are, however, considered favourable enough to justify a considerable expenditure for further exploratory work.

*Salmon-Bear River Mining Company.*

This Company owns seven claims situated a short distance east of the Bunting-Dillsworth group, and about 1,000 feet higher up the western slope of Bear River ridge. One of them, Cascade Falls No. 4, contains a very wide showing. The schists are silicified, seamed in places with small irregular quartz seams, and impregnated with sulphides for a width of fully 75 feet. The sulphides are oxidized on the surface and the mineralized zone is traceable up a steep hillside for a distance of about 200 feet, beyond which it is concealed.

The workings consist of a shallow cut across the greater portion of the zone near the base of the hill and a short tunnel higher up the slope. These show the mineralization to be very irregular, portions of the zone being entirely replaced by sulphides and quartz and others only slightly affected. Quartz and the iron sulphides are the only minerals which persist across the zone. Galena occurs in small veinlets, bunches, and scattered through areas and bands in the zone, and some sphalerite and occasional grains of chalcopyrite are also present. The galena areas carry fair values in lead and silver and some gold, and the value of the deposit depends on their permanence. The present workings are, of course, wholly insufficient to determine this point.

The Pictou claim belonging to the same Company, situated about 1,000 feet northwest from the main showing, is crossed by a second, somewhat similar, but smaller zone, apparently following a strong diorite porphyry dyke. The schists for a width of 20 feet from the dyke, as shown in a small transverse cut, are silicified, heavily mineralized with pyrite and some galena, cut by numerous quartz stringers, and in places brecciated. A hundred feet to the northwest, a second cut exposes a similar zone on the opposite or southwest side of the dyke. The proportion of galena present in the cuts is small and its distribution is bunchy and irregular.

The Simpson claim in the same group, situated higher up the slope, contains an exposure of silicified schist cut by quartz stringers, some of which carry small quantities of native silver and chalcocite in addition to the ordinary pyrite and galena.

High assays in silver and some gold have been obtained from picked samples. The lead is concealed except at a couple of points, and no attempt to trace it out has so far been made.

*Indian Mining Company.*

This Company owns four claims, situated at an elevation of about 2,400 feet, near the southern end of the Big Missouri ridge between Cascade river and the Salmon glacier. The principal showing occurs on Portland No. 2 claim, and some development work was done on it in the season of 1910 by the Portland Salmon River Syndicate, and is described in the Summary Report of the Survey for that year. During the past season a couple of men were engaged extending an exploratory tunnel started by the syndicate.

The lead crosses diagonally a wide dyke or lenticular dioritic stock very much altered, which intrudes the greenstone schists, and is better defined than most of the showings in the district. A cut across it near the summit of the ridge shows it to have a width here of nearly 20 feet, and exposes from 5 to 8 feet of nearly solid galena bordered by quartz and silicified and mineralized country rock. The galena mass has been followed vertically for 20 feet, but apparently does not extend far along the strike. A second cut, 150 feet to the south-southeast, down a steep slope, shows little galena. The lead here consists mostly of altered and silicified country rock and carries average values in gold and silver of about $10 to the ton across a width of 10 feet.

The tunnel now being driven starts 300 feet south-southeast of the galena showing and will undercut it at a depth of 150 feet, as the surface falls rapidly in that direction. At the time of my visit the face was in low grade ore, a sample assayed in the laboratory of the Department of Mines yielding 0·11 ounce gold to the ton, 1·10 ounce of silver, and 5·12 per cent lead. The extension of the tunnel is important, as when completed it ought to furnish valuable information in regard to the general character of the deposits of the district.

Some surface prospecting was in progress during the season on mineralized areas and zones on the Siwash and other claims on the Big Missouri ridge north of the Portland group, but no conclusive results were obtained. The Big Missouri claims and the thirty odd claims held and prospected to some extent in the season of 1910 by the Golden Crown Mining Company were all idle, the bond on them held by that Company having been thrown up. The Martha Ellen and three other claims held under bond in 1910 by the Salmon Glacier Mining Company and situated farther to the north immediately above the Salmon glacier, were also idle although very satisfactory results had been obtained from the small amount of surface prospecting done. A trench across a mineralized zone on the Martha Ellen, roughly sampled for 17 feet, yielded 0·57 ounce gold to the ton, 3·76 ounces silver, and 4·64 per cent lead. The zone has a width of over 50 feet and the most highly mineralized portion is not included in the sampling, as a deep transverse pit filled with ice and water prevented access to it. Still farther to the north, between Mt. Dillsworth and the Salmon glacier, are the Fortynine and numerous other claims, all staked on oxidized zones and areas, but with little work done on them.

The Silver Flat, on a hill north of Silver lake, affords an example of a narrow lead confined between nearly vertical fissures. The lead has a width of from 2 to 3 feet and consists of quartz and silicified country rock carrying some galena, chalcopyrite, sphalerite, and pyrite. Assays of $21 to the ton in gold, silver, and lead are reported.

SUMMARY.

Characterizing the region generally it may be stated that it contains a large number of mineral deposits ranging in size from small stringers to wide zones and irregular lenses often 50 feet and more across, all traversing the more or less schistose massive and fragmental greenstones of the Bear River formation. The deposits plainly follow lines of fissuring and shear zones in some instances, and probably do so in all cases. With the exception of some narrow quartz stringers they all belong to the replacement class, and in origin and the irregular and hazy outlines of some of the masses resemble contact metamorphic deposits, but the characteristic non-metallic minerals which accompany these were seldom observed and are nowhere present in quantity.

The gangue is invariably the more or less completely silicified country rock, and the common metallic minerals are pyrite, occasionally pyrrhotite, galena, sphalerite, and chalcopyrite. Of these pyrite is much the most abundant, and in some cases is practically the only mineral present. In places it carries appreciable values in gold. A specimen of pyrite in a quartz gangue from Cascade Falls No. 2 yielded 0·24 ounce of gold to the ton and much higher assays are reported. Chalcopyrite was not observed in workable quantities. Galena is more abundant and usually carries silver values averaging about one ounce to the unit of lead. The distribution of the galena in the silicified and pyritized zones and areas is usually irregular, some portions carrying a good percentage while others are entirely barren.

Development work has been retarded by the lack of transportation facilities and consists only of some surface cuts, trenches, and a few short tunnels. These in several instances have exposed bodies of ore carrying values in gold, silver, and lead of from $10 to $20 per ton. Development work has not, however, proceeded far enough to show what persistence these ore bodies have either in strike or dip. The mineralizing solutions undoubtedly came from the underlying granite, and there is no reason why the deposits should not descend to considerable depths, but whether in irregular unworkable bunches or in continuous pay shoots still remains to be proven.

# III

## PORTLAND CANAL DISTRICT.

### Introductory.

A description of the principal geological features and a somewhat detailed account of the mineral occurrences of the Portland Canal district, by the writer, were published in the Summary Report of the Survey for 1910. Further work was done in the district during the past season, and with the aid of a topographical map prepared by Mr. Malloch, the formations were outlined more correctly than it was possible to do the preceding season. Some of the more important mineral deposits were also re-examined.

### Outline of Geology.

The Portland Canal mining district covers a portion of the Coast range extending from the head of Portland canal up Bear river and is practically co-extensive with the rugged region drained by that stream and its tributaries. The irregular eastern edge of the long granitic batholith of the Coast range forms roughly its western boundaries. The batholith is bordered on the east in this latitude by sedimentary and volcanic rocks which have been grouped into three main divisions and given the following names:—

| | |
|---|---|
| Bitter Creek formation.. .. | Principally argillites. |
| Bear River formation... .. | Principally massive and fragmental volcanics. |
| Nass formation... .. .. .. | Argillites and tufaceous sandstones. |

### *Bitter Creek Formation.*

The Bitter Creek formation, the oldest series, consists mostly of dark argillaceous rocks cleaved into slates in places, but the principal partings in most cases follow the original bedding planes. They are usually more or less altered with a development of yellowish mica arranged parallel to the partings and in places pass into micaceous schists. The ordinary constituents are quartz, feldspar, and a dark carbonaceous dust. Zircon, pyrite, and secondary mica and quartz are also commonly present.

The slates or shales in places have a striped appearance, due to a rapid alternation of dark, fine-grained argillite with lighter coloured and more feldspathic layers. Other rock varieties of occasional occurrence are green bands consisting mostly of broken feldspar crystals and quartz, with chlorite, calcite, and other secondary minerals,—probably of tufaceous origin,—and beds and bands of greyish crystalline limestone. The proportion of limestone increases towards the east and on portions of the Mt. Gladstone ridge forms an important part of the formation.

The dip of the Bitter Creek argillite is generally to the southwest or towards the granite, usually at a high angle, in places reaching 90 degrees. No definite proof of faulting on a large scale or of overturns was obtained. This general uniformity of dip across the area covered by the formation results in some uncertainty in regard to the reference of the series as a whole to a position subordinate to the Bear River greenstones, as on the western slopes of the Cambria range they appear to overlie the latter at a high angle. There is little doubt that the western, and if the present dip is taken for a guide, the upper portion of the Bitter Creek argillites are older than the Bear River volcanics which adjoin them, as they are cut at various points by the intrusive members of this group and interbanded in places with sheets of porphyrite. Volcanic action, as evidenced by occasional tufaceous bands, was in progress near by during the whole period of the accumulation of the Bitter Creek argillites, and it is quite possible that portions of the wide-spread volcanic series grouped together as the Bear River formation may be contemporaneous with, or even antedate them, in order of deposition. This point could not be satisfactorily determined in the small area studied.

### *Bear River Formation.*

This complex volcanic group has a wide but exceedingly irregular distribution. It occurs all along the Bear River ridge, spreads eastward across the group of mountains between American creek and Bear river, then southward along the watershed ranges beyond the area examined, thus enclosing the Bitter Creek argillites on three sides. The rocks represented in it have a prevailingly green colour, and include porphyrites of various kinds, mostly of hyp-abyssal origin, tuffs, volcanic breccias and agglomerates, and occasional argillaceous bands. Small areas in various parts of the district have been silicified and altered into cherts. A strong schistosity approximately paralleling the eastern edge of the Coast Range batholith has developed in places, especially along American creek and in the Salmon River valley, but, as a rule, the rocks have not yielded to crushing. The alteration they have undergone is also very variable, ranging from specimens which have completely lost their identity to others comparatively fresh.

A marked feature of the formation is the general absence, except in the case of the argillite bands, not only of sharp but in most cases even of observable contacts, between the massive and fragmental members of the group. The massive porphyrites in thin sections often show flow structure, but appear to occur in irregular areas and either pass gradually in most cases into the fragmentals, or the contacts were obscured by the compression, alteration, and mineralization resulting from the granitic invasion of the Coast Range batholith, and the bordering stocks and dykes.

The fragmentals consist largely of angular greenstone fragments usually less than an inch across but often of large size, indistinguishable in composition from the massive porphyrites and enclosed in a massive or pyroclastic matrix. They show little bedding or banding and are often remarkably uniform in composition through sections thousands of feet in thickness.

Massive porphyrites predominate in the southern portion of Bear River ridge. Going north and east the proportion of fragmentals increase, and along Upper Bear river the bordering mountains are largely built of them.

The porphyrites are greyish, medium-textured, comparatively deep-seated rocks. They usually occur in a massive condition but in places have been sheared into coarse schists. A red variety, due to a development of red oxide of iron, is conspicuous in places.

A number of thin sections, studied and reported on by Mr. A. O. Hayes, my assistant in the field, show them to consist largely of plagioclase feldspar in two generations. In most of the sections examined the ferro-magnesian minerals are either absent altogether or present only in small quantities, and the rock consists largely of phenocrysts of plagioclase scattered through a fine-grained base of the same mineral. In a few sections the dark minerals are present in sufficient quantities to class the rock as an augite, and less commonly a hornblende porphyrite. Grains of black iron ore, usually titaniferous, are present in most of the sections, and apatite in small, well-formed crystals is very abundant. The common secondary minerals are chlorite, calcite, epidote, leucoxene, and the red oxide of iron.

The fragmentals occur as tuffs and volcanic breccias and agglomerates. The tuffs are made up largely of feldspar crystals, often broken, quartz grains and minute rock fragments lying in a dark, fine-grained mat, and are often difficult to distinguish in the field from the massive porphyrites. The breccias exhibit considerable diversity in character and probably originated in different ways. They consist mainly of angular porphyrite fragments, accompanied in places by slate, limestone, and rarely granite. The fragments vary in size from minute grains up to masses several feet across, but are often very uniform in size over wide areas. The matrix in the specimens examined is altered and difficult to determine but appears to be massive in some instances, although mostly clastic, and occasionally the rock has the appearance of having been crushed in place. The fragments are usually pressed closely together, but in some areas are widely separated and seem to have been thrown up and fallen back into a still liquid matrix.

Occasional dark argillaceous bands occur with both the massive and fragmental members of the Bear River volcanic group, apparently indicating that sedimentation occurred at intervals during the whole period of its accumulation. The bands are thin, seldom attaining a thickness of over 100 feet, and of little persistence. They have not been closely studied and it is possible that some of them may be built of fine tufaceous dust.

### *Nass Formation.*

The rocks of the Nass formation overlie the Bear River volcanics in the mountains on both sides of Bear River summit, on Slate mountain and other places in the Salmon valley, and along the eastern edge of the Coast range. They consist largely of dark argillites very similar in most respects to those of the Bitter Creek formation, but less generally altered. They are seldom cleaved and in some sections might be classed as shales. Beds and thick bands of tuffs, tufaceous sandstones, and breccias occur with them in places but are of subordinate importance.

In the mountains north of Bear River summit, the Nass argillites alternate near their base with heavy bands of volcanic breccia similar to that occurring in the upper portion of the underlying Bear River formation.

The attitude of the Nass argillites in the summit ranges is flat or nearly so, while along the eastern edge of the Coast range the inclination is easterly at angles of about 45°, gradually diminishing to the east. In a previous paragraph the Bitter Creek argillites are stated to have prevailing westerly or northwesterly dips, thus giving the two formations the appearance of forming opposing limbs of a wide syncline, separated by the Bear River volcanic area. They were not found in juxtaposition, and the principal reason for classing them as two series is that while the Nass argillites definitely overlie the Bear River volcanics, the Bitter Creek rocks are cut and intruded by them at various points. The lithological character of the two formations also, while generally similar, exhibit some differences. Limestones occur in the Bitter Creek formation and the proportion of coarse fragmental rocks is much less than in the Nass formation.

No evidence as to the age of either the Bitter Creek or Nass formation was obtained, beyond the fact that both are cut by the granites of the Coast Range batholithic period usually assigned to late Jurassic or early Cretaceous.

*Intrusives.*

The intrusive rocks of the district include in order of age, areas of augite porphyrite; granitic, dioritic, and porphyritic stocks and dykes belonging to the period of the Coast Range batholithic invasion; and a later system of more generally basic dykes.

*Augite Porphyrites.*—A large area of augite porphyrite, about 2 miles across, occurs at the head of Glacier creek, intruding the Bitter Creek argillites, and a smaller elongated area outcrops along the upper part of Maude gulch. Other areas intruding both the Bitter Creek argillites and the Bear River volcanics occur on Bear river near the Cañon and north of the Bitter Creek glacier. The rocks in these areas are similar to the augite porphyrites which occasionally develop in the Bear River formation, and probably belong to its closing stages. They form distinct, easily traceable, masses where they intrude the argillites, but where they enter the greenstones of the Bear River formation, the boundaries become uncertain and in places they pass into breccias indistinguishable from common varieties of the Bear River rocks.

They usually occur in a massive condition, but on Bear river have been crushed in places into a schist.

The ordinary variety consists of phenocrysts of augite and plagioclase in a base of small lath-shaped plagioclase crystals, frequently showing flow structure. Black iron ore and apatite are the principal accessory minerals. Hornblende occurs, but is evidently in most cases an alteration product from the augite. Other secondary minerals are calcite, chlorite, epidote, and occasionally quartz.

*Stocks and Dykes Genetically Connected with the Coast Range Batholith.*—The district reported on lies immediately east of the Coast Range batholith, and satellitic stocks and apophyses from it in the form of dykes, often of large size, everywhere intrude the older rock. The petrology of these presents great variety and can only be briefly referred to here. In the stocks, the principal variety is usually a transitional phase between the granites and diorites and is classed as a grano-diorite, or when porphyritic, as a grano-diorite porphyry. The ordinary constituents are plagioclase feldspar, usually some orthoclase, quartz, biotite, and occasionally hornblende. In a few instances the stocks become very basic, augite develops in quantity and the rock passes into a gabbro. Very acid phases occur in a wide band which extends from Mt. Dickie northwesterly across the district into the Salmon valley. Typical quartz porphyries are common and specimens from exposures on Goose creek consist mainly of quartz in two generations with some orthoclase.

The dykes of this period are very numerous and less variable in character on the whole than the stocks. Ordinarily they are light greyish, medium-textured feldspathic rocks, usually only feebly porphyritic in hand specimens. In thin sections the porphyritic structure is more pronounced and they are classed as diorite porphyries. The minerals present consist of plagioclase, with biotite, hornblende, and augite either separately or together, and frequently a small quantity of interstitial quartz. Dark iron and sphene are common accessories.

Acid dykes ranging from granite to quartz porphyry occur occasionally but are less numerous than the more basic type. No pegmatite dykes common along other portions of the Coast range were observed.

*Later Dykes.*—The latest intrusives in the district consist of a wide-spread system of brownish weathering dykes. These cut all the older rocks and also some of the veins and mineral deposits of the district. They are sharply discriminated in this respect from the older dykes as the latter were intruded before the region was mineralized.

They are dark coloured, more basic on the whole, and somewhat finer grained than the older set but are closely related to them mineralogically, and in thin sections appear very similar. A study of a number of sections by Mr. Hayes led him to class them as diorite porphyries. The principal constituents, as in the older set, are plagioclase with varying quantities of biotite, hornblende, and augite.

## MINERAL DEPOSITS.

The mineral deposits of the Portland Canal district occur mostly in the Bitter Creek argillaceous and Bear River volcanic formations, but are not restricted to these two series, as fissuring accompanied with mineralization occurs in the Nass argillites, in the grano-diorite stocks, and to a greater extent in the augite porphyrite areas, especially the one at the head of Glacier creek. The whole region in fact, at the close or shortly after the termination of the Coast Range granitic invasion, seems to have been crushed, fissured, and penetrated at innumerable points by mineral bearing solutions from the dying batholith. The resulting mineral deposits, while remarkable from their great number and wide distribution, are in the majority of cases bunchy and uncertain, and even where of considerable size only occasionally contain valuable minerals in sufficient quantities to make extraction profitable.

The deposits are classified generally as replacement deposits and veins, usually quartz veins. The two groups are not, however, except in extreme cases, sharply discriminated and examples occur which might be referred to either. Replacement often plays an important role in the formation of the veins, and fissuring and silicification in that of the replacement deposits.

The replacement deposits are especially abundant in the greenstones of the Bear River formations. Red patches and areas due to the oxidation of the iron sulphides are numerous and conspicuous along the bare slopes of Bear River ridge, in the mountains bordering Upper Bear river, and in those lying between Bear river and American creek. The shapes of the reddened areas are very variable. In places they are long narrow lenses, sometimes bordered by fissures and resembling veins, but usually the outlines are blunt, irregular, and defined only by the gradual cessation of the mineralization. They are often of large size, occasionally a hundred feet or more across.

The minerals present are mainly pyrite, pyrrhotite, and quartz, with, in places, subordinate and uncertain quantities of chalcopyrite, galena, and blende. Some calcite is usually present and barite and garnet in disseminated grains occur in places but are not common.

The replacement, except in limited areas, is seldom complete and the metallic minerals occur as a rule in grains and bunches scattered through the altered and partially silicified country. Small quartz veins, usually barren, cross some of the mineralized areas.

The valuable metals present are copper and lead with usually some silver and gold.

A large number of the deposits of this class have been roughly prospected, mostly with surface cuts, cross trenches or short tunnels, but so far with little success. A body of commercial ore has been developed on the Red Cliff and a few others examined are worth further exploration, but in most cases the quantity of the valuable minerals present has proved too small and their distribution too bunchy and erratic for successful exploitation.

Veins and fissured zones, with quartz as the principal filling, are common throughout the area covered by the Bitter Creek argillites and occur occasionally in the granodiorites and Bear River volcanics, and more frequently in the augite porphyrite areas, especially the one at the head of Glacier creek. The strike of the veins in the argillites is usually northerly or northwesterly, roughly parallel to the edge of the granitic batholith on the west, and the dips are westerly or towards it. In the massive rocks the strikes are more variable, occasionally trending east and west.

The quartz veins occur singly and in groups following shear zones. The principal zone in the argillites is that on which the Portland Canal mine is situated and may be called the Portland Canal fissure zone. This is clearly traceable from the Jumbo and Ben Bolt claims, situated near the head of the South Fork of Glacier creek, northwesterly to the Portland Canal mine, a distance of over 2 miles. Beyond this point the surface drops down into the deep valley of Glacier creek and exposures for some distance are infrequent. Occasional quartz outcrops, however, occur at intervals in the same strike, and there is little doubt that the zone continues across the valley. North of the valley the outcrops increase in number and the zone is easily traceable through a number of properties to the Sunbeam claim, a total distance from the Jumbo of over 4 miles.

The zone varies greatly in width and general character along its course. At the Jumbo it consists of a mass of crushed and brecciated slates over a hundred feet in width, silicified in places, and enclosing numerous small quartz stringers and kidneys but no large persistent quartz vein. Farther to the north, in the steep slopes rising up from the South Fork of Glacier creek, the quartz occurs mostly in a central band usually from 6 to 20 feet in width, bordered on both sides by crushed and partially silicified slates. Descending into the deep valley of Glacier creek, quartz outcrops occur over a width of fully 800 feet. The country here is mostly concealed and the veins have not been traced out. At the Stewart mine, half a mile north of Glacier creek, the zone has a width of 400 feet and contains four main quartz veins, the largest 27 feet wide. At the Sunbeam claim, near its northern termination, only one large vein is exposed.

While the general zone of fissuring and silicification appears to be continuous from the Jumbo to the Sunbeam, and is marked throughout its course by quartz croppings, the individual quartz leads contained in it have a more limited range. They die out when traced along the zone and are replaced by others at a different horizon. Some of them have considerable persistence, being traceable through several claims, while others are quite short.

The metallic minerals in the zone consist of pyrite, galena, and blende, with occasionally a little chalcopyrite, and in places some native silver. Concentrations of these minerals into ore bodies of various sizes occur at a number of points along the zone and are described in connexion with the mines.

Quartz veins, some of large size, occur in the argillites south of the Bromley glacier, and smaller ones in other parts of the district, but so far no important ore bodies have been found in them.

The veins in the Bear River volcanics in the argillaceous bands associated with them and in the augite porphyrite areas, are smaller as a rule than those in the main argillite area. Quartz is the principal gangue, but in places calcite, and less commonly, barite and siderite are present in considerable quantities.

Some of the veins cutting the augite porphyry area on the Middle Fork of Glacier creek contain small ore shoots running high in silver. The metallic minerals present are argentiferous galena, pyrite, tetrahedrite, tennantite, and blende. A considerable amount of exploratory work was done on these veins in 1910 and some high grade silver ore was mined and shipped, but the shoots encountered proved to have little persistence.

Free gold is reported from some of the quartz veins of the district; none was seen by the writer, and, if present, its distribution must be very limited.

### MINING PROGRESS.

The boom years of 1909 and 1910 in the Portland Canal district when any prospect, no matter how small, commanded a price, has been followed by the inevitable reaction, and during the past season work was in progress on only a few of the numerous properties in the camp. The wide-spread character of the mineralization of the district, and the numerous ore croppings encountered everywhere, raised hopes which have only been very partially realized. As development work advanced it became evident that in the majority of cases the deposits were either too low grade or the valuable minerals were concentrated in too small bunches and lenses to be successfully worked. In a few instances, especially along the Portland Canal fissure zone, ore bodies of considerable size and persistence have been opened up. Steady development has been carried on, on these, with fairly satisfactory, but still not conclusive, results. The ore bodies enclosed in a wide shear zone are difficult to follow, and the cost of finding and following them has proved a more serious handicap than was anticipated as the grade of the ore is not high.

The future of the camp does not, of course, depend entirely on these as in the slump. Work has largely stopped not only on the poorer prospects, but on some with fair chances of success, and numerous showings have not been explored in any way. It will be difficult, however, to interest capital in their development until one or more of the prospects now being operated proves able to yield returns on the amounts already expended.

### MINES AND PROSPECTS.

A large amount of work was done during the season on the long Portland Canal fissure zone, principally by: the Pacific Coast Exploration Company on the Jumbo and Ben Bolt; the Portland Canal Mining Company on the Lucky Seven and Little Joe, and the Stewart Mining Company on the George E. The Portland Canal mine has reached the producing stage, and shipments of concentrates aggregating over 1,000 tons have already been made. The other mines were engaged in exploratory work.

#### *Jumbo and Ben Bolt.*

The Jumbo and Ben Bolt are being opened up by the Pacific Coast Exploration Company, under the direction of Mr. Curran. They are situated south of Glacier creek, 4 miles from Bear river, following the valley of Glacier creek and at an elevation of about 2,500 feet above sea-level. A trail from Bear river up Glacier creek and its south branch has been built to the mine.

The claims are staked on the southern end of the exposed portion of the Portland Canal fissure zone, its further course, if any, to the southeast being concealed by drift. The zone at this point, while traversing the Bitter Creek argillites, skirts closely the southern edge of a massive augite porphyrite area and is intruded by apophyses from it.

The fissure zone in the Jumbo and Ben Bolt claims is exposed in a series of conspicuous silicified slate cliffs stained with iron, traceable for fully 2,000 feet. The width of the zone is not exactly known, but must in places exceed 100 feet. It is made up of silicified brecciated and crushed slates holding numerous small stringers and lenses of quartz, but contains no large persistent quartz vein such as crosses the Chicago claim on the same zone farther to the north.

The dip is to the west at an angle of about 30°, and the silicified zone has been explored at four points in a distance of 870 feet by cross-cuts starting in the exposed eastern face and driven into it for varying distances.

The principal workings are at what is known as No. 1 or the shaft cross-cut. At this point a zone of good ore about 5 feet thick is exposed at the surface. This has been followed by a drift in a southerly direction for a distance of 165 feet. The ore shoot is continuous along the first 80 feet, beyond which the sulphides occur only in scattered grains.

Other workings here consist of a shaft about 25 feet deep, sunk at the portal of the drift, and a short cross-cut to the west from it to reach the extension of the ore shoot exposed in the upper level. This was soon encountered, and at a distance of 38 feet from the foot of the shaft drifts have been run along it in both directions. The drift to the northwest exposes ore for a distance of 35 feet and the one to the southeast for 20 feet. Both drifts have been continued beyond the ore into waste. The ore shoot is poorly defined and difficult to follow, and the workings are as yet insufficient to show whether its limits are reached in the drifts or a change in the direction of the shoot carries it away from them.

The ore shoot exposed in these workings has a minimum length of 104 feet, and a proved extension along its dip of 50 feet. It has not been followed below the drifts from No. 1 cross-cut. Its width is variable, ranging from a few inches to 10 feet or more. It consists of iron pyrite, with smaller quantities of galena, sphalerite, and occasionally some chalcopyrite, scattered more or less densely in grains and bunches through a gangue of quartz or crushed and silicified slate. The limits of the ore zone are not marked by fissures and are defined only by a gradual, in places somewhat abrupt, diminution in the quantity of sulphides present. A diorite porphyry dyke follows the ore in the upper level, and a similar, probably the same dyke, is cut into in the lower level in a short extension of the cross-cut beyond the drifts. The dyke is altered and silicified in places and is referred to the older pre-mineralization series. The dykes of this series occur at several points in the district either adjoining or close to ore zones, but their genetic connexion, if any, is probably limited to shattering the slates and so forming a channel for the ore solution.

The ore at the Jumbo usually carries values of from $10 to $15 in gold, silver, and lead. The following assays are furnished by the management:—

| — | Gold. | Silver. | Lead. | Cu. | Zn. |
|---|---|---|---|---|---|
| | Oz. | Oz. | % | % | % |
| Sample 14 feet across shoot No. 1 cross-cut | 0·07 | 5·64 | 15·01 | 0·9 | 3·16 |
| Average No. 1 tunnel | 0·08 | 5·90 | 11·50 | .. | 4·70 |
| Average No. 3 tunnel | 0·06 | 5·77 | 15·50 | 0·11 | 8·5 |

No. 2 cross-cut, situated 265 feet northwesterly along the fissure zone from No. 1, has been driven in for a distance of 120 feet without encountering any considerable body of ore. It starts above the base of the zone, and an ore horizon may still be found in the lower unexplored portion. No. 2 cross-cut, 223 feet northwesterly from No. 2, penetrates 99 feet of silicified slates, then a wide diorite porphyry dyke dipping to the west, beyond which there is a small development of ore not yet followed up. No. 4 cross-cut is situated 380 feet in a southeasterly direction from No. 1, and, when visited, was in 50 feet without reaching ore.

The workings at the Jumbo and Ben Bolt have been planned on the assumption that the ore body encountered in No. 1 cross-cut continues north and south along the silicified zone which crosses the claims. While it cannot be said that this view is entirely disproved by the negative results of the still incomplete work on the three exploratory cross-cuts, it is more likely that ore will be found in separate shoots along the zone and probably at different horizons in it.

*Chicago Nos. 1 and 2.*

These claims are situated north of the Jumbo and Ben Bolt, on the same fissure zone. The zone is more contracted, exposures at intervals showing a quartz lead with included slate from 10 to 20 feet in thickness. Very little exploratory work has been done on the claim. An ore body outcrops on Chicago No. 2 and the extent of this is now being investigated.

*Portland Canal Mining Company.*

A description of the Portland Canal mine, ores, ore bodies, and equipment is given in the Summary Report of the Survey for 1910, and need not be repeated here. During the year, exploratory work, under the direction of Mr. W. J. Elmendorf, has been pushed steadily ahead with varying results and there has been a considerable extraction of ore to feed the mill.

The fissure zone, where it crosses the property operated by this Company, outcrops on the hillside sloping down to Glacier creek, and is opened up by three main tunnels known as Nos. 1, 2, and 3, at elevations of 2,505·06 feet, 2,464·47 feet, and 2,410·46, respectively. No. 3 tunnel, the lowest level, has been driven in for a distance following the curves of 750 feet. Ore was encountered at 410 feet and followed for 60 feet, when it either pinched or was lost. No. 2 tunnel has a length of 480 feet. An ore body was reached at 60 feet and followed for 160 feet, beyond which the drift enters and cuts a diorite dyke for 100 feet. A second important ore body was then found, practically resting on the dyke, which continued for 120 feet. This ore body extends downwards along the dip towards No. 3 level and has been partially stoped out, but so far has not been found on that level. It also probably continues upwards to the surface, as cuts in the fissure zone in the direction in which it ought to outcrop show similar ore. No. 1 tunnel, the upper level, has a length of 180 feet and follows ore for the first 100 feet.

The net result of the operations up to the present has been to expose two main ore bodies which may possibly be found to connect with each other as exploration proceeds. The first ore body has a width on the upper level of approximately 100 feet, widens to 160 feet on the second level, and narrows to 60 feet on the third. It has not been followed below this level. This ore body has been mostly stoped out between the first level and the surface, and partially between the first and second levels. Below the second level it is less regular and its outlines have not been satisfactorily determined. It has a proved length, following the dip from the surface to the lower level, of 240 feet. The second ore body, 120 feet in width, is known only in the extension of the second level beyond the first. It probably, as stated before, continues to the surface, a distance of 150 feet, and this ground is now being examined. The surface cuts show ore for some distance south of the underground workings and a considerable extension of the ore shoots in that direction is probable.

A large diorite porphyry dyke, first encountered in the second level, 230 feet from the portal, has added to the difficulties of exploration. The dyke striking and dipping in the same general direction as the ore zone, outcrops on the surface some distance below it. Its dip at the surface is somewhat less than that of the ore zone, and it gradually approached it, joining and underlying it at the second level. In the third level the dip has increased and it probably soon after bends beneath the ore zone. The dyke is comparatively fresh in some places, and in others so badly altered and silicified that it is difficult to distinguish from the ordinary siliceous gangue of the mine. It was evidently intruded before the formation of the ore bodies and shared in the mineralization. Similar dykes are common in the neighbourhood and throughout the district, and its presence in the ore zone does not appear to have any special significance.

The Portland Canal ores, which are mainly iron, lead, and zinc sulphides in a siliceous gangue, carrying values of from $11 to $12 per ton in gold, silver and lead, are crushed, concentrated and separated before shipment in a mill situated on Glacier creek, and operated by water-power furnished by that stream. During the year the nominal capacity of the mill was increased from 50 to 75 tons per day, and a number of improvements made. These include a larger Sturtevant crusher, an improved system of water classification, and the addition of 6 Wilfley tables. In the latter part of the season the mill was running at its full capacity and giving excellent results.

*The Stewart Mining Company.*

The Portland Canal fissure zone between the Portland Canal and Stewart mines, a distance of 1·2 miles, is known to contain a number of ore bodies, some small and others still unproved. The O.K., Portland Wonder, and Lulu, owned by the Glacier Creek Mining Company, all show ore, but the desultory development work so far done has not proved the existence of any large shoot.

The George E. claim, one of the group owned by the Stewart Mining Company, is traversed by four approximately parallel quartz leads all opened up for varying distances.[1] During the year the principal development work carried out consisted in driving a tunnel 570 feet in length, along No. 4 vein, the most westerly of the series. A diorite dyke overlies the vein or line of fissuring on the west, dipping and striking in the same general direction. Ore occurs at the mouth of the tunnel and was again encountered in a short cross-cut to the west, 120 feet from the portal. The ore here has a width on the tunnel level of 14 inches, but widens to 3 feet at the bottom of a winze, 50 feet long, sunk on it. It directly underlies the dyke, both dipping to the west at an angle of 48°. The ore shoot appears to curve across the drift a few feet beyond the winze, and little ore occurs along the further course of the tunnel until a point 540 feet from the portal is reached. Here a short cross-cut to the left cut a body of ore nearly 6 feet in width, striking a few degrees west of north. This ore shoot dips under the continuation of the dyke, which directly overlies the ore at the winze, but is separated from it by 15 feet of argillites. It has been drifted on for 37 feet north from the cross-cut but its full length is not yet known.

This is the largest ore body so far found in the somewhat extensive Stewart workings, and work is now in progress to determine its full extent. The ore is similar to that at the Portland Canal and Jumbo mines, consisting of iron, lead, and zinc sulphides in a quartz or siliceous slate matrix. Assays, by the management, of samples taken across the full width of the shoot along the cross-cut, gave the following values:—

[1] Described in Summary Report, 1910, p. 77.

| | Gold. | Silver. | Lead. |
|---|---|---|---|
| | Oz. | Oz. | % |
| South side of cross-cut 6 feet | 0·07 | 4·20 | 6·12 |
| North " " | 0·20 | 2·00 | 3·25 |

The Portland Canal fissure zone, north of the Stewart mine, traverses the George E, Ben Hur, and Sunbeam claims, and possibly continues to the Main Reef. An ore body 4 feet wide is exposed in an open-cut on the Sunbeam but has not been followed up. An assay of a general sample of the sulphide ore obtained from Mr. W. J. Elmendorf, showed gold, 0·20 ounce; silver, 5·8 ounces; lead, 7·41 per cent.

## *Redcliff Mine.*

The Redcliff ore body and the workings up to September, 1910, are described in the Summary Report of the Survey for that year. The Redcliff is the principal mine so far developed in the Bear River formation. The country rock is a greenish feldspathic porphyrite, crushed in places into a schist and fractured irregularly, the fissures striking in different directions and dipping at practically all angles. Some of them show movement, but there is no evidence of extensive faulting. The ore occurs in irregular bodies and consists of pyrite, pyrrhotite, chalcopyrite, and some blende, and occasionally a little galena in a matrix made up of quartz and the silicified and altered country.

The ore body developed outcrops on a steep, bare hillside, west of Lydden creek, at an elevation of 100 feet above it, and about 1,000 feet above sea-level. A tunnel along it at an elevation of 950 feet shows it to have a length at that level of 75 feet and a width of from 5 to 17 feet. On the surface it has a length of 120 feet.

A tunnel about 1,400 feet in length intended to undercut the ore body at a depth of 260 feet was completed during the year, and connected by an upraise with the upper workings. The raise is in two sections, connected by a short drift 65 feet below the upper workings, known as the intermediate level. The first section follows a steep, well-defined fissure, bordered in places by bunches of ore. The second section is nearly vertical and reaches the ore body exposed in the upper workings about 40 feet beneath it. A number of exploratory drifts branching from the lower and intermediate levels have been run in various directions, some following fissures and others directly through the country. The results of this work have been disappointing on the whole, as while ore has been found at a number of points, none of the occurrences have much persistence as workable masses. The main ore body exposed on the surface and cut in the upper level has a downward extension, as shown in the raise, of 40 feet below that level, but so far has not been definitely proved to descend as a continuous mass to the lower levels as was expected. Above the upper level, it extends to the sloping surface, a distance of 100 feet at the highest cropping.

An assay of a general sample of an occurrence of ore in the intermediate level showed: gold, 0·13 ounce per ton; silver, 2·00 ounces per ton; copper, 4·89 per cent.

Other exploratory work in progress includes the extension of the upper level to undercut an ore body 100 feet long and from 4 to 6 feet wide which outcrops on the hillside above that opened up; only negative results had been obtained at the time of my examination.

A power plant was added to the equipment of the Redcliff mine during the year, and water-power obtained from Lydden creek has been substituted for steam to operate the compressor plant and furnish other power needed. The Portland Canal Short

Line railway was completed to the mine late in the season, and ore bunkers were erected. The bunkers have a capacity of 700 tons and are connected with the mouth of the lower tunnel by a gravity tram 800 feet in length.

None of the numerous prospects on the west side of American creek above the Redcliff were worked during the season, the Big Casino, Redcliff extension, and Mountain Boy being all idle. On the east side work was commenced on a small galena showing on the Glenora claim owned by the Northern Terminus Mines Company. The country rock in the vicinity includes both the massive and fragmental varieties of the Bear River greenstones. The workings at the time of my visit consisted of a pit 8 feet deep, sunk on the deposit. This exposed a diabase dyke, 2 feet wide, dipping to the east at an angle of 45°. Resting on the dyke is a seam of nearly clean galena with some blende, 8 inches in thickness. A second vein from 3 to 6 inches wide underlies the dyke and is followed at one point by 3 feet of silicified, altered country containing some galena. The veins have only been uncovered for 15 feet. The ore runs high in silver, a sample collected showing 146·59 ounces per ton.

On Bear river above American creek, work was continued on the Ruby claim owned by the Portland Bear River Mining Company. A quartz vein traversing a band of slate enclosed in the Bear River greenstones, here mostly coarse fragmentals, occurs on the claim. The workings consist of a drift 150 feet along the lead. The vein striking to the north and dipping steeply to the west was followed for 120 feet. It is also exposed for a short distance in cuts south of the portal of the drift. The width varies from a few inches up to 2 feet. The quartz contains numerous slate fragments and is stained yellow in places from iron. Pyrite in small scattered grains is the principal metallic mineral present. The surface croppings of this vein are reported to have shown free gold. A general sample of the vein material on the dump gave on assay: gold, 0·25 ounce, and silver, 12·60 ounces per ton.

Near the head of Bear river some prospecting was done on the Copper King and Queen, staked by William George and Frank Strohn. The claims are situated high up on the range of steep craggy mountains bordering Bear river on the south. The Bear River greenstones, which form the country, show shattering along a wide zone trending east and west. Along this there is a development in places of small irregular quartz veinlets, bunches, and seams of calcspar, and areas are heavily pyritized. Chalcopyrite is present in portions of the zone but has not so far been found in workable quantities.

On Bitter creek some exploratory work was done on the Olga claim, on the L. S. and H. group on Hartly gulch, and on a quartz vein traversing the Black Bear group, south of the Bromley glacier.

The Olga, situated east of Bitter creek, about half way to the glacier, shows a quartz lead carrying considerable chalcopyrite in places cutting the Bitter Creek argillites in a northeasterly direction, and dipping to the southeast. The workings consist of a cross-cut tunnel to the lead 72 feet in length, and a drift along it 130 feet in length. Chalcopyrite in bunches and small aggregates is exposed along the drift for a distance of 60 feet, but is too sparingly distributed to constitute a commercial ore.

Work on the L. S. and H. group consisted in running a cross-cut tunnel 100 feet to reach two leads exposed on the slopes above. The work was not seen. The owners report that the lower lead, where cut, has a width of 4 feet and contains values of $15 per ton in gold and silver. The upper and larger lead was not reached on account of a flow of water.

The quartz veins on the Black Bear group, southwest of the Bromley glacier, were the cause of a wild gold stampede in 1910. One of the veins was explored by a cross-cut tunnel. The vein, where cut, contains considerable pyrite but carried only insignificant gold values.

The claims on the Middle fork of Glacier creek, described in the Summary Report for 1910 as containing small shoots of ore with high silver values, were all idle during the season.

## Reconnaissance Trip to the Nass Valley.

In August a short trip was made across the Coast range to the Nass valley to examine some quartz and placer properties staked on the east slope of the Coast range. The trip was made in company with Mr. Porter, a prominent prospector in that region, and Mr. MacIntolmy, a claim owner.

The route followed was up the Bromley glacier to McAdam point, near the southern end of the Cambria range. Here the Bromley glacier divides into three main branches, one swinging to the south along the base of Mt. Trevor towards the high snow-covered pass from Bitter creek to Marmot river, and the two others heading in a long, comparatively narrow snow field occupying a high longitudinal valley west of the Cambria range and extending southwards for an unknown distance towards the head of Hastings arm of Observatory inlet.

From McAdam point a steep ice slope 1,000 feet high was climbed, then turning to the northeast the snow-filled valley west of the Cambria range was followed, gradually rising for 5 miles to a flat, barely perceptible summit at an elevation of 5,750 feet, then descending slowly at first but with gradually increasing grade towards the Nelson glacier and creek tributary to the Nass. This great snow valley is an important feature of the Coast range. It has a width of from 1½ to 2 miles or more and a length of over 20 miles in a northeast-southwest direction, or nearly parallel to the general trend of the range. The elevation of its snow surface averages about 5,000 feet, and it is bordered by the highest and most rugged mountains in this portion of the Coast range, some of the peaks jutting up through snow fields to elevations of over 8,000 feet: Mt. Otter, the highest, attaining an altitude of 8,800 feet. Through breaks in the bordering ranges the accumulated snow, compressed into ice, pours westward towards the Pacific and eastward towards the Nass in a series of large glaciers, soon changing as they descend into roaring torrents. The Coast range is singular in having its watershed and highest mountains in this latitude along its western margin. To the east the mountains decrease gradually in height to elevations of from 4,000-5,000 feet, while to the west the surface drops quickly down to the level of the Nass valley.

In descending Nelson glacier and creek the rough topography of the highest portion of the Coast range is replaced in a few miles by the even contours and comparatively low levels of the broken plateau country bordering the Nass.

The Nelson glacier terminates at an elevation of 1,950 feet and the large stream issuing from it unites with Porter, Willoughby, and other streams to form White river, which empties into the Nass a few miles below the outlet of Meziadem lake.

From Nelson creek a ridge 5,520 feet high was crossed to Mr. Porter's camp on Porter creek, one of the objective points of the trip. This stream, like practically all the large streams descending the east slope of the Coast range in this neighbourhood, heads in a large glacier. A pass from the Porter glacier to the snow valley, previously described, affords a shorter route from Bitter creek to Porter creek than that followed and is used in winter and spring. Later in the season the glacier, which is very steep, becomes badly crevassed and is more dangerous than the longer and less broken Nelson glacier.

### Geology.

Few rock exposures were examined along the route traversed, as the way led for most of the distance along snow fields and glaciers. Those seen show that the lofty

Cambria range and the succeeding one on the east, the marginal range of the Coast mountains, consist largely of the massive, and medium and coarse fragmental greenstones of the Bear River formation. An area of limestones and slates, only seen at a distance, occurs in the angle above the junction of the Nelson glacier with a branch from the northwest. The relationship of these to the greenstones was not ascertained. They may represent a highly calcareous portion of the Bitter Creek formation, which contains considerable limestone in places, or an older formation.

The greenstones of the Bear River formation are replaced along the eastern base of the Coast range by dark shales alternating, in places, with greyish and greenish feldspathic sandstones in bands up to 20 feet or more in thickness. These rocks are referred to the Nass formation. They overlie the Bear River greenstones, resting on them, as a rule, at angles of about 45°. The dip is to the east, and, as shown in the partially scarped sides of the plateau-like ridges extending eastward from the Coast range between the valleys, decreases going eastward to less than 25° in places. The rocks of the Nass formation are not highly altered, except in places near the contact with the Bear River greenstones, are seldom cleaved, and look favourable for fossils, but none were found in the sections examined. They look young, but are probably pre-Cretaceous, in age at least, as they are cut by granite dykes and bosses presumably belonging to the period of the Coast Range batholith. The contact between the Nass argillites and sandstones and the Bear River greenstones, where it crosses Nelson, Porter, and Willoughby creeks, is very even and suggests faulting. Farther to the north the Nass rocks extend westward into the Coast range, and are exposed, lying in a nearly horizontal position in the upper portion of several mountains, Strohn creek, and Upper Bear river.

## PROSPECTS.

A wide zone, generally reddened by the surface oxidation of iron pyrites, occurs along the contact of the Nass argillites with the Bear River greenstones. A large number of claims have been staked on this zone, but up to the present little work has been done and no large body of pay ore discovered. The district, while only a few miles from Bear river, is difficult to reach, and all supplies have to be packed in either from Bitter creek, over dangerous glaciers and soft snow fields, or from the head of Bear river, following a rough foot trail down Strohn creek to Meziadem lake, then southward for many miles across a ridgy woody district practically destitute of trials. No effective work can be done until better communication is established and the cost of supplies greatly reduced.

Notwithstanding the adverse conditions, some development work has been done on the Bullion claim, staked by Mr. Porter and owned by Mr. James Mowat. The showing on this claim is situated on the hillside, north of the foot of the Porter Creek glacier, at an elevation of 500 feet above the valley, and consists of a fissured and partly silicified zone in the argillites of the Nass formation. The zone is about 7 feet wide, has a northwesterly strike, and dips to the northeast at an angle of 70°. Along the foot-wall, as shown in a short tunnel, is a layer of quartz interbanded with argillites from 1 to 2 feet wide. The quartz is copper-stained in places and contains some pyrite, galena, and zinc blende. Samples of the mineralized quartz are reported to have yielded high values in gold and silver, but a specimen collected by the writer was disappointing, as it showed only traces of these metals. This result may possibly be due to an irregular distribution of the precious metals along the lead. The fissured zone is concealed above the short tunnel and its length is not known.

The Bear River greenstones, near their contact with the Nass argillites, are heavily impregnated with iron pyrites in places, but so far no workable deposit of valuable minerals has been found.

### PLACER DEPOSITS.

From Porter creek a ridge rising about 2,000 feet above the valley bottom was crossed to Willoughby creek, on which a number of placer claims have been staked.

Willoughby creek issues from a broken, branching glacier, terminating at an elevation of approximately 2,300 feet, and is a large, rapid stream usually from 30 to 60 feet across, with an average grade of 225 feet per mile. A large branch from the south joins it 3½ miles from the glacier. The valley for a mile and a half below the glacier is wide and bottomed with gravel flats. Below that it narrows in, and in places is confined in rock canyons often bordered by narrow benches.

Willoughby's camp is situated about 4 miles from the foot of the glacier. The creek here has a shallow box canyon through the shales and tuffs of the Nass formation. A rock terrace on the left bank, about 200 feet wide and 20 feet above the water-level, is covered by 25 feet of coarse gravel.

Some coarse gold is reported to have been found in a bar in the canyon. No work had been done on the bar up to the time of my visit, owing to the continual high water, and it will evidently be difficult to work at any time, as the stream is large, rapid, and its channel filled with boulders. A tunnel has been driven part way across the terrace in the hope of finding a pay channel at that level, but so far without success.

A number of claims have been staked on Willoughby creek above and below Willoughby's camp, on Little White river, and on Little Pat creek, a small foothill stream, but no effective work has been done on any of them.

Some gold occurs on all the streams issuing from the mountains along this portion of the Coast range. Moderately fine, flaky, but still rough gold in small quantities was panned out on Nelson creek, close to the foot of the glacier, and at other points. It is quite possible, although not yet proved, that concentrations may occur in the lower reaches of some of the streams, but unless these prove to be very rich the cost of working them, unless situated above the water-level, would be prohibitive. The streams are all large, are practically continuous rapids throughout, and, as they head in glaciers, high water lasts until late in the season.

Bench gravels occur in Willoughby creek and other places, but the deposits seen were all small.

The creeks staked as placer ground traverse the shales and sandstones of the Nass formation. These rocks, away from the mountains, contain few quartz veins, and the stream gold is probably mostly derived from the greenstones and associated rocks of the Bear River formation in which all the large streams head. No evidence of an old channel crossing the district independently of the present drainage system, firmly believed in by some of the miners, was observed. The bench gravels seen all belong to former higher levels of the present streams.

### STROHN CREEK.

The return trip to Bear river was made by Meziadem lake and Strohn creek. Little White river, formed by the junction of Porter and Nelson creeks, has been bridged by the Provincial government a few miles above the mouth of Willoughby creek, and from this point a foot trail has been blazed, but very imperfectly cut out, across the wide wooded ridge separating Nelson from Strohn creek, the next large stream to the north. The ridge, where crossed, has an elevation of approximately 2,700 feet.

Strohn creek has recently acquired importance as a possible route to the Groundhog anthracite basin, at the head-waters of the Skeena, Nass, and Stikine rivers. It heads with Bear river, in a low glacier-covered pass, and flows eastward to Meziadem lake, the latter emptying by a short outlet into the Nass river. Strohn Creek valley has an estimated length of 9 miles, and a grade of approximately 100 feet to the mile.

The valley is flat-bottomed, usually half a mile or more in width, and offers no especial difficulty for railway construction.

The glacier at the summit heads in the high mountains to the south, and after reaching the pass alters its course and separates into two short branches, one flowing to the west down Bear river and the other to the east down Strohn creek. The combined length of the two branches is about 1½ miles. This portion of the route would have to be tunnelled. The Strohn Creek, or easterly branch of the glacier, terminates at an elevation of approximately 1,540 feet, and the Bear River branch at an elevation of 1,370, while the ice-covered summit, where crossed, has an elevation of 2,270 feet, measured by the aneroid.

Bear River valley, from the foot of the glacier at its head to its junction with American creek, the present terminus of the railway, has a length of about 9 miles. It is flat-bottomed along most of its course, but is narrower than Strohn Creek valley, and along one stretch, about three-fourths of a mile in length, contracts into a canyon. The grade averages about 100 feet to the mile. The bordering mountains are steep and some trouble would probably be experienced from snow slides.

The total length of a railway from the mouth of American creek to the Nass, following Bear river, Strohn creek, and Meziadem lake, would be approximately 32 miles. A tunnel 1½ miles in length would be necessary at the summit, and possibly a short one at the Bear River canyon. A railway to the same point from Nasoga bay, following the valley of the Nass, would have a length of at least 110 miles.

*Geology.*

The ridge crossed from Little White river to Strohn creek, as shown by occasional exposures, consists of the shales and sandstones of the Nass formation. The same rocks outcrop at points along Meziadem lake and in the ridges and mountains bordering Strohn Creek valley for a distance of about 5 miles above the lake. They are cut at one point north of the valley by a large granite stock, only seen at a distance. They dip to the east and approaching the mountains become harder and more altered. Four miles from the summit they are underlain and replaced by the greenstones, here largely volcanic fragmentals, of the Bear River formation. The contact between the two formations is concealed in the valley, but is plainly traceable, running a few degrees west of north in the mountains bordering the valley.

No mineral occurrences of importance are reported along Strohn Creek valley.

# RECONNAISSANCE ON THE UPPER SKEENA RIVER, BETWEEN HAZELTON AND THE GROUNDHOG COAL-FIELD, BRITISH COLUMBIA.

*(G. S. Malloch.)*

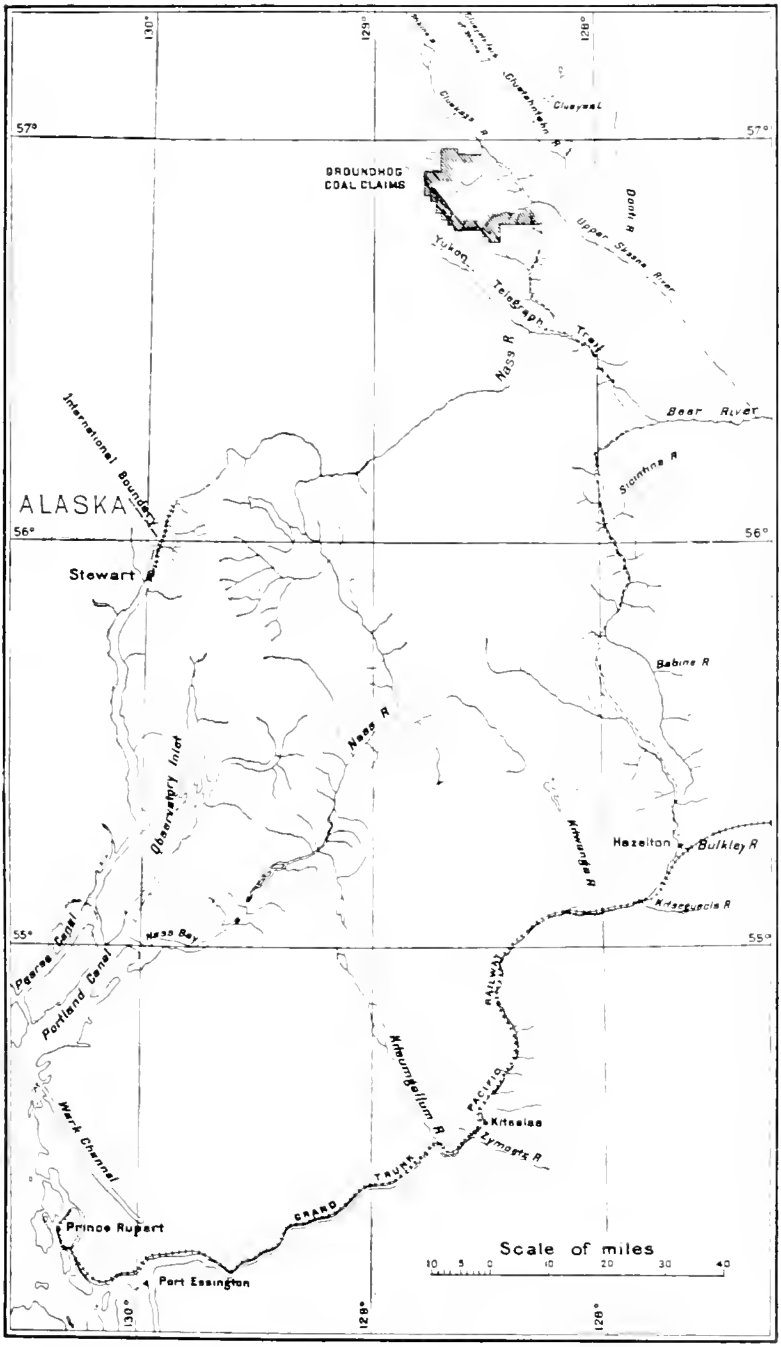
## INTRODUCTORY.

The special object of the writer's field work, during the past summer, was to gain information regarding an area of anthracite coal occurring near the head-waters of the Skeena river. This area is commonly called the Groundhog coal field, from the name of a range of mountains bordering its southern edge. As no reliable surveys were available to determine the geographic position and approximate elevation of the new field it was necessary to run a traverse to it from Hazelton, whose geodetic position was fixed in August by Mr. McDermaid of the Dominion Observatory. Sets of simultaneous aneroid readings were also made at convenient intervals along the trail to determine approximately the elevation of the basin. The time occupied in traversing the trail gave the writer an opportunity to study the geology and make topographic sketches of the route travelled, but limited the time in the coal field to seven weeks, a period much too short for the examination of a field whose area cannot be less than 2,000 square miles and probably exceeds that figure. The writer, seeing the futility of attempting to cover the entire basin, considered it better to make a somewhat detailed examination of a small portion which was being actively prospected by Mr. James McEvoy for the Western Development Company, and Mr. Campbell-Johnston for the British Columbia Anthracite Syndicate. A base was measured and triangulation extended to control an area, roughly, 6 miles by 12, and traverses were run of streams and trails. After leaving the basin, two weeks were spent in the vicinity of Hazelton examining some of the more recently discovered silver, lead, and copper prospects, and the Kispiox coal field situated some 15 miles north of the town.

A sketch map has been prepared to illustrate the position of the coal field, and the possible routes for railways which may be built to it. In the preparation of the map, use was made of a hitherto unpublished map of the lower Nass valley, made by Mr. McEvoy for this Department in 1893, while the upper part of the valley is taken from a sketch map made by a prospecter, Mr. Anthony Kobes, to whom the writer's thanks are due for permission to make a tracing. The country at the divides between the branches of the Skeena and Nass is from a sketch map furnished by Mr. Campbell-Johnston. Acknowledgment is also made of the numerous kindnesses received from him and Mr. Moncton, and from Mr. McEvoy, at the coal field; from Messrs. Kinman, Pemberton, and the Harris brothers, at Hazelton, and from Mr. Hugh Taylor, Mr. Corner, Mr. Faulkener, and in fact from all the linemen and operators along the Yukon telegraph line from Hazelton to the fifth cabin.

## LOCATION AND AREA.

The Groundhog coal field is situated 140 miles north and slightly west of Hazelton, and about 90 miles northeast of the town of Stewart at the head of Portland canal. While only a small portion of the field was seen, it has been computed from




DIAG. 5. Diagram showing the location of Groundhog coal claims.

information obtained from prospectors that the strip of country underlaid by coal seams is approximately 30 miles wide and extends to the northwest for 70 miles or more. This would mean an area of 2,100 square miles, and as has already been stated, a much larger area may be underlaid by productive coal seams.

## History.

The first authentic discovery of coal in the Groundhog field was made by Mr. James McEvoy in 1903, who staked a number of claims on his discoveries. His time was very limited, but he secured samples from a seam on Discovery creek which showed on analysis an anthracitic coal a little high in moisture and ash. In 1904, Mr. W. W. Leach visited the field with a small party, stripped several of the seams and staked additional claims in behalf of the Western Development Company, bringing the total area held by them up to 16 square miles. The field was revisited in 1908, and in 1909 a party sent out by the German Development Company, under Mr. J. Fred. Walter, opened new seams, and a number of samples were secured by Mr. C. Fergie.

In 1910, Mr. Campbell-Johnston staked a number of claims to the north and west of those belonging to the Western Development Company for the British Columbia Anthracite Syndicate, and Mr. Jackson performed a similar office for the British Columbia Anthracite Company. Mr. Jackson's claims practically surround those of the Western Development Company, except on the west, and extend for some miles to the east.

During the past summer the field was prospected by large parties under Messrs. McEvoy and Campbell-Johnston, and a large number of new claims were staked, until the total number now exceeds 400.

## Previous Work.

No geological report has yet been published on the Groundhog basin, but the geological section is approximately the same as that in the vicinity of Hazelton, which was described by Dr. Dawson in the Report of Progress for 1879-80, and by Mr. Leach in the Summary Report for 1906-1910.

Dr. Dawson mentions the occurrence on the Skeena river of a belt of Mesozoic rocks about 57 miles in width, extending down the Skeena from Hazelton. On the western margin of the region porphyrite and other feldspathic and brecciated rocks occur, but eastward the strata are composed of comparatively soft sandstones, argillites, and carbonaceous argillites, and Dr. Dawson[1] inclined to the view that the rocks on the eastern edge were the younger, though he was evidently unable to secure direct stratigraphical evidence owing to the great number of folds traversing the region, and the scarcity of exposures on the river banks.

He adds that the general distribution over the district of carbonaceous shales containing impure coal, points to the occurrence of conditions such as are required for the deposition of true coals, and indicates the possibility, if not the probability, of the occurrence of coal beds of a workable character in some part of the region.[2]

Dr. Dawson's examination of the country was confined to the route he travelled, but the summary reports published by Mr. Leach show that he was correct in all his main conclusions. Mr. Leach notes, however, that the progressive change in character, from volcanic to sedimentary, of the strata of the Porphyrite group, takes place generally to the north and not to the east as Dr. Dawson deduced from his observations. The mistake will readily be explained by remembering that Dr. Dawson was travelling in a general northeasterly direction.

[1] G. and N. S. C. Report of Progress, 1879-80, B p. 103.
[2] Ibid, pp. 104-105.

Mr. Leach has proposed that the name Hazelton group be substituted for the Porphyrite group, and recognizes the coal-bearing strata as a distinct formation under the name of the Skeena series. He describes[1] them as consisting of 'Rather soft, thin-bedded shales and sandstones, the former, in places, carrying many clay-ironstone nodules and a number of coal seams. At the base of the series,' he continues, 'there is usually found a bed of coarse, crumbly conglomerate, but this, though fairly persistent, is not always present. The maximum thickness is in the neighbourhood of from 600 to 800 feet, and a number of fossils (chiefly plants) collected at various times show that the age of the beds is lower Cretaceous and about equivalent to the Kootanie of the Crowsnest pass.'

Mr. Leach's description of the Hazelton group contains the following sentences:—[2]

'Generally speaking, it may be said that to the south this formation is built up almost entirely of flow rocks, chiefly andesites, massive, and with characteristic dark red and green colours. At the top of the series, a few thin beds of fossiliferous sandstones and shales appear, a number of fossils from which have been determined to be of Jurassic or early Cretaceous age. On travelling northward, however, it was found that these flows gradually thinned out and were replaced by a considerable thickness of tuffs and tufaceous sandstones, although a few of the endesite beds extended as far north as Hazelton.' The fossils referred to above consist of marine invertebrates containing specimens of Inocerami and Astartes.

In the vicinity of Hazelton and south of it, both the Hazelton and Skeena series are cut by intrusions of granodiorites and diorite porphyrites, which have evidently played an important part in the deposition of the metalliferous deposits found in or near bosses and dykes of the igneous rocks.

## Summary and Conclusions.

As a result of the summer's work the following geological facts were established. A thickness of 3,650 feet of strata, exposed in one section near the southern end of the Groundhog basin, is coal-bearing, though the most important seams occur in the upper 1,000 and lower 1,000 feet of the series. The rocks of the coal-bearing group form a series conformable with the underlying rocks, and both have been thrown into folds and faulted by pressure from the southwest. It is, therefore, quite possible that other areas of coal-bearing strata will be found, and perhaps some more favourably situated than the Groundhog coal basin for transportation of the coal. In the vicinity of Hazelton, many promising deposits of silver, lead, and copper ores are being prospected. The writer is also of the opinion that borings in the Kispiox coal field, near Kispiox post-office, might prove the existence of coal seams thick enough and sufficiently free from ash to make it profitable to work them.

## General Character of the District.

### Topography.

#### *Regional.*

The topography of the region traversed between Hazelton and the Groundhog basin is mountainous, the differences in elevation between the valley bottoms and bordering ranges usually exceeding 3,000 and sometimes amounting to 7,000 feet. The highest mountains seen were only a short distance north of Hazelton, and this fact is all the more striking because there the valleys are less than a thousand feet above sea-level and are much wider than those farther north. There is also an absence at

[1] Geol. Surv., Can., Summary Report for 1910, p. 94.

[2] Ibid, pp. 93-94.

Hazelton of the prevailing northwest and southwest trend of valleys and ranges which prevails farther north, and which is more or less general throughout British Columbia. Even to the north, however, the Skeena shows great disregard for the course of the main valleys, sometimes turning at right angles to them and passing through narrow clefts in the enclosing ranges. Striking examples of these anomalous bends are found near the mouths of Babine river, which drains Babine lake, and Bear river, which also rises in a lake of the same name as itself. For a great part of its course, the Skeena occupies narrow canyons cut in places, as for example above the mouth of Deep creek, through thick, terraced deposits of river gravel, but more often the river boils through an extremely narrow gorge cut in the rock floor of the valley. Some of these gorges are nearly 200 feet deep, with nearly perpendicular walls. The tributary streams also occupy canyons in their lower courses, but above, many of them meander through marshy flats and head in cirque-like amphitheatres. The main divides, between the three great river systems, *i.e.*, the Skeena, Nass, and Stikine, are usually marshy flats often containing lakes. Examples of such divides between the two former occur at the heads of the Kitoumgaloon, Chitach, Kispiox, Shalangeese rivers, Currier and Beirnes creeks; while the divides between the several branches of the Skena and those of the Stikine are reported to be of the same general character.

*Local.*

The local topography of the Groundhog basin, or of the small part of it which was examined, is somewhat complicated. Strictly speaking, there are at least five parallel basins, but since the region underlaid by the coal-bearing strata contains few elevations exceeding 6,000 feet, while many in the surrounding country exceed 7,000 feet, it is permissible to speak of the whole area as a basin. The distinction was brought out to the writer when overlooking the basin from a peak in the Groundhog mountains, after a fall of fresh snow which remained only at elevations above 6,000 feet. While only a few of the summits within the area were capped with snow, long lines of white peaks bordered it on three sides, the boundary to the north being too far distant to be made out.

The basin is bordered on the south by a high and rugged range known as the Groundhog mountains. Many of the peaks exceed 7,000 feet in elevation and glaciers are quite common. This range is irregularly dissected by streams draining to the Nass and to the Skeena, and the route to the basin crosses it by a pass 5,100 feet in elevation. On the west the basin is bordered by the broad valley of the Nass, beyond which rise the lofty peaks of the Coast range. On the east the basin extends to the valley of the Cluatahntahn, or eastern fork of the Skeena. The western fork, or the Cluakaas, flows southeast through the centre of the basin to near its southern border, where it makes a sweep to the east and joins the Cluatahntahn outside the limit of the coal-bearing strata. The original discoveries were made on Discovery creek, a small tributary of the Cluakaas, and the claims of the Western Development Company, and the great majority of those belonging to the British Columbia Anthracite Syndicate, are situated in the valley of that fork of the Skeena. The elevation of the valley bottom is about 2,900 feet where the Cluakaas leaves the basin, and the gradient of the river is about 50 feet to the mile. Just before the Cluakass takes the bend to the east, it is joined by Currier creek which flows almost east and west, taking its rise near a large lake situated at the divide leading to Panorama creek, a tributary of the Nass. The elevation of this divide is 4,100 feet. About 10 miles higher up, Beirnes creek comes heading in a slightly higher divide with another branch of the Nass, known as Anthony creek. The valleys of the Cluakaas and of Currier and Beirnes creeks are wide, and rock exposures are comparatively rare, except in places where the streams hav cut canyons through the different strata. On the hills, especially above timber line (above 5,000 feet), exposures are naturally more numerous, but there are large tracts of rolling upland covered with residual soils, and continuous rock exposures must be sought at the highest elevations, which present a more rugged outline with many cirque-like hollows often separated by comparatively narrow ridges.

### CLIMATE AND AGRICULTURE.

The climate at Hazelton is pleasant, without excessive rain or sonw fall, but farther north precipitation is somewhat greater. In some years the Hazelton district suffers from summer frosts, though those seem to be less frequent now that considerable tracts of land have come under cultivation. Farther north, and at higher elevations, frosts are of more frequent occurrence, and there is a lack of sunshine in the autumn to ripen grain crops. At Hazelton, oats and some of the hardier varieties of wheat have been grown successfully and root crops do exceptionally well. The construction of the Grand Trunk Pacific has made a large demand for hay, and it and potatoes seem to be the most profitable crops at present.

### FAUNA AND FLORA.

Hazelton has long been an important centre for the fur trade, and though fur-bearing animals are not especially abundant at present, still the Indian population secure large numbers of skins in the early spring months. Big game is rather scarce for some distance north of Hazelton, but grizzly and black bears, moose, caribou, and goat are more numerous at the Groundhog basin. Beaver are quite plentiful and the whistling marmot is abundant.

Salmon ascend the Skeena to the head of the Cluatalmtahn, but are not found in the Cluakaas branch. Bull trout are found in all the streams, but are not numerous enough to afford good sport. Rainbow trout were not seen far north, but abound in the small lakes draining to the Kispiox.

The principal trees of the district to the north consist of several varieties of spruce, balsam, aspen, and balsamiferous poplars (cottonwood). Some white birch and jackpine are also found, while, as is usual in British Columbia, the black alder abounds and often grows to a diameter of from 6 to 8 inches. Large red cedar were seen in the Kispiox valley, but apparently they do not extend far north of it. The underbrush is very thick at the lower elevations on the Skeena and there are many varieties of edible berries, though they do not reach elevations much exceeding 3,000 feet.

### TRANSPORTATION.

The Groundhog basin is reached from Hazelton by following the Yukon telegraph trail to Blackwater lake, between the fifth and sixth cabins, and then to Slowmalda creek, and crossing a divide at an elevation of 5,100 feet and descending to the Cluakaas by Trail or Canyon creek. The latter part of the route was used by several parties during the Klondike rush, and the number of abandoned pack and riding saddles to be seen along it is eloquent testimony of the hardships they endured. The route south from Telegraph creek is reported to be as short and much drier, and there is an abundance of grass for the horses, which is scarce along the present route.

In order to obtain a market for the coal in the Groundhog basin, it will be necessary to build many miles of railway. The most direct route to tide-water would be to the town of Stewart, situated at the head of the Portland canal, which affords a splendid waterway for 150 miles from the coast, as well as an excellent harbour. A line of railway has already been built up the valley to Bear river for 12 miles from Stewart, but difficult rock work, a tunnel 2 miles in length, and grades of probably over 2 per cent would be entailed in extending it to the Nass valley, a distance of some 35 miles. These difficulties would be avoided by building a line up the Nass from Nasoga gulf, which offers the nearest suitable harbour. The length of railway, should this route be chosen, would be 85 miles in excess of the Stewart route, and some rock work would be necessary in skirting the shore before reaching the Nass at all. The grade would, of course, be low. Some coal has been reported on the eastern edge of the basin, but at a considerable elevation above the bottom of the Nass valley. Probably to reach the nearest seams, 90 miles of railway would be necessary from the terminus of the Stewart line, and to reach the centre of the basin it would be necessary to cross a divide either at the head of Panorama or Anthony creeks, both of which are above 4,000 feet in elevation, and would doubtless necessitate grades of at least 2 per cent in an easterly direction, though they would probably not amount to over 1 per cent for the haul westward. The route up the Skeena from Hazelton would mean 150 miles of railway, which, from the estimates of Mr. J. S. O'Dwyer,[1] would cost about $3,200,000, and the total distance to Prince Rupert by this route would be 300 miles.

## General Geology.

### TABLE OF FORMATIONS.

| | |
|---|---|
| Quaternary | Glacial and river deposits. |
| Tertiary? | Bulkley eruptives. |
| Lower Cretaceous (or upper Jurassic) | Skeena series (coal-bearing). |
| Jurassic | Hazelton group. |

### DESCRIPTION OF FORMATIONS.

#### *Hazelton Group.*

The rocks of the Hazelton group were the only rocks seen, except at the Groundhog basin and in the vicinity of Hazelton, where comparatively small areas of the Skeena series occur as well as intrusive batholiths and dykes of the Bulkley eruptives.

The group contains volcanic flows in the vicinity of Hazelton, as well as tuffs, tufaceous sandstones, and black and more or less carbonaceous shales. North of the Shegunia, however, no flows were seen, though nearly all the sandstones contained much tufaceous material and some true tuffs occur. As the Telegraph trail follows the strike of the beds, no reliable estimate of the exposed thickness of those beds could be made, and at no point were exposures sufficiently continuous to furnish valuable sections. The base of the formation was not seen, though it is likely that it rests upon the limestones of the Caché Creek series of Carboniferous age. The tufaceous material is especially abundant in the lower members of the group, and some of the tuffs there are light grey in colour and weather to yellow-brown and reddish tints. Those were seen on the northern slope of Poison mountain, a hill 60 miles north of Hazelton,over which the trail climbs to avoid a deep canyon on the Skeena. Higher up in the series the prevailing colours are sombre grey to black, and the sandstones, which are quite coarse in places, contain, besides volcanic ash, partially rounded grains of black shales. Plant remains occur throughout the formation, impressions of entire tree trunks being found in some of the sandstones. When this is the case, thin films of coal develop usually along the outer edge of the trunk, while the remainder of what was once wood is replaced by sand grains, now cemented, and showing an apparent difference from the rest of the bed. In some of the finer sandstones and shales delicate leaf tissues have occasionally left their impressions.

[1] See Railway and Canals Report No. 8, 1901, pp. 162-163.

but, in general, the deposition of material was probably too rapid, and most of the finer lines by which genus and species might be determined have been lost. Near the top of the horizon some dark calcareous shales contain numerous interior casts and some shells of marine invertebrate. The genera Astarte and Inocerami were determined by Dr. Raymond, but not the species. In the field this marine horizon was recognized at the crest of the mountain north of Deep creek, on one south of Blackwater lake, and in the Groundhog mountain immediately south of the basin. In all probability the age of this part of the group is Jurassic, but the lower part may be older.

*Skeena Series.*

As far as is definitely known, the coal-bearing Skeena series does not occur between the Groundhog basin and a point 18 miles north of Hazelton. It is quite possible, however, that it may occur at some points west of the Telegraph trail. Indeed, some thin seams of coal were seen overlying the fossiliferous bed at the summit of the mountain south of Blackwater lake and the strata in the valley to the west, apparently belonging to a still higher horizon. On the other hand, though the river drift was carefully watched, no extraordinary number of fragments of the conglomerates of the Skeena series were noted until the Groundhog basin was approached.

The occurrence of the Skeena series above the Shegunia river has already been noted by Mr. Leach,[1] and the strata outcrop on both the Skeena and the Kispiox, from the junction up-stream, for about 7 miles.

As noted by Dr. Dawson, rocks referable to the Skeena series occur on the Skeena below Hazelton, near the mouth of the Kitseguecla, and numerous areas on the Bulkley and its tributaries are mentioned by Mr. Leach, while other areas are reported on Babine and Bear lakes.

While there is a general resemblance between the Skeena series in the Kispiox area north of Hazelton and in the Groundhog, the differences are sufficiently pronounced to make it advantageous to describe the two areas separately. The points in common are the general yellow and brown tints of the sandstones and shales which serve to distinguish the series from the underlying Hazelton group. The sandstones of the Kispiox area are also yellow and brown in colour in the lower part of the series, which was all that could be found. Exposures are confined to the banks of the Kispiox and Skeena, and with the exception of a bare slide on the Skeena 7 miles above the junction, the exposures are widely separated and the beds too much faulted to give a satisfactory section. This slide has laid bare a face of rock 300 feet high, but the continuity of the section is broken by a fault. Measurements were made of the section exposed with the following results, in descending order:—

*Big Slide Sections.*

| | | Feet. |
|---|---|---|
| 1. | Brown sandstone grey on fracture and moderately coarse, about... | 70 |
| 2. | Brown shale | 30 |
| 3. | Coarse yellow sandstone | 8 |
| 4. | Yellow and brown shales | 60 |
| 5. | Yellow sandstone | 30 |
| 6. | Coal | 1·9 |
| 7. | Brown shale | 10 |
| 8. | Yellow sandstone | 58 |
| 9. | Coal | 0·6 |
| 10. | Bone and coal | 0·9 |
| 11. | Coal | 1·3 |
| 12. | Yellow sandstone | 40 |
| 13. | Yellow and brown shales | 100 |
| 14. | Coarse yellow sandstone with stringers of calcite | 20 |
| | | 419·7 |
| | Fault | ? |

[1] G. S. C. Summary Report, 1909, p. 67.

| | | Feet. |
|---|---|---|
| 1. | Yellow and brown shales | 220 |
| 2. | Coal | 1·4 |
| 3. | Bone | 0·9 |
| 4. | Coal | 0·9 |
| 5. | Bone | 1·5 |
| 6. | Coal | 0·6 |
| 7. | Yellow and black shales | 25 |
| 8. | Coal with 0·4 ft. bone | 2 |
| 9. | Yellow shales with black bituminous bands and some brown sandstones | 20 |
| 10. | Coal | 1·3 |
| 11. | Similar series of shales | 260 |
| 12. | Yellowish and grey shales alternating | 56 |
| 13. | Black shale, bottom not seen | 6 |
| | | 595·6 |

Below the base of the lower section, exposures are missing for an interval of several hundred feet, after which the coarse, tufaceous sandstones of the Hazelton group were seen dipping under the Skeena series. The uppermost bed of these sandstones contained a number of pebbles of blue and green cherts, but these were not sufficiently abundant to constitute a conglomerate bed. As has been stated, Mr. Leach found a bed of conglomerate underlying the Skeena series, in some, but not in all the sections examined.

The Skeena series in the Groundhog basin has a thickness of over 4,200 feet, as measured on the crest line of the hills west of the Cluakaas, and 5 miles from the mouth of Currier creek. Probably the lower 400 or 500 feet should be placed in the Hazelton group. The section is in descending order.

### *Main Section.*

| | | Feet. |
|---|---|---|
| 1. | Massive bed of conglomerate with chert pebbles up to the size of hens eggs | 107 |
| 2. | Brown shale | 8 |
| 3. | *Coal* with 0·7 ft. bone | 12 |
| 4. | Brown shaly sandstone | 5 |
| 5. | Brown shale | 10 |
| 6. | *Coal* | 3·2 |
| 7. | Black shale | 24 |
| 8. | *Coal* with 1 ft. bone near centre | 4·5 |
| 9. | Black and brown shale | 15 |
| 10. | Shaly sandstone | 9 |
| 11. | Black shale | 8 |
| 12. | *Coal* | 2·8 |
| 13. | Brownish shales, and shaly sandstones | 114 |
| 14. | Massive bed of siliceous sandstone with conglomerate pebbles especially in lower two-thirds. Slightly shaly above | 37 |
| 15. | Black and brown shale with thin streaks of coal | 250 |
| 16. | Coarse but poorly cemented sandstones | 8 |
| 17. | *Coal* | 2 |
| 18. | Hard siliceous sandstone weathering to reddish tints fairly coarse in places | 34 |
| 19. | Black and brown shale with three thin seams of coal | 33 |
| 20. | *Coal* | 1 |
| 21. | Black and brown shale | 16 |
| 22. | Shaly sandstone | 16 |
| 23. | Brown sandstone with bands of calcareous shale below and conglomerate pebbles above | 51 |
| 24. | Brownish shale with bands of fossiliferous sandstone concretions | 23 |
| 25. | Brown sandstone with numerous pebbles in lower beds finer grained above | 15 |
| 26. | Partly concealed probably brown shale | 16 |
| 27. | Siliceous sandstone weathering red | 6 |
| 28. | Black shale | 8 |
| 29. | Shaly sandstone | 4 |
| 30. | *Coal* | 1·3 |
| 31. | Black shale | 21 |

| | | Feet. |
|---|---|---|
| 32. | Shaly sandstone | 2 |
| 33. | Dirty *coal* | 2·5 |
| 34. | Black shale and shaly sandstone with three streaks of coal | 41 |
| 35. | *Coal* | 4·5 |
| 36. | Black shale and a little shaly sandstone | 41 |
| 37. | Beds of soft yellow sandstone with some conglomerate pebbles and bands of brown shale | 39 |
| 38. | Coarse sandstone with conglomerate pebbles scattered through it | 35 |
| 39. | Black and brown shale with streaks of coal | 40 |
| 40. | *Coal* | 1·3 |
| 41. | Black shale with streak of coal | 22 |
| 42. | Coarse sandstone | 2 |
| 43. | Black shale with streak of coal | 11 |
| 44. | *Coal* | 1·1 |
| 45. | Black shale | 17 |
| 46. | Black shale and shaly sandstone | 40 |
| 47. | Hard siliceous sandstone | 20 |
| 48. | Black shales and shaly sandstone | 142 |
| 49. | Black shales separated by brown shaly sandstones in thin beds | 219 |
| 50. | Coarse brown sandstone | 12 |
| 51. | Black shale | 21 |
| 52. | *Coal* seam rather dirty | 2 |
| 53. | Black shale | 140 |
| 54. | Sandstone beds separated by a few bands of black shale | 75 |
| 55. | Black shales with a few ribbons of coal | 155 |
| 56. | Siliceous sandstone weathering red | 2 |
| 57. | Black and brown shale | 350 |
| 58. | *Coal* | 0·5 |
| 59. | Black shale and soft shaly sandstone | 88 |
| 60. | Coarse grey sandstone with rather weak cement weathering brown | 46 |
| 61. | Black shale with coal seam not dug out | 50 |
| 62. | Coarse grey sandstone showing concretionary forms in some parts | 38 |
| 63. | Shaly sandstone | 8 |
| 64. | Fine-grained sandstone with some shale and streaks of coal | 41 |
| 65. | *Coal*, roof fallen in, at least | 1 |
| 66. | Soft grey sandstones and beds of calcareous shale with numerous concretions | 111 |
| 67. | Coarser grey sandstone | 6 |
| 68. | Black shale | 5 |
| 69. | Black shales and shaly sandstones partly concealed | 153 |
| 70. | Brown shales and shaly sandstones with numerous concretions | 61 |
| 71. | Black and brown shales and shaly sandstones | 196 |
| 72. | Black shales and coarse sandstones, the shales predominating | 214 |
| 73. | Hard siliceous sandstone weathering red | 25 |
| 74. | Black shale | 143 |
| 75. | Conglomerate | 6 |
| 76. | Black shale | 15 |
| 77. | *Coal* | 0·4 |
| 78. | Black shales and grey sandstones, the shales predominating | 73 |
| 79. | Massive bed of hard grey sandstone | 38 |
| 80. | Black shales with a few streaks of coal and thin bands of sandstone | 86 |
| 81. | *Coal* | 0·3 |
| 82. | Black shales and grey sandstones | 115 |
| 83. | Grey sandstone | 7 |
| 84. | Black shale | 30 |
| 85. | Grey sandstone | 36 |
| 86. | Black shale with a few bands of sandstone | 80 |
| 87. | Black shale and grey sandstones weathering brown, sandstone predominates | 326 |
| 88. | Black shale with some calcareous concretions | 36 |
| 89. | Hard grey sandstone | 6 |
| 90. | Black shale, bottom not seen, at least | 300 |
| | Total | 4273·4 |

It is not likely that a section a few miles from this point would correspond closely to the above section, and, indeed, the Skeena series, like the Kootanie series in the eastern ranges of the Rockies, is very irregular, several instances of contemporaneous erosion being observed even on comparatively small rock faces.

The section is, therefore, intended to serve as a general type section, and as far as is known, the main thickness of sandstone and shale can be correlated in different parts of the basin. On the whole there is a great similarity between the rocks of this Skeena series, in the Groundhog basin, and those of the Kootanie series as exposed in the eastern ranges of the Rockies. The hard, siliceous beds of grey sandstone, weathering to reddish tints, seem almost identical, but, on the other hand, a number of points of difference were noted. The most striking of these is the great development of conglomerate beds. A band of conglomerate, capping the formation, has a thickness of over 100 feet, in no part of which is the maximum size of the pebbles smaller than an ordinary marble. In the Kootanie such thicknesses are rare, though a bed 80 feet in thickness is reported from Fernie.[1]

While many of the pebbles of both formations, *i.e.*, the blue, green, and white cherts, seem identical, there are in addition in the Skeena series, pebbles of volcanic rocks notably softer than the cherts, and the various pebbles are not nearly as well rounded. These facts would suggest that the Groundhog basin was nearer to the source of the material from which the pebbles were derived, an inference which is supported by the fact that the shales show much more variety in colour than those of the Kootanie, brown and yellow being even commoner than the black, whereas, in the Kootanie section, brown colorations are comparatively rare in the shales and no yellows are found. This lack of colour would, of course, imply a chemical disintegration of the material and reduction of the iron by humic acids, so that it is present as ferrous iron carbonate.

### *Bulkley Eruptives.*

The Bulkley eruptives form huge batholiths in the vicinity of Hazelton and for some distance north of it. The Roches de Boulées, Hudson Bay mountains, and the ranges on either side of the Skeena valley as far as Babine lake are largely composed of these rocks, which, owing to their hardness, form the precipitous crest lines characteristic of these mountains. In the vicinity of the Telegraph trail a number of dykes of igneous rock cut the Skeena series for 16 miles north of Hazelton, while the river float showed many fragments of igneous rocks as far north as Poison mountain; farther north the igneous material, while not altogether absent, was insignificant in amount. Mr. Leach describes the series as consisting of granodiorites and diorite porphyrites, but, as far as is known, no thin sections have been examined. The ferromagnesian minerals are usually hornblende, biotite, and pyroxene. Where the dykes cut the Skeena series, many interesting varieties of rock types were encountered, especially in the vicinity of coal seams, but those await further investigation.

An intrusion of a quartz porphyry seems to be connected with the rich silver lead veins visited, and some basic dykes were also noted.

## PALÆONTOLOGY.

### *Hazelton Group.*

Mention has already been made of species of Inocerami and Astartes, which were found in the Hazelton group a short distance below the Skeena series. Near the halfway house, between the second and third cabins on the Telegraph trail, a few plants were found, and Dr. F. H. Knowlton has identified *Baiere multanervis*, Nathorst, and probably *Podozamites lanceolatus* (L. and H.), Br., and says they appear to be Jurassic. The horizon here is evidently pretty well down in the group.

A collection from the vicinity of the Skeena bridge, 4 miles above Hazelton, contained the following *Gleichenia*, sp. ?, *Nilsonia*, sp. ?. Dr. Knowlton says that the horizon indicated by these is Kootanie, though lithologically the rocks at the bridge would be classified as belonging to the Hazelton group rather than to the overlying Skeena series.

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[1] G. S. C. Annual Report, Vol. XIII, Part A, p. 87.

*Skeena Series.*

A marine shell, *Mactra utahensis,* Meek, was determined by Dr. Raymond, who says it indicates an horizon in the Cretaceous. The specimens were found on the east bank of the Cluakaas, 1,000 feet north of the mouth of Currier creek, and the horizon is probably near the top of the main section.

The remaining fossils and plants were examined first by Mr. W. J. Wilson and then sent to Dr. Knowlton, who has verified many of Mr. Wilson's determinations, and has extended the list. Dr. Knowlton says that he is not able to draw any stratigraphical conclusions from them, except that, in general, they indicate the Kootanie horizon. The localities and approximate horizons are given in each case.

| Locality. | Horizon. | Series and Species. |
|---|---|---|
| Mt. Alec, north of Beirnes creek | Doubtful but low in series | *Cladophlebis virginienses* Font. |
| Main Section | No. 64 | *Cladophlebis Fickeri* Knowlton. |
| " | " | *Nilsonia parvula* (Heer) Font. |
| " | " | *Oleandra graminaefolia?* Knowlton. |
| " | " | *Equisetum Phillipsii?* (Dunker). Brongn. |
| " | " | |
| " | No. 24 | *Nilsonia parvula* (Heer) Font. |
| " | " | *Oleandra graminaefolia* Knowlton. |
| Beirnes creek, below | Choquette seam | *Cladophlebis virginienses* Font. |
| Beirnes creek, below | " | *Zamites montana* Dawson. |
| East bank Cluakaas | High in series | *Nilsonia* sp.? |
| Main section | No. 2 | *Cladophlebis?* sp. |

## Structural Geology.

North of the intrusions of the Bulkley batholiths the strata of the Hazelton group manifest great regularity in strike, the exceptions to a northwest and southeast direction being unimportant. The dips are prevailingly to the southwest, those to the northeast being much less common and usually at much higher angles. These facts were explained by finding, in many cases, monoclinal folds and thrust faults at many points near the mountain tops where extensive exposures of the strata could be viewed at once. In the valleys the exposures were usually too small and scattered to exhibit the true structure satisfactorily, though small thrust faults were observed at several points. These prevailing northwest strikes and southwest dips, and faulting with downthrow to the northeast, seem to indicate that the rocks, like those of the eastern ranges of the Rockies, have been subjected to pressure from the southwest. While in the Rockies this pressure has developed great fault planes and huge overthrust fault blocks of limestone, the pressure in the region north of Hazelton has developed more numerous faults, and a great deal of crumpling. The mountains climbed are not single fault blocks, but either complicated segments of strata thrust up along numerous fault planes, or the crests of sharp monoclinal folds. The difference in structure between these mountains and the Rockies is probably due to the absence of any great thickness of homogeneous strata offering a uniform resistance to the pressure, and which might be expected to break along a single plane when this resistance was overcome. In both regions the geological structure may be called imbricated, but the number of repetitions is much more numerous in the district now described than in the Rockies.

To the south, the intrusion of the Bulkley batholiths has tilted the strata, and in the immediate vicinity of the igneous bodies the dips are often *qua qua versal,* while in the case of the Skeena series, on the Skeena for some distance above the mouth of the Kispiox, the directions of dip and strike are so inconstant that the varying inclinations of the strata suggest a mammillary structure. Even in the vicinity of Hazelton, however, a northwest and southeast strike prevails, except near the intrusions.

The Skeena series in the Groundhog basin also exhibits strongly the effects of pressure from the southwest, and the ridges separating the five troughs, already mentioned, are either fault blocks or monoclinal folds raised by this force. The prevailing strikes on the ridges are northwest and southeast, at right angles to the supposed line of pressure, and the main fault lines run generally in the same direction. While this is true in a general sense, the basin type of structure is brought out along the southern edge of the portion of the field examined, by the presence of dips to the north, and strikes approximately east and west. These northerly dips prevail for several miles on each side of Trail or Cañon creek, and extend northward to its junction with Currier creek, and for some distance beyond. Farther north, along the west side of the Skeena, the strata still strikes east-southeast to east-northeast, but the dips are to the south, the locality where the highest strata might be expected being drift covered. This was also the case at most points on the borders of the area where the east and west strikes occur, so that its exact shape or the stratigraphical relation of its strata to those of the surrounding country were not worked out in detail.

Along the southern edge of the basin the width of the area with easterly strikes is fully 7 miles, but the area contracts northward, being only about a mile in width at 3½ miles north of Currier creek. Near the summit of the Groundhog mountains, the southern border of this area is characterized by much crumpling of the beds. At two points to the north, one on the Skeena, nearly 4 miles above the mouth of Currier creek, and the other in the north fork of Davis creek, the contact between the areas of the easterly and the northwesterly striking beds was seen, and in both cases the former dipped at very high angles and were apparently shoved over the others. To the north, in the vicinity of Beirnes creek, no distinct area of easterly strikes was observed, though a syncline traversing the beds near the Skeena river shows a distinct southerly pitch. Mr. Campbell-Johnston states that north of the divide, between the Cluakaas and the Stikine, this pitch is reversed, a condition which would suggest the existence of probably a large basin of coal-bearing strata on that river.

## Economic Geology.

As has been stated in the introduction, visits were paid to some of the silver-lead and copper deposits in the vicinity of Hazelton, which had been discovered since Mr. Leach was in the district the year before. Descriptions of these deposits will be published as an appendix to his forthcoming report. The remaining subjects of economic interest are the Kispiox aud Groundhog coal basin.

### GROUNDHOG BASIN.

#### *Sections and Correlation of Coal Seams.*

The general section of the Skeena series, published[1] above, shows a total of fifteen seams of coal, ranging from 12 to $\frac{3}{10}$ of a foot in thickness, and there were, in addition, many streaks too small to be especially noted. The situation of these seams on the crest of the ridge between cirques, at the heads of Davis and Anthracite creeks, is not at all a favourable one for mining or handling coal, but it was hoped that seams occurring in favourable localities might be correlated with these seams, and that if this was possible, the general section would serve as a guide in prospecting in such places for the remaining seams, whose outcrop might be concealed by drift. Mr. Campbell-Johnston has kindly furnished a section which he and Mr. G. F. Moncton prepared after studying the exposures on Beirnes and Anthracite creeks. This section consists of two parts: an upper section of over 500 feet, containing two seams, and a lower one, 2,550 feet in thickness, which contains seven seams. The two portions of the section are separated by a gap, whose thickness was not determined by measurements. The following table shows a comparison of this section with No 19 to 69 of the section given above in the description of the Skeena series.

| Main Section. | Mr. Campbell-Johnston Sections. |
|---|---|
| No. 19. Black and brown shale.. .. .. | 33 ft. Shale not measured. |
| No. 20. Coal.. .. .. .. .. .. .. .. .. .. | 1 ft. = No. 3 Anthracite creek. |
| Nos. 21 to 24. Sandstones, shales and two coal seams.. .. .. .. .. .. .. .. | 223 fe. = Shales, 100 ft. |
| No. 35. Coal seam.. .. .. .. .. .. .. .. .. | 4·5 ft. = No. 2 Anthracite creek. |
| Nos. 36 to 39. Sandstones and shales with streaks of coal.. .. .. .. .. .. | 185 ft. = Gap in section not measured. |
| No. 40. Coal seam.. .. .. .. .. .. .. .. | 1·3 ft. = No. 1 Anthracite creek. |
| Nos. 41 to 48. Shales with some sandstone.. .. .. .. .. .. .. .. .. .. .. .. | 255 ft. = 300 ft. Shale. |
| Nos. 49 to 54. Sandstones predominate over shales.. .. .. .. .. .. .. .. .. | 478 ft. = 580 ft. sandstones. |
| Benoit seam not recognized.. .. .. .. | Benoit seam. |
| Nos. 55 to 57. Black shales with ribbons of coal.. .. .. .. .. .. .. .. .. | 507 ft. = 554 unproved ground. |
| No. 58. Coal.. .. .. .. .. .. .. .. .. .. | 0·5 ft. = Scott seam. |
| Nos. 59 to 60. Shale and sandstone.. .. | 124 ft. = 115 ft. shale. |
| Seam not dug out.. .. .. .. .. .. .. .. | Garneau seam. |
| No. 61. Black shale.. .. .. .. .. .. .. | 50 ft. = 50 ft. shale. |
| Not recognized.. .. .. .. .. .. .. .. .. | = Choquette seam. |
| Nos. 62 to 64. Sandstones.. .. .. .. .. | 87 ft. = 80 ft. shales. |
| No. 65. Coal roof fallen in at least.. | 1 ft. = Ross seam. |
| Nos. 66 and 67. Sandstones.. .. .. .. | 117 ft. = 150 ft. sandstones. |
| Nos. 68 to 76. Shales with a few sandstones.. .. .. .. .. .. .. .. .. .. .. | 819 ft. = 600 ft. unproved. |
| No. 69. Coal seam.. .. .. .. .. .. .. .. | 0·4 ft. = Pelletier seam. |

The writer cannot be certain that this correlation is correct, for it is based very largely on the assumption that the coal-bearing horizons represented relatively long periods in which there was no deposition over the whole basin, and that between these periods the amounts of sediment deposited in different parts of the basin would be approximately equal, though the thickness of the different intervening beds of sandstones and shales might be expected to vary greatly at points a few miles apart. This variation would be particularly noticeable in the case of the coarser sediments. The section on Beirnes and Anthracite creeks is not given in detail, because of the scarcity of exposures, but except for the absence of outcrops of conglomerates, or sandstone containing conglomerate pebbles, the general nature of the beds seen was not greatly at variance with the correlation suggested above. A fossil plant, determined as *Cladophlebis virginiensis*, was seen above the Choquette seam on Beirnes creek, and *Cladophlebis Ficheri*, in No. 64, in the measured section, which would correspond with the strata between it and the Ross seam.

A second section was measured on a cliff at the western end of the ridge south of the junction of the two branches of Trail creek, as a number of seams had been observed at this point. The section is as follows:—

*Section.*

| | | | Feet. |
|---|---|---|---|
| No. | 1. | Beds of soft black and brown shales with some sandstone layers and probably coal seams, at least | 200 |
| " | 2. | Siliceous grey sandstone weathering to yellow but sometimes red. | 21 |
| " | 3. | Concealed probably brown and black shale | 15 |
| " | 4. | *Coal* | 4·3 |
| " | 5. | Black shale | 3 |
| " | 6. | Hard siliceous sandstone similar to No. 2 | 18 |
| " | 7. | Black shale, partly concealed | 16 |
| " | 8. | *Dirty coal* | 1·4 |
| " | 9. | Black shale | 42 |
| " | 10. | *Coal* | 3·5 |
| " | 11. | Black shale | 10 |
| " | 12. | Hard massive bed of bluish grey sandstone | 27 |
| " | 13. | Black shale slightly arenaceous above | 17 |
| " | 14. | Partly concealed, probably all black shale | 46 |
| " | 15. | *Coal* | 3·6 |
| " | 16. | Black shale | 2·5 |
| " | 17. | *Coal* | 0·9 |
| " | 18. | Light yellow shaly sandstone | 15 |
| " | 19. | Black shale with a few thin sandstone beds near top | 43 |
| " | 20. | Coarse yellow sandstone | 5 |
| " | 21. | Partly concealed, probably all black shale | 39 |
| " | 22. | Shaly sandstone | 3 |
| " | 23. | Black shale rather arenaceous in places | 42 + |
| | | | 573·2 |

The following is a comparison of this section with Mr. Campbell-Johnston's, assuming that coal seam No. 4 is the Scott seam.

| | |
|---|---|
| No. 4. Coal | 4·3 ft. = Scott seam. |
| Nos. 5 to 9. Shales with sandstone beds and 1·4 ft. dirty coal | 80·4 ft. = 115 ft. shale. |
| No. 10. Coal | 3·5 ft. = Garneau seam. |
| Nos. 10–14. Black shales with bands of sandstone | 90 ft. = 50 ft. shale. |
| No. 15. Coal | 3·6 ft. = Choquette seam. |

If this correlation is correct, the Ross seam, which occurs 80 feet below the Choquette in Mr. Campbell-Johnston's section, was not recognized in ours, but parts of the corresponding horizon, No. 21, were concealed.

## Description of Coal Outcrops.

*Western Development Company.*—Though the number of coal outcrops on the property of the Western Development Company is large, in no case is any considerable thickness of strata exposed, while the variations of strike and dip of those which do outcrop are so pronounced that it is impossible to certainly correlate any of them with the seams in the general section. Two tunnels have been driven on Discovery creek into what is almost certainly the same seam. The exposures in the creek bed, between the two openings, are fairly continuous, and show a regular change in dip and constant strike. At the higher tunnel the seam strikes 151° and dips 19° to the east, a dip considerably steeper than the slope of the stream. About 3,600 feet farther down, where the lower tunnel is driven, the seam dips at only 5°, a lower slope than that of the stream. About three-fourths of a mile farther down there is a quantity of coal wash, which may have been derived from the same seam, though efforts to find it were not successful. In the upper of the two tunnels the following measurements were made: coal, 1·5 feet; bone, 0·6 foot; coal, 3·9 feet. At the lower tunnel almost the same thicknesses were obtained by our measurements, viz.: coal, 1·6 feet; bone, 0·4 foot; coal, 3·8 feet, and the shales forming the roofs of the tunnels were exactly similar. From the list of analyses given below, it will be seen that this seam was much the cleanest of any of the seams sampled, and in most cases even picked samples from other seams showed higher percentages of ash. It seems probable that this seam is the same as the 4·5 foot seam, No. 35, in the main section.

A somewhat similar seam was discovered on Abraham creek, a small tributary of Currier creek, about 1,500 feet from the Cluakaas, and a 20 foot tunnel has been driven on it. The measurements are: coal, 2·35 feet; bone, 0·5 foot; coal, 2·7 feet.

This seam is within the area of east and west strikes, the strike being 54° and dip 16½° to the north. Consequently its relation to the above seam cannot be worked out from the dips, and the only outcrops in the neighbourhood consist of an arenaceous shale above the seam. Though this is similar to the shale above the seam just described, the coal is not nearly so clean, and the thickness of strata exposed to the south of Trail creek, all dipping to the north, would point to a higher horizon. Possibly it corresponds to the 4·5 foot seam, No. 8, in the section, and, if so, other important seams might be found near it. On Trail creek, 3,300 feet from Cluakaas, a tunnel has been driven into a dirty seam by Mr. Walter's party in 1909, and extended to a length of 50 feet last summer by Mr. McEvoy's party. The strike is about 133°, and the dip 17° to the northeast. Near the entry the total thickness of bone and coal is 7·6 feet, but in sampling only 6·5 feet were included on account of the large proportion of bone, and even with this deduction the sample showed over 40 per cent of ash, while Mr. McEvoy's sample, omitting as many partings as was possible, gave nearly 30 per cent. Possibly the horizon of this seam is that of the 1·3 foot seam, No. 40, in the section.

Near the mouth of Davis creek, Mr. McEvoy drove a 7 foot tunnel on a seam underlaid by 21 feet of black shales and overlaid by 29 feet of similar strata, containing many large concretions. Above there is 10 feet of hard grey sandstone. The strike is about 8°, and dip 21° to south. The thickness of the seam is 4·4 feet, and except for rather numerous pyritiferous concretions and quartz stringers it appeared fairly clean. The tunnel was so short that the effects of surface weathering were made apparent by iron stains from the decomposition of the pyrite. No suggestion as to the probable horizon of this seam can be offered.

On the west fork of Davis creek a seam was opened by a short tunnel, but solid roof had not been reached when the writer first visited it. At that time 4·3 feet of coal were seen, but, when the locality was revisited, the opening had been closed by a fall of the clay roof. Heavy coal wash was also found on this creek in a somewhat similar position to that on Discovery creek, and may have been derived from the same seam. Several openings were made on the east fork but no satisfactory seam was found.

*British Columbia Anthracite Syndicate.*—In his work on Beirnes creek, Mr. Campbell-Johnston was handicapped by the scarcity of natural exposures and by the heavy deposits of drift, which prevented him from obtaining the roofs for several of his seams, even after the expenditure of much time and trouble in trenching and tunnelling on them. The names and relative positions of the seams have already been given. A shaft some 30 feet in depth was sunk on the Pelletier seam, which is nearly vertical. A thickness of 5·2 feet was sampled. An anticline in the measures occurs just above this seam, and this fact, together with the steep dip, would make it doubtful whether this measurement represents the true thickness of the seam.

Work on the Ross seam had not advanced far enough to prove its true width, but the writer expects that it will show at least 3 feet of coal. It has a good sandstone roof. The Choquette seam was not measured, and, indeed, almost no clean coal was found in it. The Garneau seam showed 2·5 feet of clean coal, but was not sampled. The Scott seam is probably the most important: of it 5·3 feet were sampled (omitting 0·2 feet of bone), and above was about 3 feet of dirty coal. No true roof was found for the Benoit, but there seemed to be at least 2 to 3 feet of coal. The series of strata containing these seams all dip to the east, and 1½ miles above the Pelletier seam, on the other limb of the anticline, two good-sized seams were measured. The lower showed: coal, 2·4 feet; bone, 2·6 feet; coal, 5·8 feet. A fault occurred just below the point where this seam was measured, and its correlation with any of the preceding seams is at least problematic. The higher of the two seams gave 6 feet dirty coal, 8½ feet shale, 3 feet coal. No. 1, on Anthracite creek, gave the following measurements: bone and dirty coal, 4 feet; clean coal, 2·4 feet; No. 2 gave 4·2 feet coal. No. 3 was not visited. Strike at No. 2, 157°, dip 45° W.

Mr. Campbell-Johnston reports a 25 foot seam, a 10 foot seam, and four smaller seams near the forks at the head of Beirnes creek.

A picked specimen of coal from a 10 foot seam southeast of the head of Panorama creek was furnished by a prospector, Mr. Beeton.

*British Columbia Anthracite Company.*—This Company has done very little development work; two tunnels on Trail creek, one in wash and the other along a faulted seam, being the only ones of which the writer heard. A great deal of wash is exposed on Telfer creek, and in all probability two or more seams are represented, but no measurements could be made until they were dug out. The section measured on the ridge east of Trail creek has been given above, and in all probability the three seams in it might be traced down into the valley. A 3·4 foot seam (probably one of the three in the section) was measured on the northwestern slope of the hill 2·65 miles south of the mouth of Currier creek. It strikes 105° and dips 15° to the north.

A seam, perhaps 4 feet in thickness, was exposed on the hill northeast of the mouth of Currier creek at the head of Telfer creek, and a seam 16 feet in thickness is reported from the head of the small creek east of this hill. A number of small seams outcrop on Trail creek and on the stream coming in to the Cluakaas 4,000 feet below the mouth of Currier creek, but the strata are badly disturbed in both these localities.

### *Disturbances in Strata.*

The most important disturbances of the strata noted have been described under the heading of Structural Geology. The results of the disturbances consist of monoclinal folding and overthrusting in lines running southeast and northwest, and are usually to be seen on the northeastern slopes of the ridges, though in many cases the strata are concealed and it is impossible to decide whether there has been faulting or only sharp folding. The borders of the area, where east and west dips prevail, are also an area of disturbance, for where the actual border of the area was seen the strata were broken by faults, crumpled, and even away from the borders many irregularities in dip and strike and some crumpling were observed. Quartz and calcite stringers traverse the strata in different directions, but seem thicker and more numerous near the fault lines. In some cases these stringers are themselves faulted by subsequent adjustments, though in no observed case did these movements throw the stringers more than a few inches out of line. On account of the irregularity of the strata, which may be more serious than is indicated by the limited number of outcrops, the writer would advise careful prospecting before the sites for tunnels and mine buildings are chosen.

### *Character of the Coal.*

The character of the coal differs essentially from any hitherto described: it is anthracite, non-coking, and contains exceptionally high percentages of moisture. In many cases the coal has a resinous lustre, which is usually found in lignitic coal, and very likely the high moisture produces this lustre. In many of the seams the coal is much crushed, and in all the seams stringers of quartz or calcite occur. These stringers are usually from 1/16 to 1/4 of an inch in thickness, and when a lump breaks along one of them the foreign materials do not break free but stick to one or other of the faces. The number of points at which the coal has been opened are too few to permit of an estimate being made of the amount of this foreign material present, and some localities may be found where the coal is entirely free from them. As a general rule, the stringers seem to be more numerous in the lower seams, averaging, perhaps, three to the cubic foot, while in the two tunnels or the 6 foot seam on Discovery creek one veinlet to the foot would be a more likely figure.

The following are analyses of samples, by different samplers, from various seams. In each case the thickness of coal (exclusive of bone or shale streaks) is given and the locality. It is further stated whether the seam was sampled on the surface or at the face of a tunnel.

| Seam. | Locality. | Sampler. | Moisture. | Vol. Comb. Matter. | Fixed Carbon. | Ash. | Sulph. | Cal. Val B.T.U. |
|---|---|---|---|---|---|---|---|---|
| 5·5 ft. tunnel...... | Small trib. of Currier creek | J. McEvoy. | 1·17 | 6·05 | 76·20 | 16·58 | 0·72 | 12,215 |
| " ....... | " " .. | Malloch.... | 1·04 | 8·39 | 67·89 | 22·68 | | |
| 5·8 ft. tunnel....... | Lower tunnel, Discovery creek | J. McEvoy. | 1·17 | 6·54 | 83·37 | 8·92 | 0·74 | 13,238 |
| 5·8 ft. surface...... | " " .. | " . | 2·39 | 7·90 | 78·54 | 10·18 | 0·99 | |
| 1 ft. near top surface | " " .. | C. Fergie... | 4·12 | 7·43 | 82·60 | 5·85 | 0·46 | |
| 4 ft. near bottom surface.... ......... | " " .. | " ... | 5·95 | 8·00 | 82·00 | 4·05 | 0·49 | |
| 5·4 ft. tunnel....... | Upper tunnel, Discovery creek | J. McEvoy.. | 2·62 | 6·96 | 84·49 | 5·93 | 5·75 | 13,814 |
| 5·4 ft. surface....... | " " .. | W. Leach.. | 5·75 | 7·34 | 75·26 | 11·65 | | |
| " ...... | " " .. | F. Walter.. | 4·45 | 8·75 | 79·25 | 7·55 | | |
| 4·4 ft. tunnel..... | Near mouth Davis creek | J. McEvoy.. | 1·40 | 6·06 | 70·68 | 21·86 | 1·60 | 11,788 |
| " ...... | " " .. | Malloch.... | 1·57 | 7·55 | 65·52 | 25·36 | | |
| 6·8 ft. tunnel....... | Trail creek near mountain. | J. McEvoy.. | 1·39 | 5·75 | 63·02 | 29·84 | 1·08 | 10,541 |
| 6·5 ft. " ...... | " " .. | Malloch.... | 1·36 | 7·17 | 49·04 | 42·41 | | |
| 5·2 ft. shaft......... | Pelletier seam, Beirnes creek | Malloch ... | 1·35 | 7·69 | 61·90 | 29·06 | | |
| 5·2 ft. tunnel... .. | Scott seam Beirnes creek | Malloch .... | 1·08 | 7·06 | 64·97 | 26·89 | | |

The following are analyses of specimens of coal, *i.e.*, lumps taken from different seams or from surface outcrops:—

| Seam. | Locality. | Moisture. | Vol. Comb. | Fixed Carbon. | Ash. | Sulph. | Cal. Val. B.T.U. |
|---|---|---|---|---|---|---|---|
| Benoit | Beirnes creek | 3·0 | 6 6 | 74 6 | 15 0 | 0·8 | |
| Benoit | " | 4 0 | 5·1 | 82 6 | 7·5 | 0·8 | |
| Benoit | " | 4 0 | 5 0 | 82 0 | 8·0 | 1·0 | |
| Benoit | " | 4 5 | 4 5 | 84 0 | 6·0 | 1·0 | 12,852 |
| Benoit | " | 4 5 | 4·6 | 80·1 | 10 0 | 0·8 | |
| Scott | " | 3 5 | 4 6 | 81·1 | 10·0 | 0·8 | |
| Scott | " | 11 17 | | 75·66 | 13·13 | 0 4 | |
| Scott | " | 4 5 | 4·5 | 77·0 | 13·0 | 1·0 | 12,323 |
| Scott | " | 4 5 | 6 5 | 78 0 | 10·0 | 1·0 | 12,843 |
| Garneau | " | 4 0 | 4·0 | 82 50 | 8·5 | 1·0 | 13,455 |
| Ross | " | 9 33 | | 80·94 | 8·96 | 0·77 | |
| Pelletier | " | 4 0 | 4·0 | 71 0 | 20 0 | 1·0 | 11,340 |
| Pelletier | " | 4·5 | 3·5 | 83·5 | 7·5 | 1·0 | |
| No. 1 | Anthracite creek | 13 51 | | 71·76 | 14·57 | 0·16 | |
| No. 2 | " | 6·78 | | 73·36 | 19 74 | 0·12 | |
| No. 3 | " | 6 98 | | 86·74 | 6·15 | 0·13 | |

These analyses were furnished by Mr. Campbell-Johnston.

The following three analyses of specimens were made by F. G. Wait, chemist of the Mines Branch.

| Seam. | Locality. | Moisture. | Vol. Comb. | Fixed Carbon. | Ash. |
|---|---|---|---|---|---|
| 12 feet | No. 3 in Main Section | 2·23 | 13·73 | 64·39 | 19·65 |
| Pelletier | Beirnes Creek | 1·07 | 6·53 | 75·25 | 17·15 |
| 10 feet | Head Panorama Creek | 3·83 | 8·80 | 82·98 | 4·39 |

The great irregularity in the amounts of ash present is probably due in many cases to the inclusion in the samples and specimens of quartz or calcite stringers and to their absence from other specimens. The writer, in taking his samples, made no attempt to get rid of these materials, while Mr. McEvoy, and presumably the other samplers, were careful to exclude them. At the same time the high ash in many of the samples cannot be attributed to any foreign material, but must be due to impurities introduced during the deposition of the coal. Obviously, from the small part of the basin examined, and the difficulty in correlating the different seams seen, no estimate can be made of the amount of workable coal.

### KISPIOX COAL FIELD.

As has been stated, rocks of the Skeena series outcrop on the Kispiox and Skeena rivers for some 14 miles above the junction of the two rivers. Exposures of coal seams occur on both rivers, but the strata are so badly disturbed that it would be unwise to spend any money in attempting to work them near the present outcrops.

The section measured at the Big slide on the Skeena shows that there are at least five seams in the lower 1,000 feet of the series, and while the thickness of coal in them is not great, there is at least the possibility that the seams may be thicker in other parts of the field.

In the Summary Report for 1909, Mr. Leach gives an approximate section measured on the east bank of the Skeena, between 2 and 3 miles above the mouth of the Shegunia river. It contains three seams, respectively, 2, 2·1, and 5·1 feet in thickness. The writer made an examination of the west bank last summer for 4 miles above the Kispiox, but the strata are cut by igneous dykes and sills and only two crushed and dirty seams were seen. On the Kispiox river the strata are also badly disturbed for 5½ miles, though the strikes and dips were not so irregular as on the Skeena and there are fewer dykes and sills. At the upper edge of this disturbed area, and on the western side of the river, a tunnel has been driven for a few feet into a 3 foot seam on the north limb of a faulted anticline, and a few tons of coal hauled on the ice to Hazelton and used in a blacksmith forge. On the eastern side, a little higher up, a 2 foot seam was found and beyond that exposures are not numerous. These would indicate, however, that the beds form a rather shallow and presumably a regular basin. A bed of black bituminous shale is exposed at low-water on the bend south of Kispiox post-office, and a large river flat a mile north of this would probably be as favourable as any for boring in the hopes of finding workable seams.

The following two analyses, copied from the 1909 Summary, are of the two lower seams on the east side of the Skeena. The three succeeding analyses are of the three main seams in the No. 6 and Nos. 9 and 11 in upper section, and Nos. 2, 4, and 6 in lower section; big slide sections are added.

| Seam. | Locality. | Moisture. | Vol. Comb. | Fixed Carbon. | Ash. |
|---|---|---|---|---|---|
| 2·1 | East side Skeena | 1·42 | 18·76 | 58·20 | 21·62 |
| 5·1 | " " | 1·18 | 20·63 | 57·29 | 20·92 |
| 1·9 | West " | 1·07 | 20·43 | 51·26 | 27·24 |
| 0·65, 1·3 | " " | 1·19 | 10·33 | 64·77 | 23·71 |
| 1·4, 0·9, 0·6 | " " | 2·10 | 11·32 | 68·34 | 18·24 |

A specimen from the west side of the Skeena, 1½ miles above the mouth of the Kispiox, gave:—

Moist., 1·65; vol. comb., 22·86; fixed carbon, 50·02; ash, 25·47.

This and the 5·1 foot seam above were the only coals which coked.

# I

## GEOLOGY OF NANAIMO SHEET, NANAIMO COAL-FIELD, VANCOUVER ISLAND, BRITISH COLUMBIA.

(*Charles H. Clapp.*)

### INTRODUCTION.

The greater part of the field season of 1911 was spent by the writer in a detailed geological examination of a district in the vicinity of Nanaimo, Vancouver island, B.C. The topographic map prepared in 1910, under the direction of R. H. Chapman, was used as a field map. This map is a 15 minute sheet, mapped on a scale of 1:48,000 (1 inch = 4,000 feet), with a contour interval of 20 feet. The total land area represented is about 175 square miles and includes the greater part of the Nanaimo coal-field. The surface geological mapping was completed by the middle of September. In this work the writer was very ably assisted by Mr. John D. Mackenzie.

Another month was spent underground and in getting data from the mining companies operating in the district. In this work all the operating companies, with one exception, gave the writer very hearty co-operation. Those who co-operated with the Survey are the Canadian Collieries (Dunsmuir) Company, Pacific Coast Coal Mines, and Vancouver-Nanaimo Coal Mining Company. Special acknowledgment is due to Mr. W. J. Sutton, geologist for the Canadian Collieries Company, who very kindly gave the writer much information and assistance and accompanied him in the field several times. During September and October visits were made to the Comox and the Suquash coal fields, the former visit being made in company with Mr. Sutton. A few days' work was done also in the vicinity of Duncan and Victoria and in southern Saltspring island.

### PREVIOUS WORK.

The character and age of the coal measures of the Nanaimo district were known and described as early as the late fifties, but little work of a general and correlative nature was done and no maps were published until the seventies. Then Richardson worked for five years on the coal-fields of the east coast of Vancouver island, his results being published in the Reports of Progress of the Geological Survey for the years 1871-72, 1872-73, and 1876-77. His last report summarizes his work, and is accompanied by a map on a scale of 4 miles to an inch. During Richardson's examination a great many fossils were collected, and these, with many others collected since that time, have been described, chiefly by Whiteaves. Much prospecting has been done and many private examinations have been made since Richardson's reports were published; but of the extensive information thus collected very little has been made public. In 1905 H. S. Poole collected some of the data, which appeared in the Summary Report of the Geological Survey for 1905. During the writer's previous work on Vancouver island little attention was given to the Nanaimo coal field, and in his reports very little was published concerning it. A large part of the data collected in the district is in the hands of Mr. W. J. Sutton, geologist of the Canadian Collieries (Dunsmuir) Company, and he has very kindly co-operated with the writer in the present examination.

SUMMARY AND CONCLUSIONS.

The larger part of the Nanaimo map area is underlain by sedimentary rocks, sandstones, conglomerates, and shales, of upper Cretaceous age, which are grouped together and called the Nanaimo series. They contain the coal seams of the well-known Nanaimo coal district. The series has been subdivided on lithological grounds into various formations, each with its more or less peculiar characteristics. They rest unconformably on crystalline rocks of various kinds, metamorphic volcanics of the Vancouver group and batholithic rocks, diorites and diorite gneisses, granodiorites and quartz diorites, and gabbro-diorites, intrusive into the metamorphic volcanics. The crystalline rocks within the limits of the Nanaimo map area form low ridges extending east from the crystalline rock highland west of the map area. These ridges surround and project into the sedimentary rock basin. The Nanaimo series are moderately disturbed, and have in general a simple monoclinal structure with a northwest-southeast strike and a low dip to the northeast. There are a few rather large open folds involving one or more formations, and many smaller and minor folds. There are also many minor faults, and in the southwest part of the map area are two reversed strike faults with a relatively large throw.

Following the folding of the Nanaimo series the basin underlain by them was reduced to a lowland, while the crystalline rocks surrounding the basin, being more resistant, remained surmounting it. The softer rocks of the series were worn down to wide valleys corresponding to the strike of the soft beds, while the harder rocks were left in slight relief. The region was glaciated in Glacial time, and above elevations of 400 feet there is a large amount of glacial till. In post-Glacial time the land apparently stood a few hundred feet lower than at present, for up to that elevation are found deposits of stratified sand and gravel derived from glacial till and probably of delta and estuarine origin. A recent uplift has brought the land into its present position and initiated the present erosion cycle, during which the revived streams have terraced the superficial deposits and have cut narrow canyons in the indurated rocks.

Coal is the principal mineral resource, the map area embracing all the producing mines of the Nanaimo coal district. The coal deposits have been the source of a flourishing industry for over fifty years, and the present production is over 1,000,000 tons per year. The coal is bituminous, of fair grade. It occurs in the three seams, the Wellington, the Newcastle, and the Douglas. The seams are remarkably persistent considering the great variability of the associated rocks, but vary greatly in thickness and quality. Sometimes a variation as great as from 2 or 3 feet of dirty slickensided coal or 'rash' to 30 feet of clean coal occurs within a lateral distance of 100 feet. It seems as if this extreme variation has been due to a folding of dirty or silty coal seams, when at least the clean coal was in a pasty condition, permitting it to flow away from the bends where an increased vertical pressure was developed, to the limbs of the folds where there was a corresponding decrease of pressure. There are also large, barren places in the seams due to silting or other similar causes, so that it is seen that the mining of the coal is attended with considerable difficulty, which, however, is very well overcome by the mine operators.

Some of the sandstones of the Nanaimo series have been quarried for building stone, although there was no production during the past year. Some of the sandstones are concretionary, others soft and friable. Some, notably the DeCourcy sandstone, are, as a rule, of good colour, easily worked (although not regularly jointed), and, although rather soft directly after quarrying, harden with seasoning.

The importance of the Nanaimo district in the coal industry may be more easily comprehended when it is realized that it produces over one-third of the entire coal output of British Columbia. Although the production of building stone has been small, the better sandstones have a considerable prospective value.

## General Character of the District.

### TOPOGRAPHY.

The area represented by the Nanaimo sheet is a part of the east coast lowland of Vancouver island, which was developed by the more rapid erosion of the less resistant sedimentary rocks fringing the east coast and lying on the more resistant crystalline rocks which form the axis of the island. These sedimentary rocks are of varying resistance and are moderately disturbed, their strikes being predominantly northwest-southeast and their dip northeast. The less resistant beds of the sedimentary rocks have been worn down nearly to a level, thereby forming extensive valleys along the belts of soft rocks. These valleys have, therefore, a general northwest-southeast trend, while their width varies, dependent upon the width of the soft rock belts. The valleys were probably reduced nearly to sea-level, but on account of a comparatively recent uplift have a present elevation of from 100 to 400 feet. The more resistant beds of the sedimentary rocks have been greatly reduced, but not to a level, and now form long ridges with a general northwest-southeast trend. The ridges have a gentle slope in the direction of the dip of their component rocks, and a very steep slope, often a nearly vertical cliff, in the opposite direction. The general elevation of the ridges increases from the eastern to the western part of the area, those in the eastern part ranging from 300 to 700 feet above sea-level, and those in the western part from 500 to 1,000 feet. In the western part of the area the valleys are much narrower than those developed along the belts of soft rock, and have a trend across the strike of the underlying rocks. They have been formed by the larger streams flowing eastward from the highland west of the area. These streams are the Millstone and Chase rivers in the northern part of the area, and the Nanaimo river and Haslam creek in the southern part. Along the western border of the area is the slope from the coast lowland up to the highland underlain by the more resistant crystallines. On this slope, in the extreme southwestern part of the area, the highest elevation of the area, 1,540 feet, is attained. Tongues of the crystalline rocks extend eastward from the highland into the area of the Nanaimo map-sheet and form low ridges with an east-west trend, rapidly increasing in elevation to the westward. One of these ridges occurs in the extreme northern part of the area; another, in the central part, is the flank of a mountain, about 3,300 feet high, to the west of the city of Nanaimo, known as Mt. Benson. A third ridge of crystalline rocks occurs along the southern boundary of the map area, and attains an elevation of slightly over 1,500 feet. In the central portion of the southern part of the map area is a nearly isolated mass of resistant crystalline rocks, which has been left in relief by the erosion of the surrounding, less resistant sedimentary rocks, and forms a large rounded hill, 1,460 feet high, called Mt. Hayes, the most prominent elevation in the area.

It seems as if at some time following the formation of the wide valleys in the soft sedimentary rocks the eastern part of the area was depressed below sea-level and the valleys drowned, thus forming the long, but often wide channels, passes, and harbours characteristic of the shore of this region. The hard rock ridges remain above sea-level as long points and islands which are characteristically long and occur in chains.

During the Glacial period the region was glaciated and the rock surfaces were smoothed off, and the valleys were deepened. Upon the retreat of the glaciers the region apparently stood a few hundred feet lower with respect to sea-level than at present. This conclusion is based upon the occurrence up to an elevation of 400 feet, of stratified sands and gravel, largely delta deposits, but possibly in part of marine or estuarine origin. These delta deposits have been built up at the former mouths of the larger streams flowing eastward from the highland west of the area, and occur at the confluence of the east-west transverse valleys and the wide longitudinal valleys developed in the soft rock belts. The deposits near the mouth of the river which formerly occupied the Nanaimo valley contain many ice-block or kettle-holes. A comparatively recent uplift has brought the deposits above sea-level, and they have been terraced by the streams revived by the uplift. The larger of the revived streams have also cut narrow canyons, from 100 to 300 feet deep, in the indurated sedimentary rocks. These canyons are the most picturesque feature of the physiography of the area.

### CLIMATE AND VEGETATION.

The climate of Nanaimo and vicinity is similar to that of Victoria,[1] the temperature being remarkably uniform and the rainfall much less than in other portions of the North Pacific coast. The range of temperature is somewhat wider than that of Victoria, from an average of 40° F. in winter to an average of 60° F. in summer. The rainfall is slightly greater, about 35 inches, the greater part of the rain falling in the winter months, while the summer is dry.

The Nanaimo area was once heavily forested like other parts of the east coast of Vancouver island, the forest trees being chiefly conifers, Douglas fir, and red cedar greatly predominating. But a great deal of the timber has been cut, and in the wide valleys the land has been cleared and is now cultivated. Small fruit, garden truck, and grain are the chief agricultural products.

### MEANS OF ACCESS.

There are many wagon roads and several railways in the area. The Esquimalt and Nanaimo railway traverses almost across the entire area from north to south, and there are several coal mine and lumber railways. The larger part of the area is, therefore, readily accessible, the extreme southwestern portion being the only part reached and traversed with some difficulty.

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[1] Summary Report, 1910, Geological Survey, p. 103.

## GENERAL GEOLOGY.

### TABLE OF FORMATIONS.

Superficial deposits.. .. .. .. .. .. .. .. Pleistocene and Recent.
Nanaimo series.. .. .. .. .. .. .. .. .. .. Upper Cretaceous.

| — | Lithological character. | Thickness. Minimum | Thickness. Maximum | Average. |
|---|---|---|---|---|
| Gabriola formation | Chiefly sandstones | 1,400 | 1,400 | 1,400 |
| Northumberland formation | Conglomerates, sandstones, and shales | 1,100 | 1,200 | 1,150 |
| DeCourcy formation | Chiefly sandstones | 800 | 1,400 | 850 |
| Cedar District formation | Chiefly shales | 700 | 1,000 | 750 |
| Protection formation | Chiefly sandstones, coarse gritty sandstones | 600 | 750 | 650 |
| Newcastle formation. (Douglas coal seam). | Fine conglomerates and sandy shales, and contains Douglas seam | 150 | 400 | 200 |
| Newcastle coal seam. | | | | |
| Cranberry formation | Flaggy and shaly sandstones and sandy shales, and gritty sandstones and fine conglomerates | 150 | 500 | 250 |
| Extension formation | Chiefly conglomerates, also shale and sandstone horizons and small coal seams | 700 | 1,500 | 800 |
| Wellington coal seam. | | | | |
| East Wellington formation | Sandstone | 25 | 50 | 35 |
| Haslam formation (Marine shales) (Departure Bay calcarenites). | Chiefly shales | 500 | 800 | 600 |
| Benson formation | Basal conglomerate | 0 | 400 | 100 |
| | Total | 6,125 | 9,400 | 6,785 |

Batholithic intrusives.... .......... ............Upper Jurassic and possibly lower Cretaceous.
Gabbro-diorite.
Quartz diorite and granodiorite.
Diorite and diorite gneiss.
Vancouver group.. ............... ..... ........Lower Jurassic and Triassic.
Metamorphic volcanics...................... Chiefly andesite.

### GENERAL DESCRIPTION OF FORMATIONS.

#### *Vancouver Group.*

The crystalline rocks upon which the sedimentary rocks of the Nanaimo series unconformably rest consist of metamorphic volcanics, which belong to the Vancouver group, and of intrusive batholithic rocks. They occur in three low ridges extending east from the crystalline rock highland to the west of the Nanaimo area. The first ridge occurs in the northwestern part of the area, north of Departure bay, and is the northern boundary of the Nanaimo basin. The second ridge is the east flank of Mt. Benson and is situated west of Nanaimo. The third ridge occurs along the southern boundary of the map area and is the southern boundary of the Nanaimo basin. The first two ridges are composed entirely of Vancouver volcanics and the southern one consists largely of batholithic rocks, although a small area of metamorphic volcanics does occur in its western part.

The volcanic rocks are uniform in appearance and typical of the volcanic members of the Vancouver group. They are largely dense, green altered andesites, greatly fractured and sheared, cut by numerous quartz and epidote stringers, and often mineralized along shear zones. No evidence as to the age of the volcanics is to be found in the area of the Nanaimo sheet, other than that they are pre-upper Cretaceous. They are, however, placed almost certainly, in the Vancouver group, which is known to contain lower Jurassic rocks and probably Triassic rocks also.

*Batholithic Intrusives.*

The batholithic rocks, which are intrusives into the Vancouver volcanics, are, as stated, virtually confined to the southern ridge of crystalline rocks. A very small boss also occurs on the Nanaimo river, near the extreme western border of the area. The rocks consist of granodiorite grading into quartz diorite, diorite chiefly gneissic in character, and a gabbro-diorite of a sub-porphyritic texture. The granodiorite, which is similar to the other granodiorites of Vancouver island, is the chief rock type. A very uniform body of it forms Mt. Hayes, which projects above the surrounding lowland underlain by the Haslam shales that lie unconformably upon the granodiorite. Along the north flank of Mt. Hayes occurs a diorite, frequently fine-grained and gneissic, which although doubtless related to the granodiorite, is much more basic, and is also intruded and brecciated by the granodiorite.

In the extreme southwestern corner of the map area is a body of gabbro-diorite, which has a sub-porphyritic texture. It is similar in appearance to the diorite porphyrites which are intrusive into the Sicker series of the Vancouver group, on southern Saltspring island and elsewhere.[1] The gabbro-diorite of the Nanaimo area is intrusive into the Vancouver volcanics, but its relation to the other batholithic rocks is not exposed.

*Nanaimo Series.*

Lying unconformably upon the crystalline rocks are the thick series of sedimentary rocks of upper Cretaceous age which contain the coal seams of the Nanaimo district. The lower members of this series are fossiliferous, and have been designated by Dawson[2] as the Nanaimo series (group). The entire series of conformable sediments is, however, generally known as the Nanaimo series or Nanaimo formation. As the upper unfossiliferous member (Gabriola sandstones) is very unlike the Eocene sandstones near the city of Vancouver, being much more indurated, it is very doubtful that it is of Eocene age as Dawson[3] suggests it might be. It seems best, therefore, to enlarge the scope of the name Nanaimo so as to embrace the entire conformable series of sedimentary rocks. None of the lower members of the Cowichan group[4] occur in the area of the Nanaimo map-sheet.

The Nanaimo series may be subdivided solely on lithological grounds, since all of the lower formations contain an identical fauna, while the upper formation is unfossiliferous. The various subdivisions or formations are more or less characteristic and well defined. They have already been enumerated in the table of formations, and their distribution and lithological characters are described below in order of age, the lowest or oldest formation being described first.

*Benson Formation.*

The Benson formation is the basal conglomerate of the series. It is exposed and apparently developed only locally, chiefly around the north flank of the east spur of Mt. Benson and in the extreme southwestern portion of the area; it is well exposed

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[1] C. H. Clapp, Summary Report, Geol. Surv., Canada, 1910, p. 105.
[2] G. M. Dawson. "The Nanaimo group," Am. Jour. Sci., Vol. 39, 1890, pp. 180-183.
[3] G. M. Dawson. Bull. Geol. Soc. Am., Vol. XII, 1901, p. 79.
[4] C. H. Clapp. Summary Report, 1909, Geol. Surv., Canada, p. 89.

on Haslam creek. It occurs also on the shore of Departure bay. The basal conglomerate varies from a typical coarse conglomerate composed of large rounded fragments of the underlying rocks, where it occurs lying in hollows in the Vancouver volcanics along the north shore of Departure bay, to a rather fine-grained conglomerate, composed chiefly of rounded volcanic fragments, interbedded with arkose sandstones, which grade upward into interbedded arkose and shaly sandstones characteristic of the base of the overlying Haslam formation. The maximum thickness of the Benson conglomerate is about 400 feet.

*Haslam Formation (Marine Shales).*

Overlying the Benson conglomerate, and sometimes resting directly on the underlying crystalline rocks, is the Haslam formation. It consists chiefly of fine-grained shaly sandstones and sandy shales. Even the shaly sandstones are locally called shales on account of their pronounced difference from the prevailing coarse-grained sandstones of the Nanaimo series. The formation is locally called the 'marine shales' on account of the marine fossils which are occasionally found in it. The Haslam formation extends along the western border of the area in an irregular belt from one-fourth of a mile to 3 miles in width, and also underlies three narrow anticlines in the south central portion of the region. The shales are carbonaceous, being usually light to dark grey in colour. Interbedded with the typical sandy shales are thin beds of light grey, fine-grained, and often fairly siliceous sandstones. These sandstones average less than a foot thick, but sometimes occur in large numbers. Toward the base of the formation the interbeds of sandstone, although not more numerous, are thicker and usually of much coarser grain. They grade into a coarse arkose which, although interbedded with shale, shows an abrupt transition into the Benson basal conglomerate or lies directly upon the underlying crystalline rocks. Along the north shore of Departure bay the Haslam formation is composed of broken shells mixed with a large amount of sand; such a rock, composed of shell-sand, or limestone fragments, is known as a calcarenite, although in this instance the rock is an impure calcarenite. The thickness of the Haslam formation appears to be fairly uniform and averages about 600 feet.

*East Wellington Formation.*

The upper portion of the Haslam shales almost invariably grades upward into, or is limited by a uniform, fine to medium-grained and rather flaggy sandstone, called the East Wellington sandstone. The sandstone varies from about 25 to 50 feet in thickness, and sometimes contains thin interbeds of sandy shales, identical with the underlying Haslam shales. More rarely the sandstone is coarse-grained and contains interbeds of fine to medium-grained conglomerate.

*Wellington Coal Seam.*

The East Wellington sandstone is the floor of the Wellington coal seam. The seam is overlain by the Extension formation, and in places has a roof of sandy shale and in others a conglomerate roof.

*Extension Formation.*

The Extension formation consists chiefly of a very characteristic conglomerate. The formation underlies a broad belt extending entirely across the area with a N. 30° W. strike. The belt averages somewhat over a mile in width, except in the central part, where, on account of a repetition of the beds by folding and faulting, it is 2½ miles wide. The conglomerate is medium to coarse-grained, the fragments averaging about three-fourths of an inch in diameter. The fragments are sub-angular to sub-rounded and are composed almost entirely of quartz, having been derived from quartz veins and from the very fine-grained siliceous rocks of the Sicker series that resemble cherts, and are locally so called. Fragments of the normal metamorphic volcanics of the Vancouver group are rare. The fragments occur in a coarse, sandy matrix which, ordinarily, is in large amount, and the typical conglomerate grades into coarse-grained and pebbly sandstone. There are also a few horizons of sandy shales or shaly sandstones, in the Extension formation, the thickest being about 80 feet. The shale horizons are usually associated with thin coal seams or lenses. Neither the shale horizons nor the coal seams are persistent over large areas. In the central and southern parts of the belt underlain by the Extension formation sandstones and shales are confined to relatively thin interbeds in the typical massive conglomerate. In the northern part of the belt, however, in the vicinity of East Wellington, the lower 300 feet of the formation consists largely of sandstones and shales, and the upper 400 feet consist almost entirely of massive conglomerate. The thickness of the Extension formation varies from 700 to 1,500 feet, the greatest thickness being reached only in its southern part.

### *Cranberry Formation.*

The Cranberry formation overlies the Extension formation, and occupies a belt which averages about half a mile in width, with a maximum width in the central part of over a mile on account of repetition due to folding and faulting. The formation consists chiefly of dark green shaly sandstones and more rarely sandy shales. In the central part of the belt, west of South Wellington, there are one or more thick horizons of conglomerate resembling the Extension conglomerate, although there are a larger number of fragments of volcanic rocks present. In this portion the Cranberry formation is not well defined, and grades downward into the Extension formation and upward into shales, characteristic of the overlying Newcastle formation. In its northern part it is fairly well defined and represents a very characteristic period of deposition. Its thickness varies from 150 feet to a maximum of 500 feet in its southern part.

### *Newcastle (Lower Douglas) Coal Seam.*

The upper limit of the Cranberry formation is the Newcastle coal seam, or, as it is sometimes locally called, the Lower Douglas seam. The seam is overlain by the rocks of the Newcastle formation. It is well defined in the northern part of the area of the Nanaimo map-sheet and persists through the central part, but is poorly defined or absent in the southern part.

### *Newcastle Formation and Douglas Coal Seam.*

The Newcastle formation, which directly overlies the Newcastle coal seam, contains the Douglas coal seam. The formation underlies a belt extending across the area of the Nanaimo sheet, from northern Newcastle island through the city of Nanaimo and town of South Wellington to Ladysmith. The formation, although having determinative characteristics, varies in different parts. In certain portions it consists of a fine conglomerate and coarse gritty sandstone with interbeds of dark green sandy shales. The conglomerate is distinguished by its fineness and by its well-rounded fragments, which are chiefly derived from the Vancouver volcanics. In other portions, practically the entire formation consists of dark green sandy shales or shaly sandstones, composed largely of detritus of volcanic rocks. Interbedded with these shales are, however, lenses of the characteristic fine conglomerate and gritty sandstones. The formation varies in thickness in its northern part from 250 feet, where it is chiefly conglomerate, to 150 feet, where it is composed chiefly of sandy shales; but in its extreme southern portion, although apparently composed chiefly of shales, it is approximately 400 feet thick.

The Douglas seam occurs in the Newcastle formation. Its floor and roof vary from fine conglomerate to sandy shale, corresponding more or less closely to the similar variation in the lithological character of the Newcastle formation. The former conditions prevail in the vicinity of Nanaimo and the latter at South Wellington, the two centres where the Douglas seam is mined. The seam lies from 25 to 100 feet above the Newcastle seam. It is well developed from northern Newcastle island to south of the Nanaimo river, the outcrop of the seam crossing the river near the Esquimalt and Nanaimo Railway bridge at Cassidy siding. Indications of the seam also occur as far south as Bush creek, a mile north of Ladysmith.

### *Protection Formation.*

The Newcastle formation is overlain by a characteristic horizon of sandstone, which is the best horizon marker in the Nanaimo series. The horizon is called the Protection formation from its typical development on Protection island. It underlies a belt extending from Newcastle island to Ladysmith, 1 mile to 1½ miles wide in its northern portion and narrowing to less than one-fourth of a mile in width in its extreme southern portion where the dips are very high. The formation consists largely of a white or greyish sandstone, composed chiefly of rounded quartz grains with a coating of white kaolin. Associated with the sandstones are frequent interbeds of shaly sandstones and carbonaceous, siliceous, sandy shales. The formation contains also numerous small coal lenses, none of which are of commercial value. The formation varies from 600 to 750 feet in thickness.

### *Cedar District Formation.*

Overlying the Protection sandstone is a formation of dark ferruginous sandy shales with a large number of interbeds of coarse-grained sandstone. This formation, which is one of the less resistant formations, underlies a wide valley extending almost north and south from the mouth of Nanaimo river to Ladysmith harbour. The larger part of the valley is in Cedar district, and the formation is, therefore, given the distinctive geographic name of Cedar district.[1] This formation is fairly uniform throughout its entire thickness, which is about 750 feet with a maximum thickness of 1,000 feet in its southern portion. A peculiar feature of this formation is the large number of sandstone dykes which cut the shales. These dykes, which have a maximum thickness of 3 to 4 feet, usually protrude from the interbeds of sandstone and are irregular and branching, following joints in the shales.

### *DeCourcy Formation.*

Overlying the Cedar District shales, with a transition zone 100 to 200 feet thick, is a thick and uniform horizon of sandstones called the DeCourcy formation from its typical development in the group of islands known as the DeCourcy group. The DeCourcy formation extends from Jack point, a long narrow point east of Nanaimo, to the high range of hills on the east side of Ladysmith harbour. On account of a number of open folds the outcrop of the formation has a maximum width in its southern part of about 4 miles. The formation consists chiefly of a grey, rather coarse-grained sandstone usually weathering to a yellowish brown. It contains also

[1] The name Cedar has already been used to designate a formation of Juratriassic age in California.

thin horizons of shaly sandstone and carbonaceous sandy shales, with which are associated thin lenses of impure coal, none of which are of commercial value. The thickness of the DeCourcy formation averages about 800 feet, but in its southern part has a maximum thickness of about 1,400 feet.

### *Northumberland Formation.*

The DeCourcy formation is limited by an overlying, persistent horizon of shales. These shales are similar to the Cedar District shales; but in their upper portion, both in vertical and lateral directions, grade irregularly into or, more strictly, are replaced by sandstones and coarse conglomerates composed of a great variety of fragments. This formation, consisting of shales, sandstones, and coarse heterogeneous conglomerates, is called the Northumberland formation, and is exposed chiefly to the northeast of Northumberland channel along the southwest shore of Gabriola island. The Northumberland shales are exposed also along the northeast shore of Gabriola island, showing the presence of a syncline which extends through the island. The thickness of the formation varies from about 1,100 feet to about 1,200 feet.

### *Gabriola Formation.*

Overlying the Northumberland formation and separated from it by a more or less persistent horizon of shales is a very thick series of fairly uniform, massive sandstones, which since they compose the larger part of Gabriola island are called the Gabriola formation. This formation is the uppermost of the Nanaimo series. The sandstones are medium to coarse-grained, rather siliceous and characteristically concretionary. The concretionary structure and soluble cement causes them to be eroded into fantastic forms or 'gallerys' where they are subject to solution by saltwater spray and by wind and wave erosion. The formation is about 1,400 feet thick in the area of the Nanaimo map-sheet, but increases in thickness to the southeast to a maximum of over 3,000 feet.

*Structure of the Nanaimo Series.*[1]—The rocks of the Nanaimo series have as a whole a general northwest-southeast strike and a prevailing dip to the northeast. At the northern rim of the basin, in the vicinity of Departure bay, the general strike turns to the northeast and east, while the dip is to the southeast and south. With the exception of the major fold which outlines the basin, the entire series is not involved in any large single fold. There are, however, many smaller folds involving one or more formations. Of these, the largest and most important are an anticline whose axis underlies Extension valley, another anticline pitching to the northwestward, whose axis underlies Trincomali channel, and a syncline on Gabriola island. The two anticlines may be called the Extension anticline and the Trincomali anticline, and the syncline the Gabriola syncline. Along the axis of the extension anticline the Haslam shales are exposed, with the East Wellington sandstone, Wellington coal seam, and Extension conglomerate exposed on either side in the ridges fronting the anticlinal valley. The axis of the Trincomali anticline is largely under water, but the Protection sandstone is exposed on a small island, called Round island, near the axis. The DeCourcy islands along the northeast flank of the anticline and the shore of Vancouver island along the southwest flank are underlain by Cedar District shales and DeCourcy sandstones.

Minor faults, seldom more than sharp rolls with a very small actual displacement, are common. In the west central part of the basin are two large reversed or compression faults. These two faults, which occur to the southwest of Extension, have north-

[1] See accompanying map of the general structure.

west-southeast strikes and steep dips to the northeast. Along the larger fault, the northeastern, the Haslam shales on the southwestern and upthrown side of the fault are in contact with Extension conglomerate on the northeastern and downthrown side. The throw of the fault is about 300 feet. The Wellington coal seam also is brought to the surface on the upthrown side of the fault. The smaller fault is as stated of the same character, the southwestern side upthrown. The throw decreases from about 100 feet, where the fault is first recognized near the old No. 1 mine of the Wellington Collieries Company, to nothing, about a mile to the southeast. The faulting has been traced in the underground workings of the No. 3 Extension mine.

*Superficial Deposits.*

A very large portion of the Nanaimo basin, especially the parts underlain by the soft, less resistant beds, is covered with unconsolidated superficial deposits of various kinds which are, however, almost entirely referable to the Glacial period. The superficial deposits may be classified as unmodified glacial till, stratified drift, detritus, and recent alluvial and beach deposits. Glacial till is rather uncommon below elevations of about 400 feet above sea-level and in the larger valleys. It does occur, however, below that elevation near the coast on the sides of rock ridges. It is found in greatest abundance along the western border of the basin on the slope from the coast lowland to the highland west of the map area. In the southwestern section of the map area, underlain chiefly by the Haslam shales, the indurated rocks are exposed only along the various stream courses.

The stratified deposits consist chiefly of sand and gravel. Sandy clays occur but are in relatively small amount, far less than in other parts of southeastern Vancouver island,[1] and smooth plastic clays are very uncommon. The deposits are chiefly of river origin, although the finer-grained and more easterly deposits are probably of lake or marine (estuarine) origin. No marine fossils were found in the drift as have been found in the similar drift in the vicinity of Victoria. The river deposits, consisting of cross-bedded, coarse glacial sands and gravel, are best developed in the south central part of the area where the valleys of Nanaimo river and Haslam creek merge into the coast lowland. They appear to be delta deposits, as they have a typical delta structure, with conspicuous fore-set beds, and apparently have been formed at the mouths of the rivers which previously occupied the Nanaimo River and Haslam Creek valleys, when the land stood a few hundred feet lower with respect to sea-level than at present. The deposits, as already mentioned, have been terraced by the present revived streams after the uplift which brought the land into its present position. At the head of these delta deposits, especially between Nanaimo river and Haslam creek, are many well developed kames and kettle or ice-block holes, features which are developed near the terminus of large glaciers, so that it seems as if the valleys were filled with ice during at least part of the deposition of the delta deposits.

The so-called detritus or detrital deposits consist of small to large angular fragments of the immediately underlying rocks, chiefly sandstones, mixed with more or less glacial till and sometimes with stratified drift. Deposits of this character are virtually confined to the islands of the map area, notably Gabriola island. They appear to be due to the breaking down by mechanical agencies of the underlying sandstone in post-Glacial times. The sandstone must have been subject to rapid mechanical disintegration following the removal of virtually all its covering of residual soil or drift by the powerful scouring action of the large glaciers which occupied the Sound region between Vancouver island and the mainland.

Recent alluvial deposits occur in small depressions in the drift, especially in the wide northwest-southeast valleys, and at the mouth of Nanaimo river where a

[1] C. H. Clapp. Summary Report, 1910, Geological Survey, Canada, p. 107.

delta is rapidly filling the drowned valley between Nanaimo and Jack point, underlain by the Cedar District shales. A similar, but much smaller delta, is being formed at the head of Ladysmith harbour. Along the shore are small narrow beaches between rocky headlands, and rarely, where the superficial deposits have been cliffed by wave erosion, small barrier beaches and sand bars have been built.

## Economic Geology.

Of the mineral resources of the Nanaimo map area the coal deposits are of much the greatest value, and have been the source of a large flourishing industry for over fifty years. The only other products derived from the mineral deposits are building stone, sand and gravel, and common brick. Other deposits which have been prospected are the Departure Bay impure limestones (calcarenites) and the mineralized shear zones and veins in the crystalline rocks.

### COAL.

There are at present three productive coal seams in the Nanaimo district, the Wellington, the Newcastle, sometimes called the Lower Douglas, and the Douglas. The lowest seam, the Wellington, lies at the base of the Extension conglomerate and rests on the East Wellington sandstone. The Newcastle occurs at the base of the Newcastle formation, and the Douglas is contained in the Newcastle formation. Another small seam called the Little Wellington overlies the Wellington locally at a distance of 20 to 50 feet. The Little Wellington was mined at the Old Wellington collieries, and is reported to have been mined at East Wellington within the limits of the Nanaimo map area.

The Wellington seam has been mined at East Wellington and Northfield, and is at present being mined by the Vancouver-Nanaimo Coal Mining Company at the New East Wellington mine. The seam was also mined farther to the south in the vicinity of Harewood plains, and is at present extensively mined by the Canadian Collieries (Dunsmuir) Company near Extension. They have four producing mines, the output of Nos. 1, 2, and 3 mines being brought to the surface through the Extension tunnel, Nos. 2 and 3 occurring on the southwest and upthrown side of a reversed strike fault of about 300 foot throw. The No. 4 mine is located 1½ miles to the southeast, and the seam is reached by a shaft 280 feet deep.

The Newcastle and Douglas seams, which are only from 25 to 100 feet apart, are usually worked together and have been extensively worked in the vicinity of Nanaimo. There are at present two producing mines operated by the Western Fuel Company. The largest output is from No. 1 shaft situated near the shore in the southern part of the city of Nanaimo. Their other mine, the Brechin, is situated on Pimbury point opposite Newcastle island. Only the Newcastle seam is mined at the Brechin mine, although the workings of the mine are connected with older workings in the Douglas seam. There has also been a large production from the Douglas seam south of Nanaimo, notably at Chase river, Southfield, and South Wellington. There is only one mine producing at present in this district, the South Wellington or Fiddick mine, operated by the Pacific Coast Coal Mines. South of Chase river the Newcastle seam, although it can be readily located, has not been worked and appears to be of doubtful value.

The coals of the various seams, although having their individual characteristics, are, as a whole, much alike, and furnish a bituminous coal of fair grade, the amount of fixed carbon in the best quality ranging from 50 to 60 per cent and the percentage of ash from 5 to 10 per cent. The most striking feature of the seams is their great variability in thickness and character. The thickness varies from nothing to over 30 feet, sometimes within a lateral distance of less than 100 feet. This variation is caused by irregularities in either the roof or floor, and occasionally in both. The Wellington seam rests on a firm sandstone floor which is fairly regular, although a few sharp rolls do occur in it. The roof, however, is very irregular. The average thickness of the Wellington seam is from 4 to 7 feet, but the seam occasionally pinches down virtually to nothing and then suddenly thickens to 10 or 12 feet. The floor may be nearly smooth, but the roof may show a very sudden roll which is sometimes even overturned so that there is an overlap of several feet. Invariably at the thin places or pinches in the seam the coal is dirty and slickensided, while in the swelled out portion it is clean and unbroken. It appears, therefore, as if the variation were due in large part to a folding which affected the coal seams when the clean coal was in a pasty condition. This conclusion is especially well substantiated in another part of the Wellington seam where it is composed of several sub-seams separated by dirty slickensided coal, or as it is called locally, 'rash.' In the deposition of the seam conditions in which the carbonaceous matter alone was deposited must have alternated with those during which a large amount of silt was deposited with the carbonaceous matter. When the seam was folded the clean coal was apparently forced away from the tight bends where the folding caused an increase in the vertical pressure and left the seam at these places composed almost entirely of dirty slickensided coal or 'rash.' The clean coal flowed to a point where there was a corresponding relief of vertical pressure forming a swell in which, except for the 'rash' at the top and bottom, the seam consists of clean bright coal. Besides the barren places or 'wants' of this nature there are large 'wants' due solely to the silting which must have persisted throughout the period of coal formation.

The coal of the Douglas seam is, as a rule, dirtier and more variable than the Wellington coal, and contains irregular partings. The pinches and swells are caused by irregularities of the floor, the roof being fairly smooth. The seam varies from nothing to 30 feet in thickness and averages about 5 feet, although over a large area the average thickness of the mineable coal is between 3 and 4 feet.

The Newcastle seam is more regular than the Wellington or Douglas, but is thinner, varying from 20 to 45 inches where mined, and contains more numerous and regular partings. It is also less extensive in area than the other two seams.

The coal output of the district for the year of 1910 was 1,094,765 long tons,[1] which is slightly over one-third of the entire production of British Columbia.

### SAND AND GRAVEL.

The stratified deposits which occur in the south central part of the area, that is the delta deposits built up at the former mouths of the Nanaimo River and Haslam Creek valleys, furnish an abundant supply of sand and gravel. Except in a very limited way, these have been quarried only near the various railways for filling and grading purposes on the railway. The deposits could be used for all other purposes to which sand and gravel may be put. But although they could be quarried cheaply they are not favourably situated for cheap water transportation to the city of Vancouver, the chief market at present for sand and gravel.

### CLAYS.

The surface clays of the Nanaimo map area are, as a rule, very sandy, and have been utilized only to a small extent for the manufacture of common brick. Brick has been manufactured from the surface clays underlying the marshy flat bordering the Millstone river midway in its course, but at present no brick is being made. There are other localities where common brick could be manufactured from the

[1] W. Fleet Robertson, Rept. Minister of Mines, British Columbia, 1910, pp. K 183-K 197.

surface clays, but, as stated, by far the greater number of the surface clays are sandy and non-plastic and would make a weak brick of an inferior grade.

The various shale horizons of the Nanaimo series are also possible sources of clay for the manufacture of brick and of various kinds of semi-porous ware and stoneware. The greater portions of the various shale horizons, notably those of the Haslam, Cedar District, and Northumberland formations, are very sandy and of very low plasticity. They also contain too large a percentage of iron and lime to be considered fireclays, as they are sometimes called. The shales of the other horizons are very sandy and impure and may be left out of consideration. Certain portions of the Haslam shales, notably an horizon about 100 feet below the East Wellington sandstone, and to a less extent, small horizons in the Cedar District shales, are comparatively plastic and may be used in an auger machine or press for the manufacture of brick and tile and cheaper grades of stoneware. In East Wellington, just to the west of the area of the Nanaimo sheet, the shale from the upper part of the Haslam formation has been tested and the products of the tests are apparently of good grade.

STONE.

Some of the sandstones of the Nanaimo series furnish a building stone of fair quality. Three of these sandstones have been quarried, the Protection, the DeCourcy and the Gabriola. The Protection sandstone has been quarried on Newcastle island, and a small amount has been quarried in the city of Nanaimo, the latter quarry having been abandoned for some time. The Newcastle Island quarry is situated on the west shore opposite Pimbury point. A single bed about 16 feet thick has furnished most of the sandstone. The sandstone is typical of the Protection formation. It is greyish white in colour but weathers quickly to a dirty or brownish grey, and is composed chiefly of quartz fragments coated with kaolin. The rock is rather friable and weak. It is not regularly or greatly jointed, and irregular blocks as large as 4 feet × 6 feet × 3 feet have been quarried. The sandstone can, however, be easily cut. Sandstone for building stone has been the only product. The quarry has not been in operation for a few years.

The DeCourcy sandstone has been quarried at Jack point, east of Nanaimo. It has been quarried from two beds of massive sandstone separated by about 5 feet of sandy shale and shaly sandstone. It is a medium to coarse-grained, light greenish-grey sandstone, weathering to buff. It is composed chiefly of rounded quartz grains with a large percentage of feldspar and volcanic fragments. The fresh rock is strong although rather soft, but hardens with seasoning. The bedding is regular but the cross joints are irregular. The joints are few, and as large blocks as can be conveniently handled can be quarried. Sandstone for building stone has been the only product. The quarry was not in operation during 1911.

The Gabriola sandstone is quarried at North Gabriola on Gabriola island. The quarries are situated in a 25 foot bed of grey, coarse-grained siliceous stone in which are many concretions ('boulders'). It weathers to a darker and more brownish grey. The stone is strong and hardens with seasoning. There is no regular system of jointing, but large blocks may be obtained. The numerous concretions are its chief disadvantage. Sandstone for building stone has been the only product, but the quarry has not been in operation for a few years.

Up to the present time there has been no commercial production of crushed stone from the Nanaimo map area. The rocks of the Nanaimo series are of little value as sources of crushed stone, but the less altered and less fractured volcanics of the Vancouver group afford a material of fair grade. Stone of this quality conveniently situated for shipping is to be found north of Departure bay.

### LIME.

The impure limestones or calcarenites of the Haslam formation, which are exposed on the north shore of Departure bay, have been opened up by a test quarry to obtain material to be burned for lime, but the percentage of lime, 42·41 per cent, equivalent to calcium carbonate 75·73, is too small for the rock to be used for lime, and since the calcium carbonate is mixed largely with quartz sand the rock is not suitable for the manufacture of cement.

### METALLIC DEPOSITS.

The crystalline rocks of the Nanaimo area are greatly fractured and sheared, and many of the shear-zones are impregnated with pyrite and chalcopyrite. A few prospects have been located on these mineralized shear-zones, but the bodies are too low grade to be of any commercial value. The granodiorite of Mt. Hayes is cut by aplite and quartz veins. Both kinds of veins are mineralized, the former very sparingly; but the latter contains chalcopyrite and bornite in attractive amounts. Molybdenite is also an accompanying metallic mineral. One of these veins on the Thistle claim has been very thoroughly and carefully prospected, but the vein is too small to be commercially productive. It is from 2 inches to 1 foot in width, but it branches, and the branches thin out to nothing. The average width is a little more than 4 inches. It follows the chief or master jointing in the granodiorite and is closely associated with the aplite veins.

## II

## NOTES ON THE GEOLOGY OF THE COMOX AND SUQUASH COAL FIELDS, VANCOUVER ISLAND.

The Comox and Suquash coal fields were visited by the writer only in order to compare their geological conditions with those existing in the Nanaimo field, and, therefore, only a few notes can be given concerning them, but they may serve to show some of the similarities and differences of the various coal fields.

### Comox Field.

In the Comox field the coal is found in several seams that occur in a sandstone formation closely resembling the Protection formation of the Nanaimo series. Three of the seams have been mined. The formation, which may be called the Comox formation, consists chiefly of a white or greyish-white sandstone, composed largely of rounded quartz grains with a coating of kaolin, and with accessory chloritic micas. Interbedded in the sandstone are thin beds of carbonaceous sandy shale, with which the coal is usually associated. The formation has a maximum thickness of about 800 feet and rests directly on the metamorphic volcanics of the Vancouver group. It is overlain by a thick group of shales, called the Trent River shales, which are very much like the Cedar District shales that overlie the Protection sandstone in the

Nanaimo district. The sediments of the Comox basin have a much simpler and more regular structure than those of the Nanaimo basin, and form, in general, a simple monocline with a low uniform dip of about 10 degrees to the northeast. The coal seams are more regular than those of the Nanaimo basin, and must be the result of a more uniform condition of sedimentation, although a similar uniformity of conditions appears to have existed in the Nanaimo basin during the deposition of the Protection formation. However, the coal seams of the Comox district show, but to a less degree, the pinching and swelling and sharp rolls so characteristic of the Nanaimo coal seams. Large 'wants' due to a replacement of the coal by silt are probably more frequent in the Comox field. One peculiar feature met with in the Comox field is not met with in the Nanaimo field. The lowest seam of the former field occurs very near the base of the Comox sandstone, and as the Comox basin resembles the Nanaimo basin in that the crystalline rock surface, on which the sediments were deposited, was very irregular, many of the higher irregularities of the base remained above the depositional level when the lowest seam was deposited, and in consequence the lowest seam is frequently cut out by knobs of the underlying volcanics projecting through it. There is also another feature which is not met with in the Nanaimo field. North of the producing mine in the Comox field, between Browns and Puntledge rivers, a dacite porphyry has broken through the Comox sandstone and forms a flow or intrusive sheet, which overlies it. Near the dacite porphyry intrusion, which occurs near the outcrop of the lowest seam on Browns river, the coal is broken, partially coked, and rendered valueless. It is probable that the intrusion of dacite porphyry occurred in early Tertiary times and was a phase of the wide-spread Eocene volcanic activity.

## Suquash Field.

Conditions in the Suquash field are similar in many respects to those in the Comox field. Several seams of coal occur in a formation consisting chiefly of a grey, siliceous sandstone resembling that of the Comox and Protection formations. Interbeds of shale in the Suquash sandstone are, however, thicker and more numerous, and the shale is finer-grained and more plastic, some of it being a clay shale apparently of excellent quality. The structure of the measures is very regular and appears to be, in general, a broad syncline, striking about N. 60° E., and pitching slightly to the northeast. The dips are very low, less than 10 degrees, and although there are several local rolls there are no sharp ones. The measures are broken by a few normal faults of very small displacement. The coal seams are also very regular and do not pinch and swell as do those of the Nanaimo and Comox basins. The known seams are, however, thin, and the seam mined at present contains a large number of very persistent partings of various kinds. As in the case of the Comox basin, the coal measures have been intruded by Tertiary volcanic rocks, in the Suquash field by a trachyte porphyry. The trachyte porphyry occurs in the southern part of the basin, on Haddington island, where it is quarried extensively and furnishes the best grade of building stone on the coast. It probably occurs as an injected body.

The present knowledge of the Suquash field is meagre since the measures are largely drift-covered and only a few bores have been put down. The development work is also small in amount and confined to two seams. The basin is, however, somewhat larger than generally supposed, containing Malcolm and Cormorant islands and possibly extending southwest to Quatsino sound. On account of the uniformity and regularity of the coal seams and strata and their small amount of disturbance, the mining conditions are excellent. The coal is of good quality, burning with a long flame and little smoke. The large number of partings in the seam which is at present being worked, and the thinness of the other known seams are the chief disadvantages of the field. The conditions are such, however, as to greatly encourage further development and prospecting, especially in the lower part of the measures.

# I

## FRASER CANYON AND VICINITY.

(*Charles Camsell.*)

### Introduction.

What is usually known to travellers over the Canadian Pacific railway as the Fraser canyon is that part of the valley extending up from Yale to within 2 miles of North Bend, a distance of 24 miles; and although the canyon has been used as a means of entry from the coast to the interior of British Columbia for more than half a century, our information of its geology is very meagre and confined to the immediate banks of the river. Such information is contained in the reports of Dr. A. R. C. Selwyn in 1871-2, and of Dr. G. M. Dawson in succeeding years.

With the object of obtaining additional information, especially on the ore deposits of this district, a month was spent in it, from August 15 to September 15. While the writer spent most of his time in the canyon itself, his assistant, A. M. Bateman, worked in the basin of Siwash creek and his report on the geology of that district accompanies this.

### Topography.

The Cascade Mountain system, which lies to the east and south of the Fraser valley, is separated by that valley from the Coast system which lies to the west and north; and although these two mountain systems are topographically distinct and do not coincide with each other, they are structurally and genetically the same, and are strongly alike in general character. Their summits rarely exceed 4,000 feet in elevation in the immediate vicinity of the valley, and are usually rounded in outline and heavily wooded to the tops. A few miles back from the river they are much more rugged and higher in elevation, and occasionally reach above timber line. Although the annual precipitation is heavy, practically all the snow disappears from the mountains during the summer months.

The Fraser valley is here a deep, trough-like depression incised in the solid rock. It has an almost true north and south trend and cuts at a very sharp angle through the mountain axis.

In its upper part the valley is distinctly U-shaped, giving evidence of modification by glacial action, but in its lower part it is notched to a depth of 100 feet or more in the solid rock of the broader upper valley floor. This lower valley marks the depth of post-glacial deepening by stream erosion. Above and below the canyon portion the valley is wider, and notching of its old glacial valley floor is not so noticeable a feature.

The grade of the Fraser river above Hope is steep, and in the canyon portion is about 8 feet to the mile. Yale is the head of navigation, and no attempt is ever made to pass through the rapids and canyons above that point.

No large streams join the Fraser river in the canyon, the most important tributaries, Anderson river and Coquihalla, enter at the upper and lower ends, respectively. All the tributary streams entering the canyon do so through narrow canyons and in a series of heavy falls. They thus occupy hanging valleys, for the valleys above the falls are more broad and flaring.

The relation of Fraser canyon to geological structure is as significant as it is to physiographic control. The river runs in a canyon only when it lies within the limits of the Cascade and Coast Mountain systems, and its most marked canyon features are developed across a line which forms the axis of these two systems.

When the geology of the canyon is studied the fact becomes apparent that as soon as the river leaves the soft argillaceous rocks of the Caché Creek formation and enters the massive igneous rocks of the Coast Range batholith it enters the canyon and it continues in it for 25 miles to Yale. Below Yale, although the river traverses rocks of the same age and character, these rocks have been severely fractured along a north and south line, and this line of weakness is followed by the river, which cuts out a broad open valley in consequence.

From the very brief study given to it, the formation of Fraser canyon appears to be due in a minor degree to geological structure and relative hardness of the rocks, and to a greater degree to gradual uplift along the axis of the Coast and Cascade Mountain systems since the course of the valley was first defined, and to a continuance of that uplift even into post-Glacial times.

## General Geology.

The district described lies on the eastern border of the Coast Range batholith, and contains rocks referable to two main classes, namely, the granitic rocks of the batholith itself, and older stratified rocks that have been intruded by the batholith. A small unimportant area of Cretaceous is also present.

The following table of formations gives the various rock bodies that outcrop in the district:—

| | |
|---|---|
| Gravels and sands | Quaternary. |
| Sandstone, slate conglomerate | Cretaceous. |
| Batholithic igneous rocks | Post-Carboniferous. |
| Cache Creek rocks, embracing quartzite, argillite, limestone, and volcanic rocks | Carboniferous. |

### CARBONIFEROUS ROCKS.

Rocks referable to this formation, and called by A. R. C. Selwyn the Boston Bar series, are found in the Fraser valley from Anderson river northwards. They here form a narrow band lying between Cretaceous rocks on the east and granitic rocks on the west. From the mouth of Anderson river southward they lie on the east side of Fraser river at a distance never exceeding 2½ miles, as far as Saddle rock, where they cross the river to the west side, cutting across a sharp bend in the stream. They occupy most of the area of Siwash Creek basin, and are there locally described by Bateman as the Siwash series. They are exposed again on the east side of Fraser valley from Emery bar down to Hope.

The Carboniferous rocks consist of black and grey slates, cherty quartzites, small bands of limestone, and some serpentine. These rocks are everywhere more or less metamorphosed, but more particularly where they occur as inclusions in the batholith or on its contact, in which case they are altered to mica and chlorite schists, gneisses, and siliceous and garnet schists. They stand, as a rule, in vertical or highly inclined attitudes and their strike conforms, on the whole, to the general trend of the batholith, which is about N. 20° W.

At the northern end of the canyon these rocks were first called by Selwyn the Boston Bar[1] series and afterwards correlated by Dawson with the Cache Creek formation.[2]

### BATHOLITHIC IGNEOUS ROCKS.

The large igneous bodies of the district cannot all be referred to the same period of intrusion, but range from Jurassic to Tertiary. A part may be even earlier. No attempt has been made to define the areas of each. These are the rocks through which the Fraser canyon is cut, and they are exposed on both sides of the valley from the mouth of Anderson river to Hope.

The prevailing type, and that which is undoubtedly the oldest, is a coarse-grained granodiorite, somewhat gneissic in structure, and containing orthoclase, plagioclase, quartz, biotite, and hornblende. It contains many basic segregations. In places it is sheared and cut by small quartz veins, but it is usually fresh looking. A large shear zone traverses it in a north and south direction in the Fraser valley between Yale and Hope, and here the rock is shattered, leached, and otherwise much altered.

At least two igneous bodies of smaller dimensions are found in the district, and both are younger than and intrusive into the main body of granodiorite. One of these is a medium-grained biotite granite, and the other is a porphyritic granite. The latter variety, on account of its structure, is often used in the masonry of the railway line.

All of these rocks form part of the Coast Range batholith. They are accompanied by a host of dykes of both acid and basic composition.

### CRETACEOUS.

A long narrow band of Cretaceous rocks, consisting of sandstones, shales, and conglomerates, occupies the eastern slope of Fraser valley above North Bend, and extends southward up the valley of Anderson river. These rocks are referred to as the Jackass Mountain group in previous reports.[3] What is presumably an outlier of the same formation is exposed at the river's edge below Hope station. This is a coarse conglomerate containing boulders, largely of igneous origin, cemented together by coarse sand. Neither its structure nor relation to other rocks could be determined.

### QUATERNARY.

Superficial deposits of gravel and sand, deposited by stream action, are abundant in Fraser valley both above and below the canyon, where they form terraces on both slopes up to several hundred feet above the river bed. In the canyon itself such deposits are not very abundant because of the narrowness of the valley and the force of the stream. The lower of these deposits have been very important in the past because of their gold content, and have been worked in many places in this portion of the river. Sections of these lower deposits are well shown in the railway cuts, and in old placer workings. Most of them show from 10 to 20 feet of a coarse, free-washing gravel resting on a fine stratified sand which often exhibits cross bedding. The coarse gravel usually carried gold and was often mined for that metal.

## Economic Geology.

Deposits of some economic importance are found at three different localities in the vicinity of Fraser canyon, namely, at Silver creek, Gordon creek, and Siwash creek.

[1] G. S. C. Report of Progress, 1871-72, p. 62.
[2] Geol. Surv., Can., Vol. VII, p. 43 B.
[3] Geol. Surv., Can., Report of Progress, 1871-72, p. 60.
Geol. Surv., Can., Report of Progress, 1877-78, p. 107 B.

Siwash Creek district embraces a considerable area and is the most important of these. A separate report by A. M. Bateman on that district accompanies this.

### SILVER CREEK.

A group of three mining claims, known as the Jumbo group, is situated on the west side of Silver creek about 4 miles southwest of Hope. The claims lie in a steep narrow gorge at an elevation of about 1,100 feet above the sea. The country rock is massive granodiorite, in places sheared and traversed by fissures. The ore deposits lie in the fissure veins and have a width averaging about 8 inches. They contain dull-coloured arsenopyrite and a little chalcopyrite in a gangue of quartz, and carry gold as the principal valuable metal. The value of the ore in the fissures ranges from $10 to $60 to the ton. The claims are developed by three tunnels of varying length and several open-cuts.

### GORDON CREEK.

A group of ten claims staked for asbestos on a belt of serpentine, and owned by A. M. Herring, is situated on Gordon creek, about half a mile west of Fraser river.

The serpentine is associated with black slates, belonging to the Cache Creek formation, and is intruded on the west by a fresh-looking granodiorite, and on the east is in contact with sheared gneissic granite. It forms a band about 500 feet wide striking north and south. It is a dense black rock showing occasional grains of chromite, and so shattered and broken that good samples are hard to obtain.

The asbestos occurring in it is almost entirely slip fibre developed in the fracture planes. The only visible cross fibre is in very minute veins, which are not in sufficient quantity to be important. The shattered character of the serpentine at the point examined is not favourable for the development of good veins of cross fibre.

The development work on these claims consists of several open-cuts and a few short tunnels.

# II

## GEOLOGY OF A PORTION OF LILLOOET MINING DIVISION, YALE DISTRICT, BRITISH COLUMBIA.

### Introductory Statements.

Towards the close of the season a rapid reconnaissance was undertaken into the country west of the town of Lillooet and tributary to Bridge river. This reconnaissance was made more to determine the needs of that district for geological work and its importance from a mining point of view than to undertake any geological examination at tho time.

The Lillooet district lies immediately west of the Fraser river, between latitudes 50° and 51°. The town of Lillooet is the only place of importance in the district, and is reached in a day by stage either from Ashcroft or from Lytton, on the main line of the Canadian Pacific railway.

Considerable placer mining was at one time carried on in the Fraser valley and other valleys of the district, but this work is now almost abandoned. Quartz mining has been attempted at Cayoosh creek, and carried out to a small extent on ledges outcropping at Cadwallader creek and McGillivray creek, but the amount of gold extracted has not yet amounted to a great deal, for the reason that the owners of mines worked with the most primitive methods and virtually without capital.

No geological work had previously been carried out in this district by the Survey, and the only available authentic information is that obtained from the report of the Provincial Mineralogist for British Columbia, who made a brief reconnaissance of the district in the autumn of 1910.

Eight days were spent in making a rapid reconnaissance of the district with a view to obtaining information on which to base plans for more extended geological and topographical work. The route followed from Lillooet led up Seton lake to the Mission, thence northward across the divide to Bridge river and up that stream to Cadwallader creek. Three days were spent in an examination of the mines and region adjacent to Cadwallader creek, and the return to Lillooet made via Cadwallader and McGillivray creeks, and Anderson and Seton lakes.

## Topography, Etc.

The topography of the Lillooet district is mountainous and becomes increasingly so to the westward. The eastern edge of the district, embracing the Fraser valley and the lower part of Bridge river, lies in the Interior Plateau region. The central and western parts lie in the Coast range. These two features merge gradually into each other, the boundary between them following a line running northwest from the town of Lillooet. Mountain summits in the eastern portion of the district reach an elevation of a little more than 7,000 feet, giving a vertical relief of about 6,500 feet. In the western part of the district many points reach 9,000 feet and some exceed that elevation, and the maximum vertical relief is over 8,000 feet.

The district enjoys a dry, pleasant climate. It does not contain much land suitable for agriculture, and all of it is confined to the bottoms of main valleys. It is a favourite hunting ground for big game parties, and there is an abundance of grizzly bears, goat, deer, and sheep.

## General Geology.

The geological information obtained on this district is very meagre and only covers the line of route followed. The formations encountered are classified as follows:—

| | |
|---|---|
| Stream and glacial deposits<br>Volcanic ash | Quaternary. |
| Sandstone, argillite<br>Conglomerate | Cretaceous. |
| Quartzite, argillite, limestone and volcanic flows | Carboniferous. |
| Plutonic igneous rock | Post Carboniferous. |

### CARBONIFEROUS.

Rocks which are referred by Dawson to the Lower Cache Creek formation have been mapped by him at the town of Lillooet and as far westward as Seton lake. The same formation has been found to extend northwestward to Bridge river and westward to McGillivray creek. It is exposed on Bridge river from the big bend to Cadwallader creek, and, except where replaced by igneous rocks, extends from the mouth of Cadwallader creek southeastward to Anderson lake.

The formation consists largely of interbedded quartzites, argillites, and volcanic rocks, associated here and there with thin beds of limestone and some serpentine.

The rocks have, in general, a northwest strike and high dips. In detail they exhibit many close folds and are much fractured and faulted. They contain many small veins and lenses of quartz. They have been intruded by later granitic rocks and are cut by many dykes.

CRETACEOUS.

Rocks of this age are found in Fraser valley about a mile north of the town of Lillooet, and extend as a narrow band southward down Fraser valley and northward along the divide between the Fraser and the North Fork of Bridge river.

They consist of hard black argillites, dark-coloured sandstones, and some conglomerate. They have been much shattered and metamorphosed, and dip at high angles to the east.

IGNEOUS ROCKS.

The main body of the Coast Range batholith lies some distance to the west of the district examined, but many outliers from this body were encountered within the district. A broad band of granite extends from the north shore of Seton lake northwestward across Bridge almost to Tyaughton creek. Two other bodies of granite are found, one at Roaring creek on the north shore of Anderson lake, and the other on McGillivray creek. A small body of diorite, in which lie the most important ore deposits of the district, is exposed on the east side of Cadwallader creek near its mouth.

All of these bodies are elongated in a northwest and southeast direction and are intrusive into Carboniferous rocks. The age of the various bodies may be Jurassic or later.

QUATERNARY.

The surface deposits consist largely of glacial and stream deposits which are scattered widely over the lower parts of the whole district. The importance of the stream deposits depends on the presence in them of placer gold, and at many points on the stream, gold has been and is still being extracted from the gravels.

One of the most recent surface accumulations is a deposit of white volcanic scoriæ. This is found on the summits of many of the hills, on their slopes, and on the river benches of the Upper Bridge river and its tributaries. It is thickest on the summit of Tyaughton mountain, where it is said to be about 4 feet deep. At the mouth of Cadwallader creek a section of 18 inches in thickness is exposed in a recent cut. It is estimated that it covers at least 1,000 square miles of territory. The material is white in colour, and so light and porous that it floats on water. The grains vary in size from a fine powder to pieces 1 inch in diameter or more. It probably represents the outburst of some volcanic eruption in quite recent times.

ECONOMIC GEOLOGY.

So far as our present knowledge of the economic geology of the district goes, it contains two classes of ore deposits of proven value, namely, gold placer deposits and gold quartz veins.

Placer deposits have been worked for a number of years at different localities, the most important of which are on Cayoosh creek, Cadwallader creek, Bridge river, and on Fraser river. Recently, however, there has not been a great deal of activity in this class of mining, though a number of hydraulic leases and placer claims are still held with the avowed intention of working them.

No attempt was made by the writer to examine placer deposits, and only a very cursory examination was made of some of the gold quartz deposits, the intention being to make a more complete examination later.

The gold quartz deposits examined are situated on Cadwallader creek near its junction with the South Fork of Bridge river, and about 75 miles by trail and wagon road from Lillooet. They were discovered in 1897, and since 1898 have been worked every season.

The quartz veins outcrop on the eastern slope of Cadwallader creek at an elevation of nearly 4,000 feet above sea-level. The valley slopes are well forested and covered with a heavy mantle of drift which makes surface prospecting difficult.

The rock formation in which the quartz veins lie is a diorite consisting essentially of feldspar and hornblende. It has a stocklike form elongated in a northwest-southeast direction, and extends from Bridge river up to the Pioneer mine on Cadwallader creek, with a width of probably half a mile. In texture and relative proportion of its constituent minerals it is variable, and in structure massive, though traversed by a network of small quartz veinlets. The ore-bearing veins are of later formation than the veinlets and run in two well-marked directions, namely N. 20° E. and N. 80° W. magnetic.

The diorite is intrusive on the southwest into serpentine, and on the northeast into black and grey slates and andesites, which belong to the lower Cache Creek formation. The diorite probably belongs to the same period of intrusion as the Coast Range batholith, but is older than other plutonic igneous rocks in the district.

The ore deposits are in fissure veins, which traverse the rock in two main directions, namely N. 20° E. and N. 80° W. magnetic. They range in width from a few inches up to 6 and 8 feet, and are remarkable for their regularity in dip and strike. The N. 80° W. system of fissures appears much stronger than the other, and one fissure, at least, has been traced for about 1,500 feet along the surface.

The ore itself consists of a gangue of white quartz containing pyrite, tetrahedrite, and free gold sparingly disseminated through it. It often has a well-marked banded structure indicating deposition in an open fissure. The walls of the veins are clean and their faces show some movement along the plane of the vein. The wall rock has been somewhat altered by vein solutions, and contains much crystalline pyrite derived from the vein.

Free gold can be seen in many of the veins, and can be obtained by panning from almost any of the outcrops. In places the ore is exceedingly rich.

It would be difficult to give an estimate of the average value of the ore in this camp, because of its richness in certain places and leanness in others. It is safe to say, however, that some of the ore shoots mined must have yielded $50 or more to the ton, while at the same time no parts of the veins so far mined have proved to be entirely barren of gold.

The mineral claims on which quartz are known to outcrop and the number on each claim are as follows:—

| | |
|---|---|
| Lorne group | 5 veins |
| Blackbird | 4 " |
| Coronation group | 2 " |
| Pioneer | 2 " |
| Ida May | 2 " |
| Countless | 2 " |
| Forty Thieves | 1 " |

At the present time the only claims on which much development work has been done and from which gold has been extracted are: the Lorne group, the Pioneer, and the Coronation group. On all of these the gold was at first extracted from the ore by the crude method of milling in arrastres operated by water-power. More recently a 5-stamp mill has been erected at the Lorne, and a 10-stamp mill at the Coronation group. Both of these use water as the motive power.

It is stated by the owners of mines in the district that the yield in gold, since the discovery of the deposits in 1897, from the Lorne and Coronation groups alone, amounts to $155,000. The official report, however, of production from the whole Lillooet district up to 1910, is given by the Provincial Department of Mines as $137,744.

The conclusions drawn from the brief examination made of Cadwallader Creek district are that it contains some promising properties which, if not burdened with too heavy a capitalization, could be worked so as to yield a fair margin of profit; also that further prospecting in the diorite should disclose other gold-bearing quartz veins, because all the ground likely to prove productive has not yet been thoroughly prospected on account of the covering of drift.

A promising feature of the deposits is the number of known quartz veins—all of which carry some gold—and the strength and persistence of some that have been followed out. If the depth to which the veins will extend is proportional to the length of their outcrop, then there is hope that they will continue to considerable depth, since the country rock in which they occur is plutonic, and of deep-seated origin.

The diorite is the only formation in that district, from which gold ores have been mined, and it is stated that no workable deposits have yet been found in the slates and serpentine through which the diorite is intruded. Gold-bearing quartz veins, however, do occur in the slates, but they have not proved to be as strong and persistent as those in the diorite and are on that account less promising.

# III.

## GEOLOGY OF SKAGIT VALLEY, YALE DISTRICT, B.C.

### Introduction.

In July and part of August a geological reconnaissance was made of the Skagit district from the 49th parallel northward for about 15 miles. This region was the scene of considerable mining excitement during the spring of 1911 on account of the reported discovery of high-grade gold ores on Steamboat mountain. The examination of the district easily demonstrated that there was no legitimate reason for any mining boom in that particular locality, though there are some prospects in adjacent portions of the district.

In the geological work A. M. Bateman proved to be a very competent assistant and is responsible for virtually all the work in Siwash Creek basin. The topographic work done both in the Skagit district and at Siwash creek was undertaken by B. Rose and F. M. Allan.

The Skagit river rises in the Cascade mountain a few miles north of the International Boundary line, and after flowing southward into the State of Washington empties finally into Puget sound. That portion of its valley here reported on extends from the Boundary line northward to the mouth of the Sumallo river, a distance in a direct line of about 15 miles. A belt approximately 5 miles in width, whose median line is the Skagit valley, was geologically examined and mapped.

The area covered by this examination is, roughly, 75 square miles.

The district is at present not easily accessible and is most conveniently reached by pack trail from Hope, which is distant 23 miles from the north end of the district. Steamboat mountain, which was the centre of the mining excitement, is 15 miles farther down the valley. The cost of transporting supplies from Hope to this point is about 8 cents per pound. It is probable that the new Trans-provincial government wagon road, now being built, will pass through the middle of the district and make it more accessible.

Before the work of the present survey was made little was known of the geology or minerals of the Skagit valley. The only geological work known to have been done in the district previous to 1911 was that by H. Bauerman,[1] who was attached as geologist to the International Boundary Commission of 1859-61. His report, however, merely covers that portion of the valley in the immediate vicinity of the Boundary line.

In 1877 Dr. G. M. Dawson[2] reported on the country traversed by the Dewdney trail between Hope and Princeton, and skirted the northern border of this district.

Placer gold is known to have been found in small quantity in the Skagit river as early as 1858,[3] but the quantity was so small that no serious attempts have ever been made to mine it. In 1879 some fairly rich placer ground was discovered on Ruby creek, a tributary of the Skagit river, in United States territory, and, since the easiest means of access to that region was through Canadian territory from Hope, many prospectors passed through that portion of the valley now reported on. It is significant that no discoveries either of placer or lode metals are reported to have been made in it at that time.

In August, 1910, announcements were made in the Vancouver daily newspapers of the discovery by two prospectors, Greenwalt and Stevens, of high-grade gold ores on Steamboat mountain in Skagit valley. This announcement at the time created little stir in mining circles, and it was not until later in the season, when samples were exhibited which were stated to have been brought from that locality, that much interest was taken in it. After the winter had come on and that district was deeply buried in snow, a boom was gradually worked up with the aid of the press and purely on the word of the original locators. Speculators then began to go into the district or to send in men to locate claims for them. By the spring, at least 1,200 mineral locations had been made in the surrounding country, three townsites staked out, and hotels, stores, and other buildings erected for the carrying on of business.

Early in the summer of 1911 owners of mineral claims and others who had bought shares in the numerous companies floated began to realize that it was time other opinions than those of the original locators were obtained on the properties. Expert advice was then sought, but almost a year had already elapsed since the discovery was first announced, and much money had already been expended in various ways. On the mineral claims, which were the primary cause of the excitement, strongly adverse opinions were expressed as to their value, and work was discontinued by the owners. In the meantime Greenwalt and Stevens had disappeared.

Although it was becoming apparent by the time the survey was begun in the Skagit district in July that the possibilities of the district had been very much overestimated, there was still some prospecting being done and other discoveries were being made which might prove of permanent value. It was thought advisable, therefore, to carry out the survey as originally outlined and make a geological examination of Steamboat mountain and the adjacent district.

The principal results of the survey have been to prove that the original Steamboat Mountain claims did not contain the high-grade ore that they were stated to contain, or indeed any ore at all, and that there was no legitimate reason for the boom that took place over this district.

The only value of such a boom consists in the information that has been obtained by prospecting the surrounding country and in the discovery of certain deposits in

[1] G. S. C. Report of Progress, 1882-83-84, p. 5 B.
[2] G. S. C. Report of Progress, 1877-78.
[3] G. S. C. Report of Progress, 1876-77 p. 113.

the northern part of the district that may possibly prove to be of some importance. It is doubtful, however, whether the results are worth the price.

The Steamboat Mountain incident illustrates the value of having independent and reliable expert advice on mining properties, and it cannot be too strongly urged on would-be-investors in mining property the importance of obtaining such advice.

## General Character of the District.

The Skagit district lies entirely within the limits of the Cascade Mountain system, and the Skagit-Klesilkwa valley forms the dividing line between two of the ranges which constitute that system, namely, the Skagit and the Hozameen ranges. The Skagit range lies to the west of the valley and the Hozameen range to the east.

At the International Boundary line the highest points in the Hozameen range exceed 8,000 feet in elevation, but in the northern part of the range the summits are not quite as high.

In the Skagit range the highest points are also in the southern part of the district, where some peaks reach an elevation of 9,000 feet. Both of these ranges are characterized by rugged broken topography, and hold, especially on their northern slopes, many mountain glaciers and snow fields.

The maximum vertical relief in the district is somewhat over 7,000 feet, rising from an elevation of 1,750 feet in the Skagit valley.

From the Boundary line up to the Klesilkwa river the Skagit occupies a broad U-shaped valley averaging about a mile in width, through which the stream meanders with a comparatively easy gradient. Above Klesilkwa river the valley becomes very narrow, the slopes are steeper and the grade of the stream is greatly increased.

Klesilkwa river is the chief tributary of the Skagit, and flows in a broad U-shaped valley similar to that of the lower Skagit. The width of the valley is about three-fourths of a mile, and its gradient is very low. This valley is the continuation of the lower broad Skagit valley, and from information gathered the same characteristics continue to the head of the Klesilkwa and down Silver creek to the Fraser river. This feature forms the most natural dividing line between the Skagit and Hozameen ranges in their extension north from the International Boundary line.

The streams tributary to the Skagit and Klesilkwa rivers in this district are all short and descend quickly to the main streams. Some of them rise in glacial cirques and most are fed from melting snows.

The Cordilleran ice sheet overrode the whole district up to an elevation of 7,000 feet and left its traces in a modified and subdued topographic outline. Above that level the topography is more rugged.

Valley glaciation has also left its traces in developing a U-shape in the trunk valleys and in facetting the ends of projecting ridges.

A number of well-marked gravel benches can be identified on the slopes of the Skagit and Klesilkwa valleys up to an elevation of 1,000 feet above the stream.

The climate of the Skagit valley is more nearly that of the Pacific coast than of the Interior Plateau. This is evident in the forest growth which is very dense in the valley bottoms and for some distance up the mountain slopes. The elevation of the timber line is approximately 7,000 feet above sea-level.

No ranching or farming was being carried on in the district during the summer of 1910, and only at two points—Whiteworth's and Gordons—have any attempts been made to follow these pursuits on anything but a very small scale. This is due not so much to the unsuitability of the region as to the difficulty of access.

## General Geology.

The geological formations occurring within the Skagit district range from Carboniferous to Quaternary and embrace some igneous rocks as well as sedimentary.

They are, on the whole, fairly well exposed, but on account of the nature of the survey their boundaries have not been very accurately defined. They are classified as follows:—

| | |
|---|---|
| Surface deposits | Quaternary. |
| Skagit volcanics | Tertiary? |
| Granodiorite<br>Granophyre and other intrusives | Mainly Tertiary. |
| Pasayton formation | Lower Cretaceous. |
| Hozameen series | Carboniferous. |

HOZAMEEN SERIES.

This series was so named by Dr. R. A. Daly and first described at the International Boundary line, where it is found exposed on both slopes of Skagit valley. From the Boundary line it is exposed continuously on both sides of the valley northward as far as the mouth of Sumallo river. On the east it passes within a few miles underneath the Pasayton formation, and towards the west it extends for an unknown distance until cut off by later igneous intrusives belonging to the Coast Range batholith.

The Hozameen series consist of cherty quartzites, argillites, some limestone, and much volcanic material. The quartzites are thin-bedded, fine-grained rocks, usually bluish-grey in colour. They are generally fractured at right angles to the bedding planes, and are traversed by small veinlets of quartz. The argillites are generally dark coloured, and thin-bedded, and have often been so compressed as to become phyllites. The limestones at the south end of the district occur in narrow bands and are often crystalline, but to the north they are more massive and frequently show thicknesses of several hundred feet. The volcanic rocks are flows and breccias of a dark green colour and an andesitic composition.

A section of these rocks as exposed on the valley side, near the mouth of Sumallo river, shows the following succession:—

| | Feet. |
|---|---|
| Andesitic flows | 400 + |
| Interbedded quartzite and argillite, about | 1,500 |
| Massive blue and white limestone, about | 700 |
| Impure limestone, argillite, and breccia | 1,000 + |

The rocks of the Hozameen series have all suffered a great deal of deformation and metamorphism. The strata dip at high angles and have been folded into a series of anticlines and synclines striking and plunging towards the south. They are all much fractured and frequently faulted, and in detail the thin-bedded rocks show close folding and contortion.

The Hozameen series is overlaid unconformably by the Pasayton formation, with which, in places, it forms a faulted contact. It also exhibits an unconformity with the Skagit volcanics. It is intruded by granodiorite, and granophyre, and cut by many granite and syenite porphyries and lamprophyre dykes.

Although no fossils have been found in the Hozameen series, their lithological characters and structure are so strikingly like those of the lower Cache Creek rocks that the writer has little hesitation in correlating them with those rocks. Apart from that they have been traced almost continuously along their strike northward to the Fraser river, where they join with rocks that have been referred by Dawson to the lower Cache Creek formation.[1]

PASAYTON FORMATION.

The Pasayton formation occupies the whole of the eastern border of the district, and extends from the Boundary line northward to Cañon creek. Its western border

[1] G. S. C. Vol. VII, page 43 B.

follows along the crest of the hills which form the eastern edge of Skagit valley, and is in direct contact with the Hozameen series throughout.

The formation contains siliceous and feldspathic sandstones, coarse conglomerates, black and grey argillites, and at the base a thick flow of volcanic rock of andesitic composition. The whole formation has been estimated by Daly to have a thickness of over 30,000 feet.

The strike of the beds is on the average slightly west of north, and the dip. which in this district is always towards the east, is usually about 45 degrees or more. Minor folding has taken place in the formation, and faulting is common.

The Pasayton formation is traversed by many dykes and sheets of granite and syenite porphyries, and has been intruded by a body of granophyre. Its relation to the granodiorite is clearly shown by an intrusion of the latter into it. With the Hozameen series it shows a faulted contact, or in places an unconformity.

The age of the Pasayton formation has been determined from fossils found in it at different points. Daly places it in the lower Cretaceous from fossils collected at the Boundary line. The lower Cretaceous fossil, *Aucella piochii*, was this year obtained from these rocks on Lightning creek, and last year *Prionocyclus* was obtained from Mamloos creek to the east of the Skagit district.

### GRANODIORITE.

Plutonic igneous rocks are only represented in the district by granodiorite. which occurs in two separate bodies at either end of the district. The southern body is dyke-like in shape, and extends from the mouth of Galena creek northwestward towards the upper waters of Klesilkwa river. The northern body is exposed on the north side of Sumallo river and in the angle between that stream and the Skagit.

The granodiorite is a light-coloured, medium-grained rock, containing orthoclase, plagioclase, quartz, biotite, and some hornblende, with accessory magnetite and titanite. It is quite fresh and unsheared.

Both bodies of this rock are intrusive into the Hozameen series; and the northern one cuts the Pasayton formation as well, and is consequently younger.

### GRANOPHYRE AND OTHER INTRUSIVES.

The dyke rocks of the district include lamprophyre, diabase, granophyre, syenite. and diorite porphyries. The diorite porphyries were, in many instances, thought to carry gold and were covered by mineral claims. Assays, however, proved them to be barren. They are all much altered and decomposed, but are seen in the thin section to consist of plagioclase, feldspar, chlorite, and calcite.

Granophyre occurs as a large sill about 500 feet thick, intrusive into the Pasayton formation at the head of Twentyfourmile creek. It is a fresh light-coloured rock of medium grain, containing quartz, feldzpar, biotite, and chlorite and titanite, with much secondary calcite.

### SKAGIT VOLCANICS.

A small area of these rocks is found at the Boundary line on the western side of Skagit valley. They consist of massive beds of volcanic breccia containing angular fragments of quartzite, andesite, and plutonic rocks in a cement of andesite. Associated with these are some andesite flows.

These rocks are fresh, and have been very slightly disturbed. The beds dip at low angles to the west, and rest unconformably on the upturned edges of the Hozameen series.

No conclusive evidence has been obtained as to their age; but from the fact that they are lying nearly flat and show no evidence of metamorphism they are probably of late Tertiary age.

### SURFACE DEPOSITS.

The bottoms of the Lower Skagit and Klesilkwa valleys are covered with a thick deposit of gravels, and patches of these gravels can also be seen clinging to the sides of the valleys up to an elevation of 1,000 feet above the stream. Glacial drift is found covering the surface of the district up to an elevation of 7,000 feet above the sea.

## ECONOMIC GEOLOGY.

Although the Skagit valley has been known to prospectors and explorers for a great many years, it has never been considered to be mineral-bearing until last year, when in August two prospectors, Greenwalt and Stevens, announced the discovery of rich gold ores on Steamboat mountain, a mountain formerly known as Nepopekum, or Lost Musket, situated on the east side of Skagit valley, about 10 miles north of the International Boundary line. A large influx of prospectors took place during the autumn and winter, and by spring the whole surrounding country was covered by mineral claims.

In the spring of 1911 development work on several of the claims was started, but was soon abandoned on account of the unsatisfactory results obtained. By July the district was almost deserted.

Some work, however, was carried out during the summer in the vicinity of the mouth of Sumallo river, where conditions were more promising.

The results of the examination of this district show that the deposits on and around Steamboat mountain do not carry gold, and that those at the mouth of the Sumallo river—known as Twentythreemile Camp—while being more promising, are of low grade.

### DISTRIBUTION AND CHARACTER OF THE DEPOSITS.

The deposits of the Skagit valley on which development work was done fall into three main divisions:—

(1) Quartz veins and porphyry dykes supposed to carry gold.
(2) Contact metamorphic deposits in limestone containing copper and gold.
(3) Silver-lead deposits.

Deposits of the first class are situated on Steamboat mountain and in the surrounding district, and were the primary cause of the boom in that region.

The rocks in which they occur belong to the upper part of the Hozameen series, which consists of thin-bedded, interbanded quartzites and argillites, small bands of limestone, and much volcanic material. They have been folded, fractured, and metamorphosed, and are traversed by dykes of diorite porphyry, diabase, and lamprophyre. They hold many short discontinuous lenses of white quartz which occupy the saddles of the minor folds. The quartz lenses, as well as the country rock, have been fractured, and pyrite has been deposited in the fracture planes. The mineralizing action appears to have been connected to some extent, at least, with the intrusion of the diorite porphyry dykes, which are also mineralized to a small extent by pyrite.

Deposits of this class are of no economic importance whatever, though much of the development work of the district was done on them.

The copper-gold deposits are situated at Twentythreemile Camp, near the junction of the Skagit and Sumallo rivers. They are also found in the Hozameen series, but in a lower horizon than that of the first class, where the limestone beds are thicker. These limestones have been altered in many places to hard compact lime-silicate rocks by the contact metamorphic action of many andesite and granophyre dykes.

The ore bodies have a very irregular outline, though, in general, following the strike of the andesite intrusives. Their boundaries are very indefinite.

The ore consists of a mixture of pyrrhotite, pyrite, arsenopyrite, chalcopyrite, and some magnetite occurring as bunches or scattered disseminations in a gangue of quartz and lime silicate minerals. These minerals are epidote, hornblende, pyroxene, wollastonite, and garnet. Beyond the borders of the main deposits are a few small stringers containing quartz with galena, pyrite, and arsenopyrite, apparently the hydrothermal end phase of the contact action.

The geological association, the irregular outline, and the intimate intergrowth of admixed sulphides indicate that the deposits are of contact metamorphic origin. The value of these deposits still remains to be proven, but it is certain that they are of low grade.

The silver-lead deposits occur at the head of Galena creek, near the International Boundary line, and are quite distinct from the others.

The country rock in which they are found is a flat-lying andesitic breccia of volcanic origin, which lies unconformably on the Hozameen series, and is probably of Tertiary age. The ore deposits are banded fissure veins cutting the breccia, and containing sulphides of lead, copper, iron, and zinc in a gangue of quartz. The deposits are valuable principally for their silver content, which, however, is not high.

## DESCRIPTION OF PROPERTIES.

### *Steamboat Mountain Gold Mines.*

This group comprises three claims located in June, 1910, on the west slope of Steamboat mountain, at an elevation of 3,950 feet above the Skagit river.

The development work consists of a number of open-cuts along the outcrop of a diorite porphyry dyke, and a tunnel 62 feet in length driven to cut the dyke below the surface. Lower down the slope a tunnel penetrates the hill for a distance of 120 feet, from which a cross-cut 18 feet in length has been driven along a lens of quartz.

The country rock consists of a series of interbanded quartzites and argillites. This is cut by a diorite porphyry dyke which is considered to be the ore deposit, and varies in width from 4½ to 8 feet. It is exposed along the outcrop for a distance of 350 feet, and is sparingly mineralized with pyrite and chalcopyrite.

The quartz lens exposed in the cross-cut of the lower workings occupies a small saddle in a fold of the country rock. Its greatest width is 7 feet and length 22. Both the lens and the adjacent country rock are mineralized sparingly with pyrite and chalcopyrite.

The following samples from this property were assayed in the laboratory of the Department of Mines:—

(1) Sample taken across the face of the porphyry dyke in upper tunnel—gold, none.
(2) Sample across quartz lens in lower tunnel—gold, none.
(3) Sample of mineralized country rock in lower tunnel—gold, none.

### *Yellow Jacket.*

This is a group of four claims, staked in October, 1910, on the east side of Skagit valley, opposite the mouth of Silver Tip creek. The claims lie in the quartzites, argillites, and volcanic rocks of the Hozameen series. Large boulders of a yellowish decomposed porphyry dyke rock are strewn over the surface, and these are considered to be the ore deposit. Samples of this rock taken for assay yielded no trace of gold.

### *Ella Group.*

This group of seven claims is situated on Red mountain and adjoins the Yellow Jacket on the south. The development work consists of a few open-cuts on a soft yellowish oxidized rock resembling that on the Yellow Jacket. Assays of this yielded no trace of gold.

### *Utah Group.*

This group of four claims is situated on the west side of the Skagit and about 900 feet above it, opposite the Yellow Jacket. A tunnel 37 feet in length has been driven in on a bed of oxidized ferruginous limestone. The limestone is cut by small stringers of quartz containing pyrite and chalcopyrite which are also scattered through the country rock. A sample from the tunnel containing quartz, calcite, pyrite, and chalcopyrite yielded on assay no trace of gold.

### *Diamond Group.*

This group, consisting of four claims, is situated on the west slope of Skagit valley, about a mile below the mouth of Sumallo river.

The deposits occur in an impure limestone which is cut by dykes of andesite and granophyre, altering it to a lime silicate rock. The ore body, as shown in the large open-cut, is roughly 40 feet in length and 26 feet in width, fading off on all sides into low-grade rock. Its general trend is parallel to that of an andesite dyke underlying it. The ore consists of a mixture of pyrrhotite, arsenopyrite, pyrite, and chalcopyrite in a gangue of quartz and the lime silicate minerals epidote, garnet, hornblende, and wollastonite. Some native copper appears in the fracture planes of the surface rock. Extending beyond the boundaries of the main deposit are a few small stringers, rarely more than 4 inches wide, of quartz holding galena, zinc blende, arsenopyrite, and pyrrhotite. Specially selected samples—one of clean arsenopyrite and the other of mixed chalcopyrite and pyrrhotite—were taken for assay to determine where the gold and silver values lay. The results show that the arsenopyrite only carries a trace of gold, while the chalcopyrite and pyrrhotite yielded 0·06 ounces in gold and 34·10 ounces in silver.

### *Horseshoe Group.*

A group of three claims under this name is situated on the south side of Sumallo river about a mile above the Skagit.

The country rock consists of massive, impure and crystalline limestones cut by diabase, lamprophyre, and granophyre dykes. The ore body, as exposed in an open-cut, lies in the limestone on the upper side of a diabase dyke. It is 12 feet in width and has been traced for over 150 feet along the strike. The ore minerals are pyrrhotite, chalcopyrite, and pyrite in a gangue of quartz and lime silicate minerals. The gold and silver values are low.

### *International Group.*

This is the oldest group of mineral claims at present held in the Skagit valley, having been staked in 1906. They are situated at the head of Galena creek within half a mile of the International Boundary line.

The country rock is an andesitic breccia which is traversed by a strong fissure running southwest up the creek bed. The fissure is filled with banded vein matter, consisting of successive layers of quartz, galena, and chalcopyrite, with the middle of the vein filled with pyrite, chalcopyrite, and quartz. The actual width of the fissure where exposed in the workings is 4 feet, but the wall rocks are altered and mineralized for a distance of about 6 feet on either side of the vein. The chief values are in silver and copper, gold being very sparing.

*Whipsaw Creek District.*

Whipsaw creek is a tributary of the Similkameen river, lying to the northeast of the Skagit district. Claims were taken up at the head of this stream in 1908 and 1909, and a certain amount of prospecting and development work done on them. They lie on either side of the main Dewdney trail and are most conveniently reached from Princeton, which is distant about 20 miles.

In this area a gneissic granodiorite is intrusive into hornblende and chlorite schists, which strike N. 20° W. and dip to the west. The granodiorite has produced considerable contact metamorphism in the schists and sends many apophyses into them. Both rocks are traversed by acid dykes.

The mineral deposits belong to one type, namely, fissure veins carrying lead and zinc. The veins are found in the schists in the zone of contact metamorphism, and occupy a cognate set of fissures striking N. 2° W. and N. 45° W. Fissuring and ore deposition are probably both connected with the intrusion of the granodiorite.

*The Lucky Pair Group.*—The Lucky Pair group consists of three mineral claims lying on the south side of Whipsaw creek. Most of the development work on this group was concentrated in a tunnel 230 feet in length. Owing to a miscalculation this tunnel does not cut the vein, which was afterwards found by a 10 foot cross-cut 45 feet from the tunnel entry.

The ore deposit is a well-defined fissure vein, 18 inches wide, in a zone of brecciation, cutting the schists and striking N. 45° W. The vein has a banded structure and is filled with zinc blende, galena, chalcopyrite, and pyrite in a gangue of quartz. The whole is greatly oxidized and much of the sulphides have been leached out. The deposit is of low grade and the chief valuable metal is silver.

*The Marian Group.*—The Marian group consists of five mineral claims located on the north side of Whipsaw, near its head. The country rock in these claims is granodiorite, in which are exposed three distinct veins, respectively 3 feet, 34 inches, and 12 inches in width. They all contain blende, galena, chalcopyrite, and pyrite in a gangue of quartz, and are much altered by surface oxidation. Samples taken for assay show the ore to be very low grade.

*The S. and M. Group.*—The S. and M. group adjoins the Marian group on the east and is developed by a number of open-cuts and three short tunnels. The country rock is a schist, the surface of which is very much decomposed, and holds hard nodules of ore. None of the tunnels have penetrated into the solid rock beyond the zone of oxidation.

# IV

## NOTE ON THE OCCURRENCE OF DIAMONDS AT TULAMEEN, AND SCOTTIE CREEK NEAR ASHCROFT, B.C.

At the beginning of the season the Tulameen district, where field work had been carried out the preceding year and where an interesting discovery of diamonds was made in the peridotite of that district, was again visited for the purpose of searching in the gravels of the streams and other places for diamonds of a larger size than those previously found in the solid rock. The season of the year at which the examination was made was not favourable for such work, because the streams were at high-water stage and the most likely gravels could not be reached. Nevertheless some tests were made both on the gravels in the stream beds and on the decomposed rock which was already known to carry diamonds. Concentrates obtained by panning from each of these localities were submitted to Mr. R. A. A. Johnston for examination, and in both samples Mr. Johnston was able to detect diamonds, not, however, of a commercial size.

In this connexion some work was also done towards the close of the season on the gravels of Scottie creek, a tributary of Bonaparte river near Ashcroft, where diamonds are known to occur under similar geological conditions; but here, also, no diamonds larger than those previously found in the rock in place were obtained from the gravels.

# GEOLOGY OF FRASER CANYON AND VICINITY, B.C. SIWASH CREEK AREA.

(*A. M. Bateman.*)

## Introduction.

During the past field season, work of a preliminary uature was carried on from August 22 to September 16, under the direction of Mr. Camsell, in the Siwash Creek district of southern British Columbia. The work consisted of reconnaissance areal geology based on a topographic sketch map, and a brief examination of the ore deposits.

The Siwash Creek district forms a part of the Yale Mining division in southern British Columbia, and is situated on the eastern border of the Coast range. It covers a portion of the drainage basin of Siwash creek, which flows into the Fraser river at a distance of 2½ miles above the town of Yale. The area forms a reetangle 6 miles long by 5 miles wide, the western side of which is bounded by the Fraser river.

Attention was first directed to the district some 50 years ago by the discovery of placer gold near the mouth of Siwash creek. Since the first period of operation, placer mining has been carried on in a desultory manner. At present, preparations are being made for the reinstallation of an hydraulic plant. The gold extracted from gravels has been estimated at about $1,000,000, but information is too unreliable to bear much weight.

Quartz prospectors followed up the placer miners, and in 1891 and 1892 mineral claims were staked around Siwash Forks. Little work was done until 1896, when a 3-stamp prospecting mill was erected, followed in 1905 by two larger mills. Interest was renewed in the district last spring, when several lodes were discovered containing free gold in quartz; but development work has progressed slowly and the camp is still in the prospecting stage.

## Summary and Conclusions.

The rocks underlying the area consist of a metamorphosed sedimentary series represented by slates, garnet-schists, mica-schists, siliceous-schists, quartzites, and thin bands of crystalline limestone. This series is intruded by the Coast Range granitic batholith and its accompanying acid and basic dykes. A small remnant of volcanic tuff overlying the granitic rocks is exposed in one locality. Glacial deposits are found along the borders of the stream.

The gold, without exception, is associated with porphyry dykes and occurs in the porphyry itself, or in quartz veins along, or adjoining, the contact of the porphyry with slate. The gold is thus seen to be genetically dependent on the dykes, and the great number and wide distribution of these dykes makes it a promising field for prospecting.

Some of the gold deposits have rich surface showings, but are usually pockety, and the gold appears to have undergone considerable surface enrichment. Large superficial areas may contain a sufficient number of rich stringers and pockets to be worked commercially, while the others would only justify inexpensive mining methods.

## Topography.

The most prominent topographic characteristic of the district is its youth, as shown in the steeply-notched stream valleys, in contrast with a more gentle sloping, mature topography of the higher levels. The streams are short, with steep gradients in their upper courses, less steep in their intermediate parts, but plunging rapidly by a series of falls into the Fraser river. The range in elevation is from about 200 feet at the Fraser river up to 5,700 feet, the general elevation being about 3,600 feet —3,800 feet above sea-level. Along the canyon of the Fraser river which forms the western boundary of the sheet, the hills rise abruptly and are much cut up and deeply notched by small streams, giving the region a very broken character which becomes less marked towards the east.

The topographic break between the more gentle upper slopes and the lower steep slopes signifies uplift of this region in late geologic time. Glacial till, occurring as high as 400 feet above the streams which have cut through it, indicates that this uplift was accentuated in post-Glacial time. Siwash and Eightmile creeks have relatively easy gradients in their intermediate courses but enter the Fraser with a precipitant gradient. This sudden break in their profiles shows them to be hanging valleys.

An example of stream capture is illustrated in the case of the upper North Fork whose waters appear to have originally entered the Fraser by way of Eightmile creek, but which now flow into Siwash creek. At present the divide between the North Fork and Eightmile creek is only a few feet above the stream-level.

## General Geology.

The rocks and rock formations represented in the Siwash Creek area are provisionally classed as follows, in order of relative ages:—

Glacial deposits.
Volcanic tuff.
Hidden Creek series—sandstones and greywacke.
Acid and basic dykes.
Coast range granitic rocks.
Siwash Series—Slates, schists, and crystalline limestone.

### SIWASH SERIES.

The Siwash series covers the greater part of the area. It is largely made up of dense fissile slates, garnetiferous schists, mica schists, quartz schists, and thin bands of impure crystalline limestone. The general strike is to the northwest with steep dips to the southwest.

Along the Fraser river the series is much mashed and contorted, and it shows the effects of regional metamorphism. To a minor extent contact metamorphism has occurred where the series is intruded by the granitic rocks. The Siwash series is cut by the rocks of the Coast Range batholith, and is tentatively referred to the lower Cache Creek formation.

### COAST RANGE GRANITIC ROCKS.

The Coast Range granitic rocks outcrop on the eastern and western portions of the area, and in the central portion are intruded as sheets and dykes into the Siwash series. The batholithic invasion has taken place by the removal and engulfing of portions of the overlying series. The cover has been removed deep enough in the eastern part of the area to expose a zone of slates with intruded granitic apophyses grading into a zone of granite containing numerous inclusions of slate. The granite immediately surrounding the inclusions takes on a greenish hue, probably due to the partial assimilation of them.

The rocks range from light-coloured, medium-grained biotite granites to dark-coloured dioritic varieties. The dominant dark mineral is generally biotite, sometimes hornblende. Along the Fraser river they are mostly gneissic in character.

### DYKE ROCKS.

With the batholithic intrusion, injections into the overlying Siwash series took place in great profusion in the form of sheets and dykes. Some show foliation due to subsequent folding. The acid dyke rocks are nearly all light-coloured, fine-grained types, sometimes porphyritic, containing large phenocrysts of feldspar and locally known as "bird's-eye" porphyry. The different varieties are syenite porphyry, quartz syenite porphyry, granite porphyry, syenite aplite, and pegmatites. It is with the acid dykes that the ore bodies are associated.

The basic dykes are fine-grained, dark-coloured hornblendic varieties, or peridotites largely altered to serpentine. A sheet of serpentine with a width of over 400 feet, which can be traced for over 3 miles, is exposed on Siwash creek. It contains chromite and is the result of alteration from peridotite. It is locally called the "Nickle dyke," and is reported to contain nickel and cobalt, but some samples collected from the dyke, when assayed, were not found to contain either of these metals.

### HIDDEN CREEK SERIES.

This name has been applied for convenience in describing them to a series of arkoses and greywackes occurring in the vicinity of Hidden creek, a tributary of Eightmile. The rocks are made up of quartz, feldspar, calcite, and small fragments of andesitic and trachitic tuff. Their relation to the Siwash series and granitic rocks has not been definitely established.

### VOLCANIC TUFF.

One isolated outcrop of andesitic tuff occurs between the North and Middle Forks of Siwash creek. Only a small portion of it is exposed and its extent could not be determined, but it probably covers only a very small area.

### GLACIAL DEPOSITS.

The glacial deposits consist of unconsolidated till, made up of subangular boulders and gravels. They are found along the valleys of Eightmile creek, and the North, South, and Middle forks of Siwash creek, and occur as high as 500 feet above the present stream-level.

## Ore Deposits.

The deposits of proven value are of two classes, namely:—

(1.) Gold veins associated with porphyry dykes.
(2.) Placer gold deposits.

All the lode deposits so far discovered are situated in the area included between the three forks of Siwash creek, and in the vicinity of Hidden creek. The placer deposits extend from the mouth of Siwash creek up to the Forks.

The lode deposits that were examined are directly connected with the intruding porphyry dykes. They are found as quartz veins along the contact between the slate and porphyry, or as quartz veinlets traversing the porphyry and slates. The form is irregular and the gold appears to occur in small pockets.

The mineralogy of the deposits is simple. Pyrite, chalcopyrite, and small amounts of galena are contained in the quartz and porphyry. Small globules of quicksilver and lead carbonate are reported to have been found in pannings from three different properties. The gold appears as disseminated grains and as secondary flakes surrounded by iron oxides, associated with quartz veins in the slates and porphyry.

In only one place are the workings below the zone of oxidation, so that we are dealing almost entirely with superficial secondary minerals. The quicksilver and lead carbonate were probably derived from the sulphides, cinnabar, and galena. The pyrite has become oxidized, imparting a yellowish colour to the porphyry, and the gold has undergone concentration. It is to be expected then that the gold value will be greater on the surface than below the zone of oxidation.

The deposits owe their origin to the intruding granitic batholith. The porphyry dykes and sheets were later phases of the granitic intrusion injected into the Siwash series. Mineralizing solutions accompanied some of these dykes, and gold, sulphides, and quartz were deposited along the contact, and in fractures in the porphyry and slate.

### DESCRIPTIONS OF PROPERTIES.

#### *Ward Claims.*

The two Ward claims, owned by the Martel Mining Company, are located near the forks of Siwash creek. Work is being carried on in a large surface excavation, about 300 feet above the creek, from which two tunnels are being driven into the hill. Another tunnel 75 feet above the creek penetrates underneath the open-cut for 300 feet.

The ore is associated with quartz-syenite-porphyry dykes which intrude slates. The dykes vary in width from 1 foot to 50 feet, and constitute in the vicinity of the workings about 50 per cent of the rock exposed. They are irregular in outline and have forced apart and enclosed masses of slate. Five of these dykes are cut in the lower tunnel, two of which are sheared parallel to the schistosity of the slates, while the others are normal. The slates are hard, dark coloured, and fissile, and dip at high angles.

Ore is at present being removed from a shallow surface excavation 150 feet wide by 250 feet long. The portion mined consists of bunches and stringers of quartz, which occur along the contacts and in the adjoining rocks, and of mineralized porphyry. Because of the method of mining no estimate can be made of the proportion of porphyry that is milled.

The gold occurs in the quartz and porphyry in a finely divided state, generally coated with a film of iron oxide. Pyrite is scattered through the gangue, and occasional globules of quicksilver have been reported.

The ore is carried in 1-ton cars from the open-cut to the mill by means of a 500 foot gravity cableway, and the oversize from the grizzly passes through a jaw-crusher to the stamp-bins. After being crushed in two 3-stamp batteries it passes over amalgamating plates and then through blanket sluice boxes to the slime pond.

The following samples were assayed in the laboratory of the Department of Mines:—

| | Gold to ton. |
|---|---|
| 1. Representative sample of mineralized porphyry from open-cuts.... | $20 87 |
| 2. Representative sample of quartz with small amount of porphyry from ore bins.................. .................. ........... | 3 10 |

#### *Lake View Mines.*

This group of three claims was located in June, 1911, on Hidden creek, a tributary of Eightmile creek. Only a small amount of surface open-cutting had been done at the time of examination, but preparations were being made to carry on more extensive development.

The country rock is slate with an easterly strike and steep dip to the north. Intruding this and parallel to the schistosity is a syenite-porphyry dyke containing large phenocrysts of feldspar, and known as "bird's-eye" porphyry.

The porphyry dyke, with included quartz stringers, constitutes the ore deposit. The width of the dyke is 12 feet, its length is undetermined. On the surface it is yellowish coloured, soft, and decomposed. Three quartz stringers, from ½ inch to 2½ inches wide, cut diagonally across the dyke. The quartz stringers and the porphyry adjacent to the stringers carry the gold which can be seen readily with the naked eye. It appears as small grains disseminated through the quartz, and in greater amount as loosely adhering flakes and grains surrounded by oxide of iron along the fracture planes of the quartz and porphyry. A minor amount of quartz and galena is associated with the gold.

The following samples were taken and assayed:—

| | Value of Gold per ton. |
|---|---|
| 1. Sample of quartz and porphyry collected from the dump.. .. .. .. | $ 4 76 |
| 2. Representative sample of all quartz stringers exposed in upper-cut. | 14 28 |
| 3. Sample of porphyry remote from quartz stringers............... | 20 |

*Mount Baker and Yale Mining Company.*

This Company controls a group of eight claims located at the forks of Siwash creek, adjoining the Ward claims. They were staked in 1891, but practically no work was done on them until 1902, when a 10-stamp mill was erected and a number of open-cuts and tunnels started. The mill is not being operated at present and the entries to most of the tunnels have caved in.

The geological character of these claims is similar to that of the Ward group.

The ore was originally taken from a few small open-cuts and tunnels scattered in the vicinity. The tunnels, now inaccessible, penetrate porphyry dykes which contain only a little quartz. To the west of the mill a 50 foot tunnel penetrates a porphyry rock slide, but does not break the solid rock. Oxidized porphyry from the rock slide when panned showed colours of gold, but an assay of a representative sample gave only a trace of gold.

*Roddick Claim.*

The Roddick is the Discovery claim of the district, and is located on Roddick creek, 450 feet above the Marvel Mining Company's stamp-mill. A porphyry dyke, 25 feet wide, and containing numerous small quartz stringers, cuts the slates. An open-cut a few feet from the dyke exposes to view a parallel series of short bunchy lenses of quartz, ½ inch to 4 inches wide, included in the slates. Gold, associated with iron oxide, occurs in pockets with the quartz, and some remarkably rich specimens have been found. Samples taken for assay, however, only yielded a trace of gold.

*Dolly Varden Group.*

This is a group of three claims, staked in April, 1911, and located between the North and Middle forks of Siwash creek, and at an elevation of 1,700 feet above the creek. The development work consists of a number of open-cuts spread for 625 feet along the outcrop of a porphyry dyke. A tunnel is being driven to intercept the dyke.

A quartz vein varying in width from 12 inches to 24 inches occurs along one wall of the porphyry dyke, and the slate and porphyry on either side of the quartz vein are intersected by a network of quartz stringers. Pyrite, chalcopyrite, and galena occur in the quartz and porphyry. Colours of gold may be obtained by panning the surface material.

*Reciprocity Claim.*

This property is similar in occurrence to the Dolly Varden, and is located on what is probably a continuation of the Dolly Varden dyke. Specimens of quartz, rich in free gold, have been found in some of the small irregular pockets.

# BEAVERDELL MAP-AREA, YALE DISTRICT, B.C.

*(L. Reinecke.)*

## INTRODUCTORY.

The season of 1911 was spent in geological field work in the Beaverdell map-area, on the West Fork of Kettle river, British Columbia. The topographical map of this area was completed during the autumn of 1909 and the summer of 1910. Work began on May 25 and continued until October 12. Besides the mapping and examination of deposits within the area, about a week was spent in visiting promising claims on the Kettle and West Forks rivers outside the area of the map-sheet. Mr. W. J. Wright acted as field assistant during the summer.

Two summary reports have already been written on this area[1] and the final report is now being prepared for publication. Some idea of the general topographical and geological features of the area, as well as the economic deposits and the history of mining, can be obtained from the two summary reports mentioned above.

## TOPOGRAPHY.

The area examined is a part of the Interior Plateau system of British Columbia and lies along its eastern edge. Uplands of moderate relief are cut by steep-sided and often deep valleys. The maximum difference of elevation within the map is about 3,500 feet; the main valley flats are from 800 to 1,500 feet below the near-by hilltops. The greater part of the area is drained by the West Fork and its tributaries, while a small area in the southeastern corner drains directly into the Kettle river. One of the interesting phases of the topography is the part played by glacial débris in determining the direction of drainage in the uplands.

## GENERAL GEOLOGY.

A series of metamorphosed sediments and crystalline rocks occupies perhaps one-third of the area examined; they are intruded by quartz diorite and granodiorite batholiths, both of which cover extensive areas. Small patches of Tertiary volcanic flows and sediments are found in scattered localities over the map. The river bottoms are generally covered with unconsolidated alluvial deposits, while glacial debris is found in varying thickness everywhere in the district.

TABLE OF FORMATIONS.

| | |
|---|---|
| Pleistocene and Recent | River deposits, glacial till. |
| Miocene? | Basalt, andesite, and dacite flows. |
| Oligocene? | Dense white tuff, coarse sandstones, and conglomerates. |
| Jurassic? | Augite porphyrites, quartz porphyries.<br>Granodiorite.<br>Quartz diorite.<br>Diorite. |
| Pre Jurassic | Andesite stocks and flows.<br>Dense argillites.<br>Crystalline limestones.<br>Quartzites.<br>Green mica hornblende schists. |

[1] Summary Report of the Geological Survey Branch of the Dept. of Mines, 1909, pp. 118-122.

### PRE-JURASSIC.

The pre-Jurassic series consists of metamorphosed sediments of uncertain age, mica hornblende schists of igneous origin, and stocks and flows of andesite. A batholith of diorite was intruded into the sediments and andesites some time after their deposition. The upper surface of this intrusion was extremely irregular, due to the injection of molten matter into cracks in the roof above, and to the sinking of detached blocks of that roof into the diorite. A section of this roof, such as is now exposed in a great many places, gives a patchwork of sediment and crystalline, in which the two members are distributed in so irregular and haphazard a manner that their separation is, for practical purposes, impossible. The diorite has, therefore, been mapped with the older series.

Following this intrusion there was a period of crustal disturbance which brecciated and metamorphosed both the diorite and the older rocks.

### JURASSIC?

In Jurassic time there were further intrusions of batholiths of a grey quartz diorite, followed by a pink-white granodiorite. The latter was accompanied, or followed, by extensive intrusions of quartz porphyries and porphyrites. These two plutonic rock types seem to be in series with the first diorite intrusion. They have, however, not been metamorphosed to the same extent and lie in large masses easily separable from the older group.

The quartz diorite is a grey, medium-grained, and even-textured rock. It consists essentially of plagioclase feldspar, hornblende, biotite, and quartz, the latter in varying amounts. The feldspar ranges, from oligoclase to labradorite.

The granodiorite varies from pink to white, and is very often porphyritic, with large crystals of pink orthoclase. The orthoclase lies in a coarsely crystalline groundmass of quartz and orthoclase with some plagioclase and biotite. These two intrusive masses together occupy nearly two-thirds of the area mapped, and the granodiorite extensive areas outside of it.

### TERTIARY.

#### *Oligocene?*

The Tertiary sediments consist of beds of coarse agglomerate or conglomerate, overlain by coarse sandstone and dense white tuff. The conglomerate at the base contains pebbles of practically all the rocks of the older series. The tuff contains remains of land plants. There is probably 500 feet of these sediments in places. They lie unconformably on the older formations. There are about 4 square miles of this within the mapped area around Goat peak, and a small patch in the southeast corner near the Kettle river.

#### *Miocene?*

Basalts and andesites are the prevailing types of lavas. Basalt without olivine is often the latest flow, while a white andesite or dacite is very frequently the earliest. Intermediate in age is a series of dark grey and reddish andesites. Olivine basalt is more frequently found in small patches by itself. These Tertiary lavas occupy about 7 square miles in the northwestern corner of the map and occur as small patches in other parts of the area. They overlie the Oligocene? sediments unconformably at Goat peak and to the northwest of it.

RECENT.

### *Glacial Deposits.*

Glacial debris evidently at one time covered the whole of this area. It has since been considerably modified and cut away by erosion. Typical glacial deposits are not often seen, and then only in places where erosion has been exceptionally retarded.

### *River Deposit.*

The material deposited by the rivers is relatively coarse throughout the Upper West Fork valley. Fine alluvial material occurs only in small patches, generally near the river bed. A great part of the present river plain is made up of modified glacial drift. A series of river terraces are found along the sides of all the larger valleys. They indicate frequent changes in the rate of erosion, due perhaps to successive slight uplifts.

## ECONOMIC GEOLOGY.

During the field season an attempt was made to examine all the more important deposits of ore in the district. A short description of each of these will be given in the final report. No ore has been shipped from the Beaverdell area since the beginning of 1910. Last summer a small shoot of silver-lead ore was opened by Mr. W. H. Rambo on the Rambler claim. About 30 sacks of ore were taken from a pit 6 by 3 feet and 6 feet deep. This is close to a rich shoot from which $10,000 worth of ore is said to have been taken some years ago. The ore sacked should run well over $100 to the ton. and that part of the vein exposed, at the time of our visit, looked very promising.

Another development of immediate interest is the building of the Kettle Valley railway, which will connect Midway with Merritt. Last October rails had been laid on this line to a point within 10 miles of Beaverdell, and contracts had been let for the construction of about 30 miles beyond that place. In another year or so this road should be available for the transportation of ore to the Boundary smelters.

# FRANKLIN MINING CAMP, WEST KOOTENAY, B.C.

(*C. W. Drysdale.*)

## Introduction.

The Franklin camp is situated on the east branch of the North Fork of Kettle river, about 43 miles by wagon road in a northerly direction from Grand Forks. The Kettle Valley branch of the Canadian Pacific railway terminates at present at Lynch creek, some 20 miles up the valley from Grand Forks.

During the past field season a detailed geological map on the scale of 1,500 feet to 1 inch was completed. The Franklin map embraces an area of some 16 square miles and includes the most important mineral deposits of the region. Previous work of a less detailed nature was done in this area by R. W. Brock in 1900 and 1906,[1] and the geology and topography of Franklin mining camp are shown on the West Kootenay sheet mapped on the scale of 4 miles to 1 inch.[2]

The first mining claims located in Franklin camp were the Banner and the McKinley, which were staked in the summer of 1896. The locator of the Banner claim was Frank McFarlane, after whom the camp was named. The Gloucester and adjoining claims were located by Thos. Newby in the summer of 1898. These were followed by the White Bear in 1899; the Maple Leaf in 1902; the Evening Star in 1903; the Buffalo in 1904; the IXL in 1904, and many others.

The year 1906 saw the greatest activity in Franklin, when considerable development was carried on. Since then comparatively little prospecting and mining have been done.

The past season's field work was carried on with a view to determining the probable extent, value, and geological relations of the mineralized areas opened up in this camp.

Messrs. C. A. Fox and F. J. Alcock rendered most efficient service as field assistants.

## General Character of District.

The Franklin area falls within the Columbia Mountain system, which here has an elevation of 2,800 feet above sea-level in the valleys and 5,000 feet on the summits.

The district has a mature upland surface from 4,000 to 5,000 feet above the sea, and, except where lava cliffs occur, may be characterized as gently undulating with hills seldom rising over a few hundred feet above its general level. Many of the depressions on this old upland are occupied by stagnant ponds or "sloughs."

The main valleys which trench the upland have a north and south regional trend and vary in width from about 3,000 feet, as is the case in Franklin Creek valley, to over a mile in the main Kettle River valley. The valleys have steep, sloping sides converging to narrow bottoms with an average depth of over 1,500 feet.

The valley sides show the scouring and smoothing effects of glaciers, while their bottoms are largely filled with re-sorted glacial material which the rivers, since the retreat of the ice-sheet, have excavated in a series of step-like terraces. These river terraces of glacial outwash gravels have since then been deeply dissected by the

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[1] Summary Report, 1900, Geol. Surv., Canada, p. 70 A.
Summary Report, 1906, Geol. Surv., Canada, pp. 62-65.
[2] Map sheet No. 792, Geol. Surv., Canada.

rivers which have entrenched box canyons and ravines, leaving in some places the tributary creeks and "draws" as hanging valleys high above the water level of the main stream. These "hanging valleys" and "draws" are characterized by the presence of ribbon-like waterfalls and cascades at their confluence with the main valley.

Those portions of the district underlain by the coarse heterogeneous phase of the Kettle River conglomerate, present striking land forms in the shape of many hummocky mounds with outstanding pinnacles or "hoodoos."

The fall of the North Fork of Kettle river between Franklin and Grand Forks amounts to about 1,100 feet, giving the river an average grade of about one-half of one per cent.

There is sufficient water-power available for ordinary mining purposes in Franklin and Gloucester creeks as well as in the main Kettle river.

The average rainfall amounts to about 20 inches per annum, a large part of which falls as snow in the winter months. The summers are moderately warm and dry with cool nights, while the winters are severe with heavy snowfall, particularly on the western slopes of the mountains.

This region was once heavily wooded with fir, tamarack, spruce, white cedar, cottonwood, white birch, and poplar; but forest fires have swept over a large portion of the district and only isolated groves of good timber remain.

Black-tail deer are numerous, and beaver, owing to protective game laws, have become very plentiful. Black and brown bear, mountain lion or "cougars," and coyotes are less frequently seen.

## General Geology.

The rocks in this region are chiefly igneous, and, as no sections for microscopic study have been examined, only field terms are used in the following descriptions.

### TABLE OF FORMATIONS.

| System | Formation | Lithological character. |
|---|---|---|
| Quaternary | Superficial deposits | Gravel, sand, silt, boulder clay. |
| Miocene (?) | Midway Volcanic group | Pinkish pulaskite porphyry, dark basic dyke rocks—lamprophyres; quartz porphyry, and lavas ranging from basalt to andesite and rhyolite. |
| | Syenite | Pyroxenites (local term "Black Lead")—syenite. |
| Oligocene (?) | Kettle River formation | Conglomerate, grit, and tuff. |
| (?) | Monzonite | |
| Post-Jurassic (?) | Granodiorite | Massive igneous rocks from granite to diorite and in places sheared to gneiss. |
| Palæozoic (Upper ?) | Gloucester formation. | Crystalline limestone. |
| | Franklin group | Greenstone, altered tuff, jasperoid, and silicified argillite. |

DESCRIPTION OF FORMATIONS.

*The Franklin group* includes the oldest rocks in the district. It has been subjected to the metamorphic action of intrusive magmas of Mesozoic and Tertiary ages and to so many mountain-making movements that its record of sedimentation and vulcanism has been greatly obscured.

The group consists of impure grey quartzites, jasperoids, altered tuffs, greenstones in places porphyritic, and brecciated and sheared volcanic and intrusive rocks indicating a complex of igneous and sedimentary rocks in their original state.

The rocks of this group have a general strike a few degrees east of north and dip steeply to the west. In places they exist as down-hanging portions of an ancient roof suspended in the underlying granodiorite batholith—termed by R. A. Daly, "roof-pendants."

*The Gloucester formation* consists of light to dark grey crystalline limestone which occurs as irregular masses interfolded with the Franklin group. The limestone usually grades off into jasperoid and in a few places it has been entirely replaced by silica. These limestones are possibly of the same age as those occurring farther south, which Daly included in his Atwood series of Carboniferous age, correlating them with the limestones in Rossland mountains.

*The post-Jurassic (?) granodiorite* varies in composition from a mica or a hornblende granite to more basic rock types. Foliated structure is frequently developed in it. It underlies all the other rocks of the region and possesses igneous contacts, proving its younger age. Its border contacts are irregular and steep in character, widening downwards.

The massive and underlying character of the igneous rocks composing it defines it as a batholith, and after the fashion of other batholiths its plunging contacts are evidences of a wider development below, so that at the time of its origin the overlying rocks were in the nature of a roof resting on a molten magma.

*Monzonite.*—This is a medium to coarse-grained mottled rock. It is fresh looking, with dark pyroxene and dark brown mica with white and grey feldspar. It outcrops in two bosses, one at the base of Tenderloin mountain, and the other to the north of Franklin mountain. The monzonite is cut by dykes of pegmatite, and more rarely by others of the pinkish pulaskite porphyry type. In places it is sheared and brecciated, having magnetite and quartz developed along the planes of shear. The monzonite resembles closely the Rossland monzonite which R. W. Brock refers to the Mesozoic era.[1] Here, on account of its fresh appearance and lack of dynamic metamorphism as compared with the Mesozoic granodiorite, it has been tentatively referred to Tertiary time.

*The Kettle River formation*, which has a very strong development in this area, consists of a conglomerate with pebbles ranging from a few inches up to 2 feet and more in diameter. In places the conglomerate grades into well-stratified white to light grey grits and silts which display cross-bedding and current markings. In a few localities obscure plant remains were found in the shaly portions of this formation.

The zone of maximum deposition appears to have been near the junction of Franklin creek with the East Fork, where the conglomerate is very coarse and heterogeneous and is here exposed to a depth of 150 feet.

[1] Prelim. Rept. of Rossland, B.C. Mining Dist., No. 939, pp. 14-15.

This formation may possibly be correlated with the Coldwater group of Dr. G. M. Dawson lying to the south,[1] which occurs in several localities throughout the Boundary district, notably at Phoenix,[2] Baker mountain,[2] and west of Midway.

The age of this formation is Oligocene, as determined by the plant remains found in it.[3]

*Syenite.*—Intrusive into all the preceding formations is a syenitic rock characterized by elongated crystals of feldspar which lie usually parallel to each other. It occurs as an irregular mass ranging in character from a sill to a laccolith, and appears to be closely associated with the monzonite into which it is intruded.

The syenite varies in composition from the normal form to a phase rich in hornblende, black mica or biotite, and pyroxene crystals with which is associated copper sulphides. This phase or differentiation is consequently black in colour and is locally known as the "Black Lead." Where the syenite formation is narrowest, as in the northwest corner of the district, this differentiation is the best developed.

*Midway Volcanic Group.*—The Midway volcanic group here occurs as remnants of Tertiary lava flows, and is found chiefly on the hill tops. The rocks range from rhyolite to basalt and vary in thickness from 500 to 1,500 feet. Agglomerates, volcanic breccias, and vesicular, and amygdaloidal lavas are common. The borders of the exposures, as a rule, form prominent cliffs, at the bottoms of which caves occur in many places.

A prominent dyke rock, older than the above-mentioned lavas, is a pinkish porphyry (pulaskitet porphyry), locally known as "birds-eye porphyry," consisting largely of feldspar with biotite, hornblende, and pyroxene sparingly developed. In many places it becomes quite granitoid in texture and passes off into alkaline syenite. Similar pulaskite dyke rocks occur commonly throughout the Boundary district as at Phoenix and Deadwood, but in the latter localities are older than the local development of the lavas.[4]

The youngest dykes which, on McKinley mountain, cut through lavas, quartz porphyries, and conglomerates alike, are dark, soft, basic lamprophyres (minettes) made up largely of pyroxene and biotite. Some of the eruptives of this group appear to occur as sills along the upper border of the granodiorite batholith, between it and the rocks of the Franklin group, as exemplified in the quartz porphyry capping McKinley mountain.

*Quaternary.*—Superficial deposits. The recent deposits consist of glacial till grading from boulder to fine clay; scattered glacial erratics on hill tops; glaciofluviatile deposits in the form of terraces ("bench-lands") occurring at frequent intervals on valley sides from 5 feet to over 100 feet above the valley floors; and talus from cliffs and residual soil formed from the disintegration of rocks beneath.

## Economic Geology.

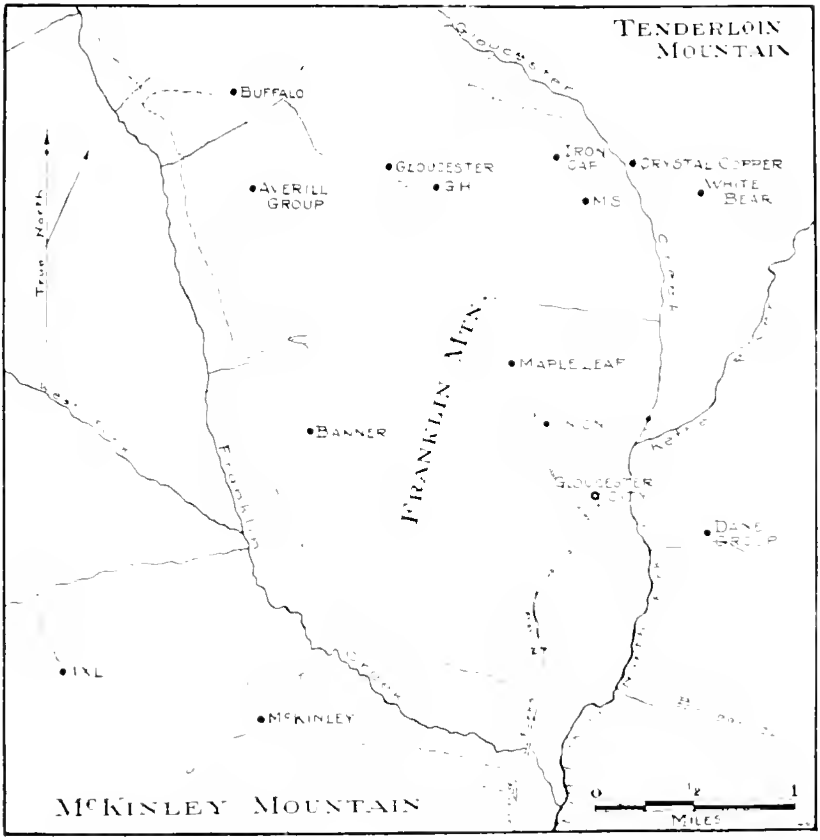
Development work was carried on this last summer on the McKinley property under bond by the British Columbia Copper Company. Besides this work done on the McKinley, assessment development work was carried on at the Dane group, Averill group, Union, Buffalo, and Royal Tinto claims.

[1] G. M. Dawson, Geol. Soc. Am., Vol. 12, 1901, p. 59.

[2] Summary Rept., 1908, Geol. Surv., Canada, pp. 65-66.
Geological and Topographical Map of Boundary Creek Mining district, B.C. Map 828, Geol. Surv., Canada.

[3] D. P. Penhallow, Trans. Royal Soc. of Canada, Geol. Surv., Canada, 1908, Report on Tertiary Plants of British Columbia, XIII, 1907, iv, No. 1013.

[4] Summary Rept., 1908, Geol. Surv., Canada, p. 66.




DIAG. 6. Location of principal mining properties, Franklin district, B.C.

The list of mining claims arranged in alphabetical order is as follows: Ajax, Aldie, Alert, Alpha, Alto Fr., Antelope, Athelstan, A.X.; Banner, Banner Fr., Big Cub, Black Bear, Blue Jay, Bryan, Buffalo, Bullion, Buttercup, Bystander; Columbia, Cottage, Crystal Copper; Doris Fr.; Eclipse, Eganville, Evening Star; Florence, Franklin; Gloucester, Gloucester Fr., G.H., Golden Age, Grande; Hanna, Hennekin, Hit-or-Miss, Homestake; Ida, Iron Cap, Iron Hill, IXL; Jumbo; Last Chance, Little Cub, Lucky Jock; Maple Leaf, May, McKinley, Montana, Montezuma, Mountain Lion, Munster, M.S.; Nakusp, Nellie, Newby Fr.; Old Dominion, Omar, Opher, Ottawa, Ouray; Pinto; Rio; San Francisco, Shelby, Standard; Thuot, Tiger, Tiger Fr.; Union; Verde, Violet Fr.; Wallace, Waverly, White Bear; Yellow Jacket; altogether 75 claims, all of which are Crown granted with the exception of the Blue Jay claim.

### MCKINLEY.

The McKinley property is located on the north slope of the McKinley mountain, about 1¼ miles west by pack trail from the crossing of Franklin creek by the road to Gloucester City. There are three distinct types of ore deposits on this property: galena-blende, pyrite-chalcopyrite, and magnetite types. The galena-blende type follows predominantly the limy portions of the mineralized zone, while the pyrite-chalcopyrite and magnetite types follow the siliceous portions, as a rule.

The mineralized zone is irregularly distributed and is always close to the Gloucester limestone which is interfolded with the Franklin group rocks.

The gangue minerals include garnet, epidote, chlorite, quartz, calcite, and actinolite. The rock and ore associations here resemble in many ways those occurrences at Phoenix, Deadwood, and other copper camps throughout the Boundary district, where the ores appear to be of contact-metamorphic origin.[1]

### MAPLE LEAF.

The Maple Leaf property, which has not been worked for four years, is situated on the east slope of Franklin mountain. The ore, consisting of copper sulphides and carbonates, is in the contact zone of the Tertiary syenite with the altered tuffs of the Franklin group, and the ore is chiefly confined to the syenite, in which it occurs as replacements along shear-zones. Work was carried on also in the basic differentiate from the syenite or "Black Lead" along the lower border of the syenite sill.

### BUFFALO.

The Buffalo claim, which is situated in the northwest corner of the map area, is one of the "Black Lead" claims; and here the differentiate of the syenite has copper sulphides disseminated through it in small quantities. The ore is not far from a monzonite contact, and both syenite and monzonite are cut by a northeast and southwest system of pulaskite porphyry dykes.

Similar so-called "Black Leads" occur on the Averill group, situated on the same contact but farther to the southeast, where bornite is associated with the chalcopyrite, and also on the Blue Jay claim adjoining the Buffalo to the southeast.

### BANNER.

On the Banner claim, one of the pioneer properties in the camp, no work has been done for some years. The ore is zinc-blende, galena, and chalcopyrite in a quartz gangue. The country rock is jasperoid and altered tuff of the Franklin group.

[1] Summary Rept., 1908, Geol. Surv., Canada, pp. 66-67.

GLOUCESTER.

The Gloucester property is situated on the Gloucester Creek slope of Franklin mountain. It was bonded by the Dominion Copper Company in 1906, and before that to the British Columbia Copper Company. No work has been done on it since 1906. The ore is chalcopyrite, pyrite, with a little molybdenite occurring in the contact zone between much brecciated grey granodiorite, which is largely calcified and silicified near the contact, and the Franklin Group greenstones.

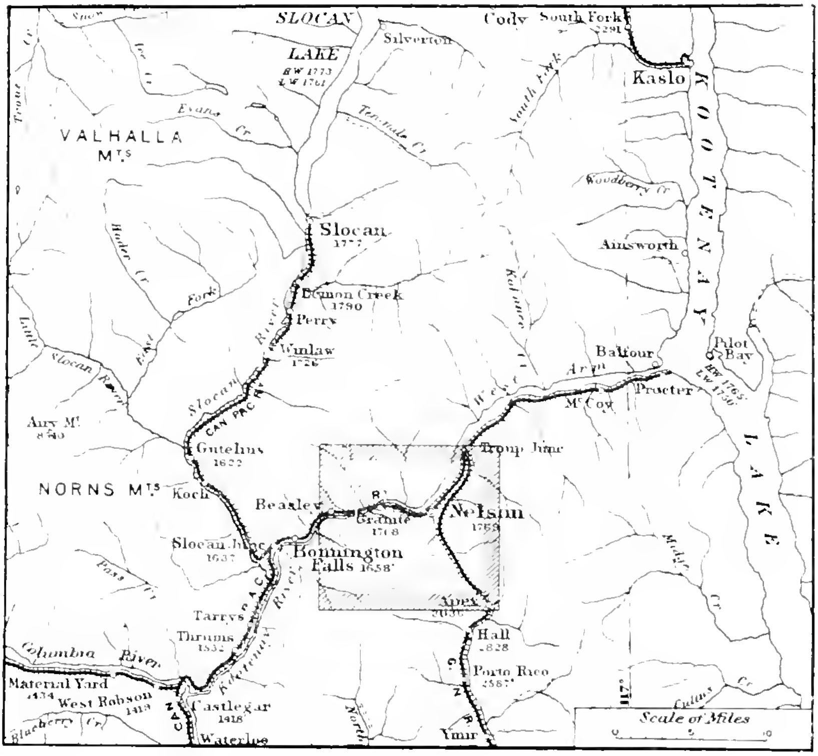
Adjoining the Gloucester to the southeast is the G.H. claim, on which is a magnetite and pyrite deposit. This occurrence also is similarly associated with the granodiorite which underlies it.

Other claims staked on this contact are the Iron Cap, M.S., and Crystal Copper, on which very little development work has been done.

COPPER AND RIVERSIDE CLAIMS.

These two claims, owned by A. Gelinas and J. Senter, are situated about 1 mile south of the map area and across the East Fork of the North Fork of Kettle river from Lower Franklin townsite. The property at present is under bond to the British Columbia Copper Company.

The ore is disseminated chalcopyrite and pyrite with some molybdenite in a quartz and calcite gangue. The country rock is sheared, calcified, and silicified granodiorite. The strike of the shear zone along which the mineralization has taken place is north 55° W., and can be traced for some hundreds of feet.




DIAG. 7. Index map showing position of the Nelson map area.

# GEOLOGY OF NELSON MAP-AREA.

(*O. E. LeRoy.*)

## INTRODUCTION.

The area embraced by the Nelson map comprises about 106 square miles, with the city of Nelson lying a little to the north and east of its centre (Diag. 7.) It includes within its area the mines and prospects occurring on Toad and Morning mountains, and those along Cottonwood, Anderson, Fortynine, Bird, and Eagle creeks.

The city of Nelson is situated on the west arm of Kootenay lake, at an elevation of 1,769 feet above sea-level. The city, including the suburbs, has a population of about 7,000 (1911), and as a commercial centre occupies the foremost position in the interior of British Columbia. The city owes its initial growth to the development of the mining industry, which, however, has been subsequently supplemented by the lumbering and agricultural industries. In more recent years a manufacturing industry has been developed, which will in time assume a greater importance commensurate with the growth of the surrounding country. Railway and lake communication has made it the chief distributing point for East and West Kootenay and the Boundary district.

The Canadian Pacific railway reaches Nelson from the east via the Crows Nest line, and from Vancouver via Revelstoke and the Arrow lakes. A new line now under construction by the same Company will give Nelson a southern and more direct connexion with the Pacific coast via the Boundary and Similkameen districts. The Great Northern railway has a northern terminus in Nelson which gives a direct connexion with Spokane and all points to the south of the International Boundary.

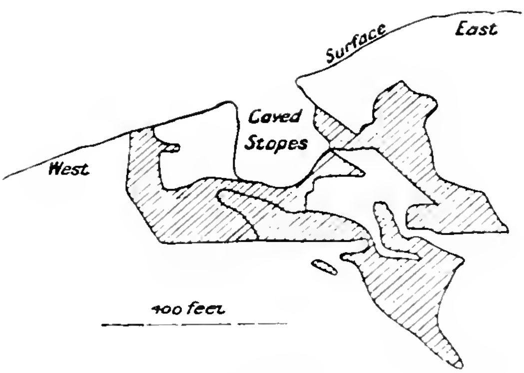



FIG. 1.—Vertical longitudinal section of the ore bodies of the Silver King mine.

The history of mining in the Nelson district dates back to 1886, in which year one of the pioneer mines, the Silver King, was staked on Toad mountain. Nelson at that time could be reached by two routes, either from the main line of the Canadian Pacific railway via Revelstoke and the Arrow lakes, or from the Northern Pacific railway via Bonners Ferry and Kootenay lake.

Geological work of a reconnaissance nature was carried on in this district under Dr. G. M. Dawson[1] in 1888, and Mr. R. G. McConnell[2] in 1894-6.

The history of mining development and production is to be found in the annual reports to the Minister of Mines of British Columbia from the year 1887. According to these reports the approximate total production of the Nelson division from 1895 to the end of 1910, a period of 16 years, amounted to 875,954 tons of ore and concentrates valued at $10,227,134. The area reported on last season only covers a portion of the division, and the above figures are given solely to show the importance of the district as a whole.

The field work in 1911 was done by the writer, assisted during the month of September by Mr. C. W. Drysdale and his party, the result being a geological sketch-map constructed on the scale of about 1 mile to the inch with a contour interval of 250 feet.

The writer wishes to acknowledge his indebtedness and express his thanks to the mine owners, managers, engineers, and others for the many courtesies extended to him during the course of his field work.

## General Character of District.

### TOPOGRAPHY.

The Nelson map-area lies within the Selkirk system of the Western Cordillera, and includes parts of two subdivisions known respectively as the Slocan mountains and the Pend d'Oreille mountains, the former lying north of the west arm of Kootenay lake and the latter to the south of it. In the vicinity of Nelson the country, though rugged, lacks to a certain extent the more alpine characteristics of the mountains to the north which culminate in the Kokanee massif. The peaks and ridges are more or less rounded and the slopes are usually covered with a varying thickness of glacial drift and "wash," the area of bare rock forming a comparatively small percentage of the whole. The mantle of rock waste, and the heavy forest growth over the more important mineralized areas, formed very serious obstacles to the pioneer prospector in his search for ore. Even at present the tracing of veins over any distance on the surface requires much cutting of timber and deep trenching, though occasionally streams may be deflected and ground sluicing carried on over limited areas.

The maximum range in altitude above Kootenay lake (1,760 feet above sea-level) is about 5,500 feet. The crests of the ridges are usually over 6,000 feet above sea-level, and culminate at intervals in peaks from 1,000 to 1,300 feet higher. The highest peak within the map-area is that of Toad mountain, which has an elevation of 7,334 feet above sea-level.

The minor drainage of the map-area is approximately at right angles to the west arm of Kootenay lake, and Kootenay river, its western continuation. The west arm and Kootenay river occupy one of the main transverse valleys of the Cordilleran belt and extend from Kootenay lake proper to and beyond the Columbia river at Robson, thus connecting the drainage systems of two of the chief longitudinal valleys of British Columbia. The west arm of Kootenay lake preserves its lake-like character as far as Nelson, a distance of 19 miles. From Nelson to Robson, some 27 miles west, the valley is occupied by the swift-flowing Kootenay river, with a grade of about 15 feet to the mile. The main falls are at Bonnington (Diag. 8), 11 miles west of Nelson, at which point two electric plants—the West Kootenay Light and Power and the Nelson Power plants—have been installed, which furnish various industrial and mining centres in West Kootenay and the Boundary districts with light and power.

[1] Ann. Rep. Geol. Surv., Can., Vol. IV, pp. 55-56 B.
[2] Ann. Rep. Geol. Surv., Can., Vol. VII, p. 35 A, Vol. IX, pp. 20 and 27 A.
Geological Map of West Kootenay (No. 792).

This transverse valley is bounded by comparatively steep slopes and in places precipitous walls. The tributary streams flow in steep U or V-shaped valleys and partly in box canyons. Some of the larger streams, such as Grohman and Sproule, have, near their mouths, trenched themselves in narrow canyons, the bottoms of which are 20 or 30 feet below the general level of the valley.

The gradients vary from a fall of 250 feet per mile in Cottonwood creek to about 900 feet per mile in the east fork of that creek. The streams head in basins or cirques, whose steep walls have been much modified since the disappearance of the glaciers. The broader basins support grassy meadows, which in the early summer are covered with a variety of flowering plants. The larger streams have built up deltas which extend into the lake for considerable distances, and form limited, though suitable sites, for habitation. Nelson and the neighbouring town of Fairview are built upon the connected deltas of Cottonwood and Anderson creeks.

### CLIMATE AND AGRICULTURE.

The climate on the whole is one of the finest in Canada. Warm summers and moderately cool winters prevail in the more habitable portions of the area. Excessive temperatures, either of heat or cold, are rare and of short duration. The following statistics have been kindly furnished by the Dominion Meteorological Bureau, based on the averages of four consecutive years at Nelson.

*Temperature (Fahrenheit degrees).*

| — | Mean Highest. | Mean Lowest. | Mean. |
|---|---|---|---|
| February | 32·7° | 21·2° | 27° |
| July | 81·1° | 51·9° | 66·5° |
| Annual | | | 46·2° |

The average annual precipitation for the same period amounted to 29·27 inches. The snow fall is heavy on the hills, which, melting slowly, furnishes reserves for the streams for a considerable portion of the summer.

The mining industry was the first cause to attract the pioneers to form a settlement at Nelson, but in more recent years land has been cleared of the original dense forest growth, and a flourishing industry in fruits and vegetables has developed. From the point of view of demand this industry is capable of an expansion only limited by the land area suitable for such cultivation.

Lumbering in the vicinity of Nelson is at present confined to the valley of Sproule creek. The principal trees of the area are the fir, red and bull pine, spruce, cedar, hemlock, tamarack, balsam, larch, aspen, cottonwood, birch, juniper, and alder.

## General Geology.

### INTRODUCTION.

The Pend d'Oreille group, largely sedimentary, is the oldest rock series in the Nelson map-area. On the West Kootenay sheet (No. 792) this group was mapped under Niskonlith and tentatively referred to the lower Cambrian. More recently, Daly, in his section along the International Boundary, gave the name Pend d'Oreille to this group, and referred it to the Carboniferous period. It is thus provisionally placed until more detailed data are available.

The rocks of the Pend d'Oreille group are succeeded by those of the Rossland volcanic group, which are largely of igneous origin, and between which, so far as could be inferred from the field relations, there is an absence of any marked stratigraphical break or conformity. The age of the latter is tentatively placed as Carboniferous and post-Carboniferous. The rocks of both groups are intruded by the Nelson batholith of Jurassic or post-Jurassic age. The rocks composing the batholith range from granite to diorite, and its intrusion was probably closely associated with the mountain-building epoch of later Mesozoic. The rocks of the Rossland volcanic group and the Nelson batholith are the most important economically and contain practically all of the commercial deposits of ore.

Subsequent to the ore deposition, the country, generally, suffered from faulting and fissuring accompanied by the intrusion of a series of basic (lamprophyric) dykes which have in this area a wide-spread distribution. The Tertiary is apparently not represented in this area. The Quaternary deposits consist of some glacial clays, boulder drift, "wash," and the more modern alluvial deposits of the present day deltas.

TABLE OF FORMATIONS.

| | | |
|---|---|---|
| Quaternary. | Glacial and Recent. | Some boulder clay and drift 'wash' alluvial clay, sand, and gravel. |
| ........ | (?) | Basic mica, hornblende and pyroxene dykes (lamprophyres). |
| (?) | Period of Ore Deposition. | Gold-silver, silver-copper, copper-silver-gold deposits. |
| Mesozoic........ | Jurassic (?)........... | Nelson batholith intrusion (rocks range from granite to diorite). |
| Palaeozoic........ | Carboniferous and post-Carboniferous. | Rossland volcanic group consisting of hornblende and pyroxene porphyrite, chlorite and mica schist, quartz porphyry, sericite schist, with a few beds or lenses of limestone and slate. |
| | Carboniferous (?)....... | Pend d'Oreille group sandstone, slate, phyllite, andalusite schist, quartzite, quartz schist. |

THE PEND D'OREILLE GROUP.

The Pend d'Oreille group has only a small superficial distribution in the Nelson map-area, and occurs along the east border at the head-waters of Anderson creek and the east fork of Cottonwood. The rocks composing the group consist of interstratified grey sandstones, grey and black slates which along the contact with the granite have been altered to quartzites, quartz, and andalusite schists. The strike of the rocks generally conforms to the trend of the border of the granitic batholith, and varies from north to west, with dips from 60 to 90 degrees to the west and south.

The actual contact between this group and the Rossland volcanic is concealed[1] by drift. The outcrops of both groups when noted near the probable contact were practically vertical and coincided in strike. At one point the contact appeared to be

[1] No microscopic examinations have as yet been made of the rocks and the field terms solely are used in the following descriptions.

an igneous one, the intrusive from hand specimens resembling a deeper-seated phase of the augite porphyrite of the Rossland volcanic group.

### THE ROSSLAND VOLCANIC GROUP.

The rocks of the Rossland volcanic group occupy the greater part of the southern half of the Nelson map-area. That they had a wider distribution in the past, is evidenced by the many isolated exposures in the area underlain by the granitic rocks of the Nelson batholith. The rocks are in the main of igneous origin and consist of interbanded porphyries and porphyrites and their brecciated, sheared, and altered (metamorphosed) equivalents, now porphyrite-breccia, chlorite, hornblende, quartz-biotite and quartz-sericite schists. There is a minor development of compact greenstones and quartzose rocks which may have been originally tuffs now silicified. Amygdaloidal rocks were noted in two instances and may represent original surface flows, being the extrusive equivalents of the main masses, which apparently occur in sills or sheets and indicate several periods of intrusion.

Interbedded with the above rocks are small bands or lenses of quartzite, slate, and crystalline limestone indicating rather brief periods favourable for the deposition of sediments. The basic igneous rocks are prevailingly green or dark green, weathering to a light greenish grey or to rusty brown, while the acid types are usually dark grey or light grey. Both types, especially the schistose phases, are more or less pyritic, and in some cases the pyrite carries gold values.[1]

The rocks throughout have been much folded and altered by dynamic as well as igneous action. The strike of the schistosity and of the bedding, in the case of the stratified rocks, conforms in general to the trend of the border of the Nelson batholith. From east to west across the map-area the strike gradually swings from northwest to west with south and southwest dips ranging from 30 to 90 degrees, the average dip being over 45 degrees.

### THE NELSON BATHOLITH.

The enormous intrusion of granitoid rocks, termed the Nelson batholith, which underlies hundreds of square miles in the southern part of the West Kootenay district, occupies about three-fifths of the Nelson map-area, and underlies the whole of it at no great depth. These rocks are exposed almost continuously in the northern half of the area, especially north of the west arm of Kootenay lake. In the areas underlain by the rocks of the Pend d'Oreille and Rossland volcanic groups, this intrusion is represented by numerous dykes, and bosses of considerable size, which at moderate depths are no doubt connected with one another and also with the main body of the batholith. The age of this intrusion is tentatively referred to the Jurassic or post-Jurassic period.

The term Nelson granite, though widely used, is not applicable to any great portion of the rock mass, which is rather a granodiorite or a rock transitional between a granite and diorite. In mineralogical composition the rocks range from a true granite to a quartz diorite and to possibly more basic types. That portion of the batholith in the Nelson map-area is apparently a unit, though differentiation has played an important role, and assimilation to a minor extent, judging from field relations along certain contacts with the rocks of the Rossland volcanic group. Orthoclase and plagioclase feldspar, biotite, hornblende, and quartz are the essential constituent minerals. An analysis of the average type occurring on Kokanee mountain gave the following result which places the rock among the more acid of the Monzonites.[2]

[1] On the Starlight claim the pyritized schists are stated to carry $3 in gold.
[2] Geol. Surv., Can., Sum. Rep., 1902, p. 101 A.

| | |
|---|---|
| $SiO_2$ | 66·46 |
| $Ti_1O_2$ | 0·27 |
| $Al_2O_3$ | 15·34 |
| $Fe_2O_3$ | 1·68 |
| FeO | 1·83 |
| CaO | 3·43 |
| MgO | 1·11 |
| $Na_2O$ | 4·86 |
| $K_2O$ | 4·58 |
| $H_2O$ | 0·29 |
| $P_2O_5$ | 0·08 |
| | 99·93 |

The texture ranges from coarsely porphyritic to fine granitoid. The colour varies from light to dark and brownish-grey weathering in lighter tones. Some of the more basic types readily disintegrate to a coarse sand. The most remarkable type is a granite porphyry which contains large-zoned crystals both single and in Carlsbad twins, varying in size from ½ to 1 inch in diameter and from 1 to 2 inches in length. This porphyry appears to be a differentiate in a rather coarse granite, and occurs in masses ranging from a few feet to hundreds or thousands of feet in diameter. The associated dykes cutting this granodiorite are light grey or pinkish aplite of two or more generations, coarse quartz-feldspar-biotite pegmatite, quartz porphyry, and quartz syenite porphyry. The aplite contains in rare instances small plates of molybdenite lying in minute fracture planes. The aplites and pegmatites are more numerous in the more basic phases of the granodiorite at or near its contact with the schists of the Pend d'Oreille and Rossland volcanic groups. These contact rocks are mainly quartz, quartz-biotite, and andalusite schists, and also occur as rounded and lens-like inclusions in the granodiorite mass, especially when the latter is foliated, in which case the longer axis of the inclusions coincides in trend with that of the foliation. A migration of material is also apparent, and phenocrysts of feldspar are found developed in the main body of the schists at or a few feet from the contact.

The granodiorite is much jointed throughout by broadly developed planes. Vertical planes in two directions almost at right angles, together with an almost horizontal plane, are the most prominent. An inclined plane (varying from 30 to 80 degrees in dip) passing into sheeted zones is locally common. Shearing occurs along the joint planes, especially in the vicinity of the basic lamprophyre dykes, and it probably marks the directions of later fissuring and faulting, though in the latter case criteria for its determination are usually lacking.

### BASIC (LAMPROPHYRE) DYKES.

Basic dykes, with biotite, hornblende, or pyroxene as the chief phenocryst constituent, have a widespread development throughout the whole area. They are dark green to black in colour, weathering to greenish grey, and readily disintegrating to a coarse brownish sand. They are intrusive in all the older rocks, and they cut and sometimes fault the ore bodies in contra-distinction to lithologically similar dykes at Sheep creek and in the Slocan district which are older than the vein fissures. At Nelson the dykes are almost invariably steeply inclined or vertical, and when cutting the granodiorite, usually follow the main plane of jointing. They hold as inclusions, angular fragments of the wall rock which they have rifted off. In the bedded and schistose rocks they follow along the planes of stratification and foliation, and occasionally, though rarely, cut across the strike or dip. The dykes range from a fraction of an inch to over 20 feet in thickness, and in length from less than 100 to 1,000 or more feet. The wider dykes show at times a variation in texture, coarse-grained alternating with finer-grained, arranged in parallel bands. Being less resistant than the granodiorite they are easily eroded and leave small canyons with vertical walls. The gorge of Cottonwood creek just south of Nelson has been formed in this manner by the wearing down of a broad dyke leaving the vertical walls of granite.

### GLACIAL AND RECENT DEPOSITS.

In the Glacial period the whole country was covered by the Cordilleran ice sheet, which, in this area, appeared to be moving S. 30° E., as evidenced by striæ and grooves on the higher slopes and ridges. At a latter period when the sheet was broken up into individual glaciers the trend of movement coincided with the present valleys. The highest erratics noted were on the slope of Toad mountain about 150 feet below the peak, at an elevation of 7,184 feet above sea-level, on Copper mountain 500 feet below the peak at 6,960 feet above sea-level, and on the ridge at the head of the east fork of Cottonwood creek 6,685 feet above sea-level. The highest outcrop of striated rock was noted on the east slope of Connor mountain 450 feet below the peak at an elevation of 6,600 feet above sea-level.

Boulder clays and sands, morainic in character, are common on the lower slopes of the ridges and in portions of the valleys. They are, however, much obscured by angular waste material or "wash." Morainic tongues evidently extended across the Kootenay valley at one or more points near Nelson, which were later cut through by the river, leaving bars and gravelly islands.

Stratified sands with some clays and gravels overlie the unassorted material, and have been noted up to an elevation of 3,000 feet above sea-level, or 1,240 feet above Kootenay lake. The highest terraces or bench lands noted were 460 feet above Kootenay lake.

## ECONOMIC GEOLOGY.

### INTRODUCTION.

The ore deposits in the vicinity of Nelson occur either in the granitic rocks of the Nelson batholith, or in the schists and limestones of the Rossland volcanic group. In the granitic rocks the veins occupy well-marked fissures, and the ore is essentially gold or gold-copper with a quartz gangue. The lodes or mineralized zones in the schists consist of elongated and parallel lenses of quartz alternating with bands of schist, both of which are mineralized. The ore bodies or shoots are lens-like in form, and in altitude approximately conform to the strike and dip of the schists. In a few instances distinct fissure veins occur across the strike or the dip of the schists. The ores in the schist are silver-copper, gold-copper, and gold-silver. The ore bodies in the limestone are contact deposits, occurring at or near the border of the batholith, and are characterized by a gangue composed essentially of the lime silicates, garnet, epidote, and actinolite. They are similar to the low grade deposits of the Boundary district but are of much less importance.

The ore deposits have been arranged and are described under the following heads:—

(1.) Gold-silver.
(2.) Copper-gold-silver.
(3.) Silver-copper.
(4.) Non-metallic minerals.

The principal metallic minerals found in the Nelson map-area are native gold, silver, and copper; pyrargyrite (ruby silver), iron pyrite, chalcopyrite (yellow copper), bornite (peacock copper), tetrahedrite (grey copper), chrysocolla (silicate of copper), azurite (copper carbonate—blue), malachite (copper carbonate—green), stromeyerite[1] (sulphide of copper and silver), molybdenite, galena, zinc blende, pyrrhotite (magnetic iron pyrites), scheelite (calcium tungstate), magnetite, and limonite. The gangue minerals are quartz, calcite, siderite (spathic iron), barite, fluorite, garnet, actinolite, and epidote.

## STATE OF MINING IN 1911.

The properties from which shipments were made during the past season (1911) were the Granite-Poorman, 380 tons (concentrates); Athabasca, 101 tons (concentrates); California, 33 tons; Royal Canadian (Nevada), 28 tons; Ophir, 5 tons, and a clean-up at the Silver King mine of 77 tons.

Minor development work was done on the Alma, Pingree, Perrier, and George V. During the summer there was considerable activity in prospecting for metals of the platinum group. Samples were taken from a few of the prospects, but the assays by the chemistry division of the Mines Branch gave negative results.

The profitable exploitaton of many of the smaller properties lies in the amalgamation of the several interests, in order to economize and secure the best results from systematic development. The owners also should be willing to permit their properties being developed under a practical working bond without any cash consideration. If the property is not sold the development work proves its value to a certain extent, and if the property is worthless the sooner that fact is discovered the better for the owner. There are so many cases throughout the country generally where the owner is spending his money in desultory development which is oftentimes valueless. The majority of mineral deposits are not easily exploited, but call for the employment of strict technical and business methods beyond the resources of the small holder. If reputable people could be secured to interest themselves every facility should be given to encourage them. Such a policy if generally adopted would undoubtedly yield results beneficial both to the individual and the community.

## DESCRIPTIONS OF MINES.

### Gold-Silver Deposits.

*The Kootenay Gold Mines, Limited.*—The Kootenay Gold Mines, Limited, own the Granite-Poorman group, situated about 5 miles west of Nelson at an altitude of from 1,200 to 2,400 feet above Kootenay lake. The group consists of fifteen claims and fractions, on which five main veins have been partially developed (Fig. 2).

The mill, situated about 1 mile west of Granite station on the Canadian Pacific railway, is equipped with twenty stamps, amalgam plates, and four Wilfley tables. An 8-drill Rand compressor is also situated in the mill building. Both water and electric power are used. A Riblet aerial tram about 5,000 feet long with a drop of about 1,200 feet connects the Granite shaft with the mill. Loading stations at convenient points along the line are connected with the several lower levels of the workings. The production from 1899 to January, 1912, amounted to about 83,175 tons. About 80 per cent of the gold is collected on the plates and about 10 per cent is recovered in the concentrates. The latter average about 1½ ounces of gold and 1½ per cent of copper per ton. The milling ore ranges in gold values (recovered) from $6.50 to $12 per ton with a very low silver content.

[1] A specimen of stromeyerite from the Silver King gave the following analysis: silver, 52·27%, copper, 31·60%, sulphur, 15·74%, iron, 0·17%. See Geol. Surv., Can., Vol. VIII, 1895, p. 12 R.

The veins are of the fissure type and occur in a medium or coarse-grained quartz hornblende diorite. They vary in thickness from an inch or so to over 6 feet, and the length so far as developed ranges from 500 to 2,500 feet. Usually a certain width of the country rock, either on the hanging or the foot-wall side, is sufficiently mineralized to stope. The predominant and almost exclusive gangue mineral is quartz. The chief metallic mineral is pyrite, with which is locally associated small quantities of galena, chalcopyrite, and in rare instances in the Poorman mine, scheelite. The galena is always an indicator of high gold values. Limonite is present in the oxidized portions of the veins in which visible free gold may occasionally be seen. The veins are cut by basic mica dykes (minettes), and are faulted, but usually with small displacements. The main fault cutting the Granite and Beelzebub veins has a throw of at least 180 feet.

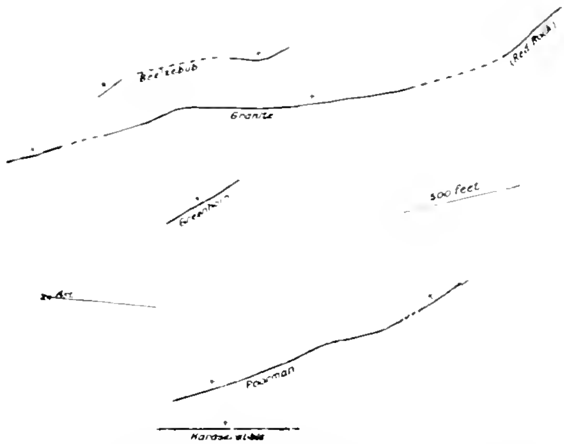



FIG. 2.—Vein system on the property of the Kootenay Gold Mines, Limited.

The five veins, going from west to east (Fig. 2), are the Hardscrabble, Poorman, Greenhorn, Granite, and Beelzebub. At the level of No. 4 cross-cut tunnel of the Poorman, and taking the Hardscrabble vein as the initial point, the other veins lie east of it at the following approximate distances, respectively: Poorman, 330 feet; Greenhorn, 1,300 feet; Granite, 1,900 feet; Beelzebub, 2,020 feet.

**Hardscrabble Vein.**—The Hardscrabble vein is intersected by No. 4 cross-cut tunnel of the Poorman, 60 feet from the portal. The vein is now being developed, and in recent drifting has shown an ore body at least 300 feet long with an average width of 2 feet. The vein strikes N. 10° W. with an average dip of about 45 degrees to the northeast. Little stoping has been done so far; the ore stoped, however, is, on an average, of higher grade than is found in the other veins, and the gold is coarser.

**Poorman Vein.**—The Poorman vein has been developed by five levels, giving a depth on the vein of 700 feet. The bulk of the ore mined and milled by the Company in 1911 was derived from the Poorman, and stoped between the fourth and fifth levels. The main avenue is No. 4 cross-cut which intersects the vein about 480 feet from the portal. This level is connected to No. 5 by an incline shaft. The productive portion of the vein above 4 has in great part been stoped out. The vein strikes N. 22° W. and dips northeast from 30 to 4. degrees. The ore shoot is continuous from the surface, and on the fourth level was stoped for a length of over 1,000 feet. The shoot pitches rather flatly to the southeast. The thickness varies from a few inches to 8 feet, and the average stoping width is about 2 feet. The ore stoped during the last five years averaged $6.50 in recovered values. The average run of the ore in the vein proper is about $15, but the width of mineralized rock stoped below the foot-wall lowers the average to the former figures. The gold is "shotty" in character and easily recovered on the plates. Free gold in small but extremely rich pockets has been found at rare intervals down to the present lowest level. Scheelite also is found but is of rare occurrence. It occurs in small grains, pale brown in colour, in massive white quartz. The zone of oxidation is shallow in the Poorman and does not exceed 50 feet in depth.

**Greenhorn Vein.**—The Greenhorn vein has been opened by two drifts giving a vertical depth of 150 feet. The vein strikes N. 33° W. and dips northeast at 45 degrees. Stoping has been carried on from the surface to within 30 feet of the lower level. The shoot was about 300 feet long with an average thickness of 3 feet. Above the sill of the first level (Greenhorn tunnel), which represents the limit of oxidation, the ore averaged $12 per ton in gold (recovered values).

**Granite Vein**—The Granite vein has been developed by seven levels, giving a vertical depth of 450 feet. The several levels in ascending order are, the lower tunnel 230 feet above No. 4 level of the Poorman, the Davenport, the Granite shaft with four levels, the lower being the White tunnel, and the Red Rock tunnel.

The vein varies in strike from N. 12° W. to N. 50° W. with an average dip to the northeast of 45 degrees. The stoping width averages 2½ feet.

In the absence of through connexions with all the workings it is impossible to outline with accuracy the limits of pay-ore. There appears, however, to be four shoots: the Red Rock; the Granite shoot, 285 feet long on the level of the White drift, and extending to the surface at the Granite shaft, 280 feet high on the dip; the White shoot, 230 feet long; and the shoot in the lower tunnel, 200 feet long with a maximum height of 80 feet. A fault cuts this latter shoot off to the south, on a strike of N. 85° E. and a north dip of 50 degrees, the vein at this point striking N. 30° W. and dipping northeast at 55 degrees. The fault zone, from 1 to 17 feet thick, consists of crushed country rock, gouge, and dragged ore. The throw along the horizontal plane is not less than 180 feet. Sufficient work has not yet been done to definitely locate the vein south of the fault.

The ore is largely oxidized, and the gold is flaky in character. The recovered values in gold averaged $8 per ton. In the Red Rock shoot crude ore ran $45 per ton in carload lots, and the milling ore averaged $11 per ton.

**Beelzebub Vein.**— The Beelzebub vein has been opened up on two levels giving a vertical depth of 175 feet between them. The vein varies in strike from N. 30° W. to N. 40° W. and dips northeast at from 30 to 50 degrees. The eastward continuation of the fault displacing the Granite vein was encountered, and until the threw is definitely determined in the Granite workings no further work will be done on this vein. The stoped width varies from 14 to 22 inches. One thousand tons stoped above No. 2 level yielded $9 in gold (recovered) per ton. One rich pocket of oxidized ore gave a return of $7,000 from a barrow load.

*Athabasca Mine.*—The Athabasca mine, controlled and operated by the Athabasca Syndicate of Vancouver, is situated on the east slope of Morning mountain, about 3 miles in a direct line from Nelson, and about 2,200 feet above Kootenay lake. A branch from the Hall Mines road leads to the Athabasca mill. The property originally consisted of four claims, to which was added the Venus group in 1903. The Athabasca mine is connected with the mill by a surface gravity tram and the Venus by Riblet aerial tram 7,300 feet long. The mill, situated on Giveout creek, about

1,000 feet below the former mine, is equipped with ten stamps, amalgam plates, Frue vanners, and cyanide tanks.

The Athabasca mine[1] has been operated since 1897, though not continuously. During the past two years development has been steadily advanced and a limited amount of ore stoped. There are several ledges on the property, only one of which has been developed. This well-defined vein occurs near a granite-schist contact and the fissure traverses both rocks (Fig. 3).

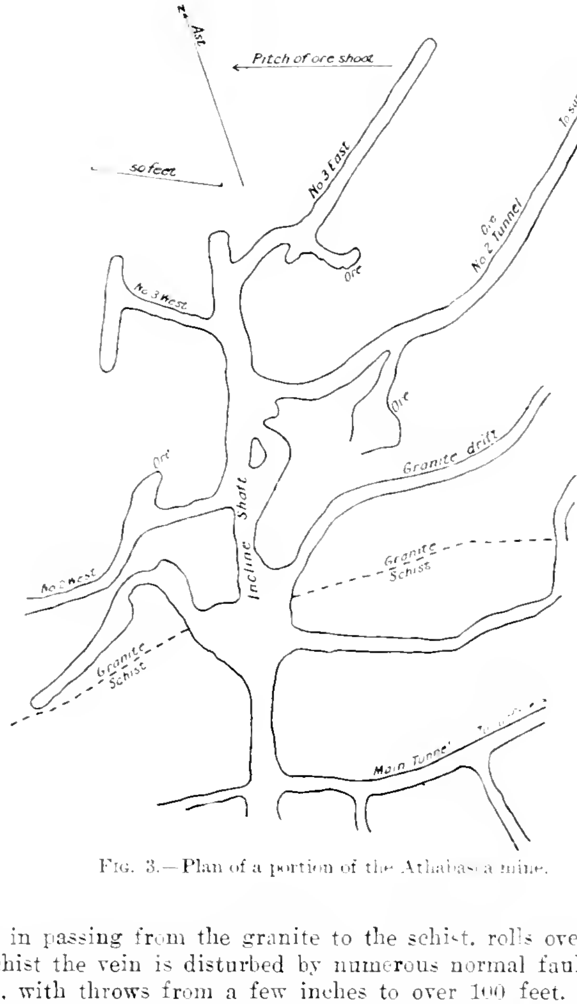



Fig. 3.—Plan of a portion of the Athabasca mine.

The vein, in passing from the granite to the schist, rolls over and flattens (Fig. 4). In the schist the vein is disturbed by numerous normal faults running in various directions, with throws from a few inches to over 100 feet. In the granite the vein is more regular and when faulted is but slightly displaced. The faulting is associated with the intrusion of a series of basic dykes which cut the vein. In its normal course the vein strikes N. 40° E. and dips northwest, the angle varying from 30 to 50 degrees. The vein has been developed by two main (adit) levels, and intermediate drifts connected by an incline shaft. The more recent development consisted in prospecting above No. 2, and opening a third level to explore the downward continuation of the ore shoot to the northwest (Fig. 3).

[1] Fell, E. N. Notes on the Athabasca Mine, Jour. Can. Min. Inst., Vol. V, 1902, pp. 15-20.

Stoping was general on and south of the main level for nearly 600 feet along the strike. The pay-streak varies in thickness from about 2 inches to 3 and even 4 feet, the general average being about 1 foot. The ore is a mixture of galena, zinc blende, and pyrite with occasionally free gold either in the quartz gangue or in the solid sulphides. The values are less regular in the granite than in the schist belt. A remarkable concentration of values was noted along the contact, especially on the schist side. The recovered values in 1900 averaged $33.66 per ton in gold and silver.

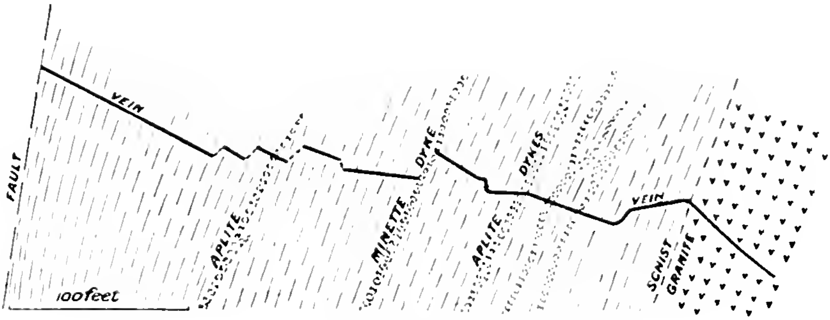


FIG. 4.—Section across the Athabasca vein.

The latter is in small amount and never exceeds 6 ounces per ton. An assay of the pulps of the mill-runs of 14 days (December, 1900) gave the following values, the ore being classed as medium low grade[1]:—

| | |
|---|---|
| Gold | 1·35 ounces per ton. |
| Silver | 0·45 " " |
| Zinc | 2·20 per cent. |
| Lead | 1·60 " |
| Iron | 10·70 " |
| Sulphur | 6·00 " |
| Silica | 68·80 " |
| Lime | 1·90 " |
| Alumina | 6·00 " |

The Venus mine has been idle for some years and was not visited. The vein is stated to occur in the schist belt (Rossland volcanic group). It has a northerly strike and is stated to vary from 2 to 4 feet in thickness. The vein has been developed by four tunnels and the workings are connected with the neighbouring Juno mine. The ore is of lower grade than that of the Athabasca.

*California Mine.*—The California mine is owned by Mackenzie and Mann and at present is being worked under bond by Messrs. Bell and Hudson. The mine is situated above and to the south of Giveout creek at an elevation of about 2,000 feet above Kootenay lake. A branch of the Hall Mines road leads to the lower tunnel and ore bunkers.

The vein or lode has been traced by stripping and open-cuts for about 800 feet; it occurs in a band of schist near a granite contact and has a westerly strike with a dip to the south of between 50 and 60 degrees. On the California ground the main development is a drift tunnel about 250 feet long, which has opened up two ore shoots, one 37 feet long and from 10 inches to 2 feet thick, while the other is at least 150 feet long and varies in thickness from 3 inches to 2½ feet. Shipments from the former ran $40 and from the latter $30 per ton. The value is mainly in gold, as the silver content never exceeds 8 ounces per ton. The ore is similar to that of the

[1] Jour. Can. Min. Inst., Vol. IV, 1901-2, p. 83.

Athabasca and consists of pyrite, galena, and blende in a quartz gangue, occurring as a series of parallel bands or long attenuated lenses in the schist. The values are rather spotty and are best when there is an intermixture of the sulphides. The foot-wall streaks usually carry the richest ore.

The Exchequer adjoins the California to the west and is on the same lode, which has been developed by a shallow shaft connected with a short cross-cut tunnel. At the intersection of shaft and tunnel the lode is from 10 to 15 feet thick and consists of interbands of quartz and schist. In 1899, a trial shipment of 50 tons gave $20 per ton in gold.

*Perrier Group.*—The Perrier group, owned by Messrs. Hinton, Crossley, and associates, consists of seven claims situated on the Great Northern railway about 4 miles south of Nelson, at an elevation of 1,200 feet above Kootenay lake. The mine is equipped with a boiler, Akron-Chilian mill, plates, and a one-drill compressor.

The main vein has been traced on the surface for over 700 feet by small cuts and tunnels, and an incline shaft, at present 60 feet deep, is being sunk on the dip. The strike varies from N. 5° E. to N. 20° E. and dips east from 35 to 60 degrees. The fissure cuts across the foliation of the chlorite schists (Rossland volcanic group). The thickness of the vein varies from 10 to 22 inches and consists of quartz, zinc blende, galena, chalcopyrite, and occasionally a little free gold. A nine ton shipment to Trail gave $23 in gold and from 4 to 5 ounces of silver per ton.

About 200 feet southeast of the shaft a vertical lode outcrops, striking N. 30° W., or with the trend of the schists. It consists of bands of quartz, with an aggregate thickness varying from 7 to 15 inches, interbanded with the schists. The mineral content is the same as that of the main vein, but in addition minute quantities of ruby and native silver have been found in small fissures associated with calcite. It is probable that this vein is a branch of the main one, but development work is not yet sufficiently advanced to prove it.

*Royal Canadian Group.*—The Royal Canadian, owned by a Victoria syndicate, consists of five claims and fractions situated on the Nelson-Bonnington road at the junction of the road to Fortynine creek, about 7 miles west of Nelson. There are two veins on the property, named the Royal Canadian and Nevada, respectively. The Royal Canadian vein has been developed by three short drift tunnels, giving a vertical depth of about 125 feet. A limited amount of stoping has been done, and it is stated that some years ago 300 tons put through the Granite mill gave appropriate returns of $4.75 per ton in gold. The vein occurs in a grey granodiorite and has a strike N. 15° W. with a dip of between 60 and 70 degrees to the northeast. In the lower tunnel the vein has been cut and slightly faulted by a basic mica dyke. The ore consists mainly of pyrite with very slight amounts of chalcopyrite in a quartz gangue and varies in thickness from 2 to 33 inches.

The Nevada vein lies to the south and higher up the hill. A cross-cut tunnel intersected the vein about 70 feet from the portal, and from that point a drift was driven about 70 feet to the east and connexion made with a shallow shaft sunk from the surface. The vein occurs along a contact of granodiorite and schist, the former being the hanging-wall and the latter the foot-wall. The strike is N. 78° E. with a dip to the south of 53 degrees. The thickness varies from 8 inches to 3 feet. A shipment (1911) of 28 tons was made from an underhand stope in the east end of the drift which averaged $20 per ton in gold. The mineral content of the vein is similar to that of the Royal Canadian.

*The Ophir and George V.*—These properties adjoin one another and are situated on Bird creek, about 10 miles from Nelson by wagon road. The Ophir is owned by John Baxter and the George V by John Smallwood, both of Nelson.

The lode crosses both claims and occurs in quartz-mica and chlorite schists, with which it coincides in the main, both in strike and dip. The strike is N. 85° E. and the dip is south, varying from 30 to 45 degrees.

The lode consists of bands and lenses of quartz with interbands of pyritic and siliceous schist having a maximum aggregate thickness of about 3 feet. Pyrite was the only ore mineral noted, but it is stated that visible free gold occurs in the oxidized portions. A trial shipment of 5 tons has been sent to Trail but the results are not yet to hand. The lode has been exposed at several points by short tunnels, open-cuts, and a shallow incline shaft. A main cross-cut is now being driven which will give a depth of about 90 feet on the dip. The George V has been developed by a short and shallow cross-cut tunnel and an open-cut.

*The Juno.*—The Juno mine, owned by the Juno Mines, Limited, Montreal, is situated on Morning mountain, adjoining and above the Venus mine. The property has been idle for several years and was not visited last season. The vein is exposed by some open-cuts on the surface. The underground development consists of a shaft 300 feet deep with levels at 100 foot intervals. No. 2 tunnel of the Venus is connected with the lowest level by a 550 foot raise.

The vein strikes at about N. 50° E. and dips southeast at about 60 degrees. The vein is quartz varying in thickness from 15 inches to 2 and 3 feet on the first and second levels. It is stated that some years ago the Athabasca mill was leased and about 2,000 tons of ore was milled. It is not known what values were recovered.

The Venus vein extends into the Juno ground, but has not been developed beyond driving the tunnel and making the raise connexion.

*The May and Jennie Group.*—This group, consisting of four claims and owned by the Reliance Gold Mining Company of Nelson, is situated on the east side of Fortynine creek, about 9 miles west of Nelson by wagon road.

The mine is connected to the mill by a Riblet aerial tram 1,750 feet long with a drop of about 550 feet. The mill is equipped with a 50 ton Akron-Chilian mill, plates, and cyanide tanks. No work has been done on the property for several years.

There are two lodes, of which the main one has been developed by two cross-cut tunnels with drifts connected by a raise of 112 feet. Nos. 3 and 4 tunnels have been run only short distances and have not reached the vein. The aggregate footage amounts to rather more than 2,500 feet. In No. 2 tunnel, driven about 235 feet below the outcrop, the lode has a general strike of N. 30° W. with a dip to the southwest of 75 degrees, northeast or to the north at from 60 to 85 degrees. In general the lode coincides in strike and dip with the hornblende and chlorite schists forming the country rock. The lode consists of interbands of pyritic quartz and schist, the latter being much crushed and oxidized in places, with lenses and masses of fairly clean pyrite. The thickness varies up to a maximum of 2½ feet with bands of massive pyrite up to 18 inches thick. The ore is low grade and is stated to run about $4 per ton in gold.[1]

In the same tunnel the cross-cut intersected another lode about 230 feet from the portal on which a little work has been done. It occurs as a shear zone in basic porphyrite, and consists of a filling of crushed rock, quartz, and pyrite.

*Anderson Creek.*—An interesting occurrence of a vein showing crustified and comb structure is to be seen on the east fork of Anderson creek, about half a mile above the Great Northern railway. The vein occupies a fissure in a light grey medium-grained granodiorite and is exposed by a drift tunnel about 200 feet long. It strikes N. 20° W. and dips northeast from 85 degrees to vertical. The vein con-

[1] Ann. Rep. Min. of Mines, B.C., 1904, pp. 138-139.

sists of heavy gouge and quartz up to 4 feet in thickness, the quartz having a maximum thickness of 18 inches. The ore consists of alternate bands of galena, zinc blende, chalcopyrite, pyrite, siderite, calcite, and quartz. These, in its best development, correspond on each side of the central drusy zone. The centre is marked by quartz crystals with well-developed terminal faces and strong zonal structure. The crystals either interlock or are separated by open spaces from a fraction of an inch to 2 or 3 inches across. In certain places the lower three faces of the pyramids are coated by small cubes of pyrite indicating that vapours carrying sulphide of iron passed upwards and deposited their metallic content on the planes facing the direction of movement.

## Copper-Gold-Silver Deposits.

*The Eureka Mine.*—The Eureka mine, owned by the Eureka Copper Mines, Limited, of Nelson, is situated on Eagle creek, about 8 miles by wagon road from Nelson, at an altitude of about 2,700 feet above Kootenay lake. The group consists of seven claims and fractions. The mine workings consist of an incline shaft 200 feet deep with drift at the 100, 150, and 200 foot levels, and a cross-cut tunnel which gives an additional depth of 82 feet. In all about 3,000 feet of work has been done exclusive of open-cuts and trenching.

The mine has shipped to date 2,660 tons of ore, which averaged 5·5 per cent copper, 0·21 ounce of gold, and 2·5 ounces of silver per ton.

The country rock is a dark grey quartz diorite cut by several basic mica dykes, which also cut, and in cases, fault the vein. There appear to be at least two vein fissures (Fig. 5), which may be connected, though development work is not sufficiently

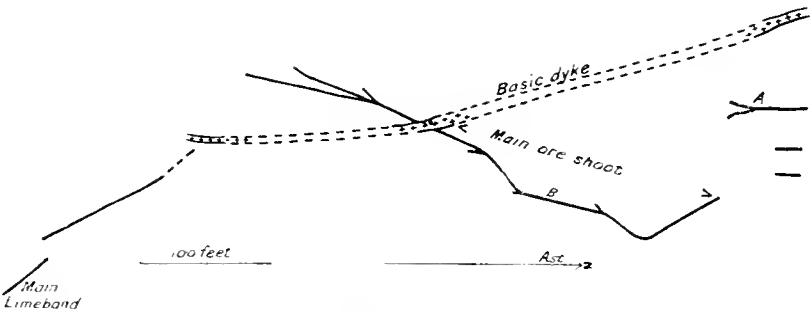



FIG. 5.—Vein system of the Eureka mine.

advanced to prove it. In the old workings at the shaft the main vein strikes N. 52° W. and dips northeast from 85 degrees to vertical. The main fissure in the cross-cut tunnel strikes N. 17° E. with a high dip to the east. A fault near the north end changes the trend to the northwest, or practically parallel to the main vein in the old workings. Both are intimately associated with bands of crystalline limestone which have apparently been engulfed in the diorite when it was in a molten condition. These bands probably served as suitable directions for fissuring at a later period. The principal gangue is quartz which has apparently replaced the limestone to a greater or less extent, and the latter in many places is sufficiently mineralized to constitute ore. The ore was primarily a sulphide, but has been extensively oxidized to the lowest level now exploited; the minerals are azurite, malachite, chrysocolla, and chalcopyrite in a gangue of quartz and calcite. There are four main shoots which have been partially developed.[1]

[1] Personal communication from Mr. L. B. Reynolds.

In the shaft workings the north shoot (Fig. 6) is 60 feet long and over 140 feet high. It commences 60 feet below the shaft collar and extends below the 200 foot level. It varies in thickness from 1 inch to 4 feet. On and below the 150 foot level a band of crystalline limestone from 2 to 10 feet thick forms the hanging-wall. The ore is all oxidized and shipments gave 5½ per cent of copper, 0·21 ounces of gold, and 2·1 ounces of silver per ton. The south shoot has been opened on all levels and sulphide ore begins to appear on the 200 foot level. On the 150 foot level the shoot is 50 feet long and 2 feet thick, and averages 6 per cent copper, 0·2 ounce of gold, and 2 ounces of silver per ton.

On the level of the tunnel the first shoot occurs at the junction of the cross-cut and drift (Fig. 5A). It has been developed in two sections, the one north of the cave being 30 feet long and up to 13 feet in thickness, while south of the cave it is 20 feet long and 3 feet thick. The ore averages 5 per cent copper, $2 in gold, and $1.50 in silver per ton. The main shoot on the tunnel level (Fig. 5B) is 300 feet long and averages 25 inches in thickness. The ore occurs in mineralized limestone and in quartz, and, therefore, both calcareous and siliceous types are present. The oxidized calcareous ore ranges from 5½ to 6 per cent of copper, $2 to $3 in gold, and from 2 to 9 ounces of silver per ton. The siliceous ore, partially oxidized but containing some sulphide ore, gives 2¼ per cent of copper, $1 in gold, and 13 ounces of silver per ton.

*The Queen Victoria Mine.*—The Queen Victoria mine, owned by John Swedberg, is situated at Beasley on the Canadian Pacific railway, 7 miles west of Nelson, at an altitude of 1,050 feet above the track.

The mine is connected with the ore bunkers at the track by an aerial tram about 2,800 feet long. The development consists of a series of open quarries and three short tunnels cross-cutting the mineral zone. The zone is composed of bands of garnet and epidote alternating with bands of quartz mica and chlorite schists. The bands vary in thickness from a few inches to 50 or more feet, and have been developed along their strike for about 500 feet. The general strike is N. 82° E., but in its western extension curves and strikes N. 65° W. The dips are respectively north and northeast, varying from 25 to 60 degrees. Faulting with small vertical throws occurs along planes varying in direction from N. 15° W. to N. 25° W., and is accompanied by shearing and slicken-siding. The bands of epidote, garnet, etc., represent a replacement of limestone near a contact with the granodiorite and are similar in origin to the mineralized zones containing low grade ores which occur in the Boundary district. The mineralized zone here represents a lens-like patch probably 2,000 feet long and a few hundred feet wide composed primarily and chiefly of calcareous rocks of the Rossland volcanic group. The zone is cut by basic hornblende dykes. The ore is low grade, too low for shipping at present prices of copper. It consists of pyrite, chalcopyrite, small amounts of magnetite and pyrrhotite in a gangue composed of garnet (andradite), epidote, actinolite, quartz, and calcite. The ore also contains nickel and cobalt, an analysis giving 0·41 per cent of nickel and a trace of cobalt.[1]

The production to date amounts to 6,189 tons, the metal content being: gold 49 ounces, silver 3,947 ounces, copper 263,409 pounds, with a total gross value of $49,771.

## Silver-Copper Deposits.

*The Kootenay Bonanza Mines, Limited.*—The above Company owns a group of about 40 claims situated on the slopes of Toad mountain. It includes the Hall Mining and Smelting Company, the Dandy and Ollie Consolidated, the Starlight

[1] Geol. Sur., Can., Vol. ix, 1896, p. 39 R.

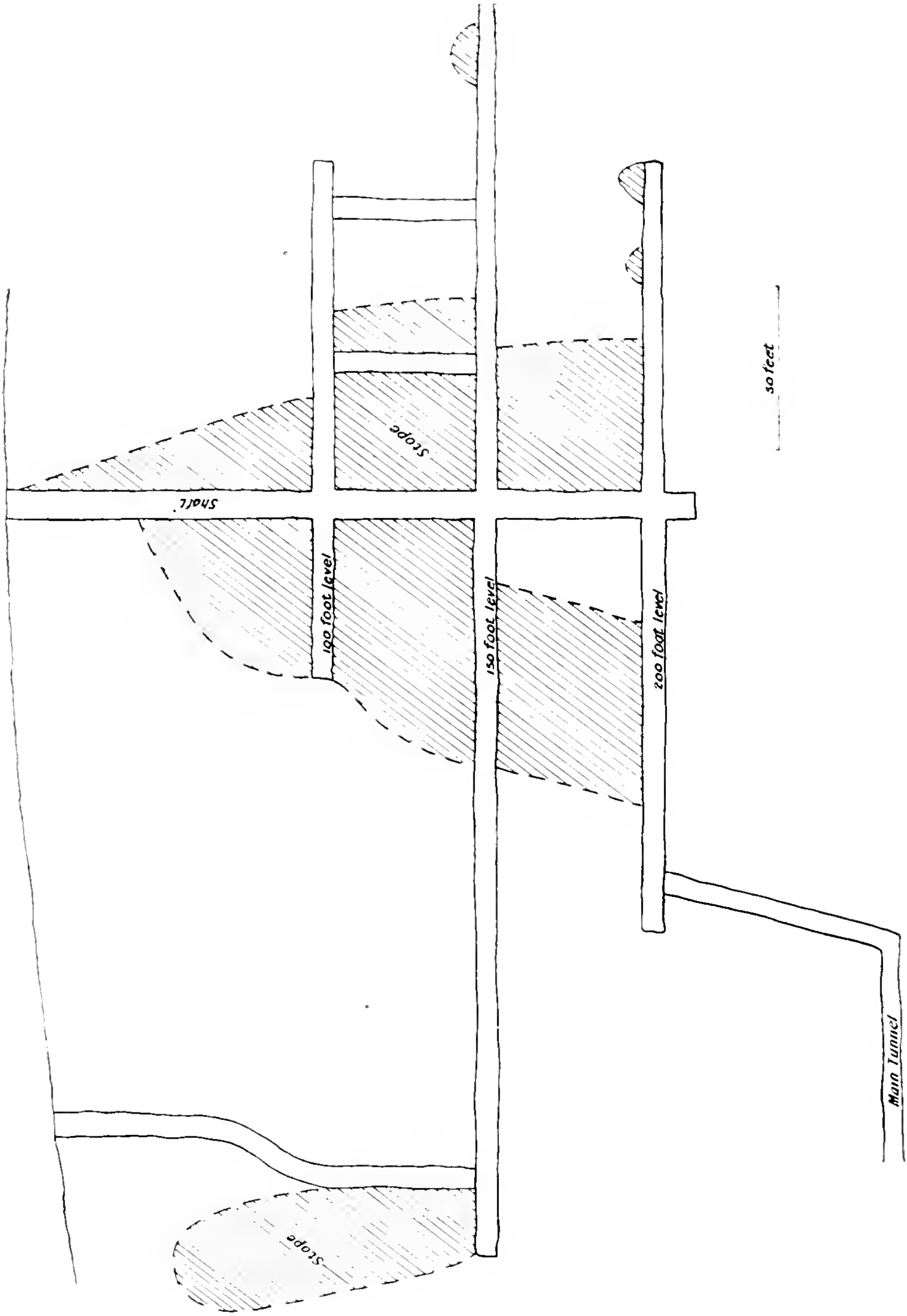



FIG. 6.—Eureka mine. Stope plan.

mines, the Kootenay Development Syndicate, and several smaller groups. This consolidation was effected by Mr. R. S. Lennie in 1910. The Silver King mine is the oldest and best known of the whole group. It is situated on Toad mountain, about 8 miles by wagon road from Nelson, and at an altitude of about 4,200 feet above Kootenay lake.

The Provincial Mineralogist has kindly furnished the following information taken from the annual official returns which show that the production to the end of 1910 amounts to 198,650 tons, containing 3,614,762 ounces of silver and 13,140,005 pounds of copper.

The mine has been developed by open-cuts, four tunnels (Nos. 1, 3, 4, and 5), with a main shaft from the level of No. 5 to the 10th level, giving a total vertical depth on the lode of 927 feet. From No. 8 level to the surface the several levels are connected by stopes and raises. As the mine was idle last season only the surface openings were examined.

There are two approximately parallel lodes, named, respectively, the main and the south vein, with a cross-vein between the 5th and 6th levels. The latter is higher in silver and lower in copper than the main lode. The country rocks consist of chlorite and sericite schists, being the sheared equivalents of hornblende porphyrite and quartz porphyry, cut by later hornblende and mica dykes. The lodes practically coincide with the schists in strike and dip. The strike of the main lode is N. 65° W. with a southwest dip varying from 55 to 70 degrees. The lodes are mineralized portions of the above schists, caused by a very complete system of cross-fissures now filled with quartz and ore. From examples seen last season the ore appears more concentrated along the fissures and gradually diminishes on passing away from them. They occur at such short intervals, however, that the metallics are sufficiently disseminated throughout to form continuous stoping ground over considerable distances. The importance of the cross-fissures was noted in the early development, as evidenced by a statement that the ore shoots crossed the lode at right angles.

The stope plan of the mine shows that the main lode has been stoped from the surface to the sill of No. 5 level (Fig. 1), and the south lode from No. 5 to the level of No. 8.

The length of the ore bodies along the pitch of 40 degrees to the east is about 730 feet, and they were stated to average 12 feet in thickness in the upper levels.

The ore consists of tetrahedrite (grey copper), chalcopyrite, pyrite, and galena disseminated through the schists and associated with quartz and calcite. The concentration of tetrahedrite at several points in the main ore-body furnished very high grade and profitable stoping ground. Bornite and occasionally stromeyerite occurred in the superficial portions.

Ore from the south lode is now being subjected to experimental tests in England. If a satisfactory solution is evolved there appears to be every indication of a large tonnage of low grade ore available for stoping. In the further development and prospecting of these low grade ore-bodies, it is by no means improbable that smaller shoots of high grade ore will be discovered.

The Dandy belongs to the same group and the claim covers the western extension of the Silver King's lode. The lowest tunnel of the Dandy is about 240 feet below the level of No. 5 of the Silver King. A limited amount of stoping has been done above the level at and east of the intersection of the cross-cut and drift. The lode averages 4½ feet in thickness and is no doubt the continuation of one of the lodes of the King. The ore consisted of chalcopyrite, pyrite, galena, some zinc blende with a gangue of schist, quartz, calcite, and some siderite.

## Non-Metallic Deposits.

*Fluorite.*—A deposit of fluorite occurs at Fivemile point just east of Troup junction, and has been opened up by a drift tunnel about 80 feet long. The country rock is granite porphyry, the vein occupying a fissure in the sheared rock. It strikes N. 60° W. and with a dip to the northeast varying from 55 to 90 degrees. The filling is largely crushed granite and gouge, having a maximum thickness of 43 inches.

A band of bluish and purplish fluorite, with a maximum thickness of 14 inches, occurs along and near the foot-wall, and smaller parallel streaks lie in the central and hanging-wall portions of the vein. Other streaks of a light grey dense siliceous material have a similar occurrence. An analysis of the latter by Mr. R. A. A. Johnston gave silica 91·28, alumina 6·16, and water 2·26. These streaks are apparently quartz containing a little kaolin from the crushed granite. Vuggs up to a foot or more in diameter with concentric banded borders are common in the fluorite bands. Barite in minute crystals and aggregates is found in some of the vuggs deposited on the fluorite.

### *Quarries.*

Two quarries are being operated at present by the Canadian Pacific railway, one 2 miles west of Nelson and one 2½ miles east of Nelson, both being adjacent to the railway tracks. The rock is a light grey to almost white granite or granodiorite, medium to coarse-grained with approximately vertical and horizontal joint planes permitting large blocks to be quarried. The stone is used entirely by the railway for culverts and bridges.

# RECONNAISSANCE IN EAST KOOTENAY.

(*S. J. Schofield.*)

## INTRODUCTION.

During the field season of 1911, geological investigation was pursued in an area to the southwest of Cranbrook, B.C., enclosed by 49° 18′ and 49° 30′ north latitude and 115° 45′ and 116° 30′ west longitude. In addition, a geological examination was made of the section across the Purcell range along the Crows Nest branch of the Canadian Pacific railway from Wardner to Sirdar. McEvoy's topographical map of East Kootenay was used as a base in detailing the geological boundaries. Mr. L. E. Wright again ably assisted in the work.

## SUMMARY AND CONCLUSIONS.

The region is underlain by a huge thickness of sedimentary rocks, the Purcell series of Cambrian or Pre-Cambrian age, intruded by numerous sills of diorite and small cross-cutting bodies of granite and granite porphyry. Mountain building forces, acting probably in post-Jurassic time, folded the sediments into a series of anticlines and synclines trending for the most part in a northerly direction. Normal faulting followed, the faults having a northeast-southwest strike. Thus the strike of the fault blocks in the Purcell range is at right angles to that of the Rocky mountains to the east, which have a northwest-southeast trend. An area of Carboniferous limestones occupies the Kootenay River valley or Rocky Mountain trench in the neighbourhood of Wardner. This is interpreted as a down-faulted block of Mississippian limestone in contact on the east and west with the Purcell series which is Cambrian or Pre-Cambrian in age. Hence the Kootenay valley in this region is a "graben." The presence of this limestone supports the idea that Carboniferous rocks once were present in the Purcell range and have since been removed by erosion.

The silver lead deposits of commercial importance were found, as was the case last year, to be confined to the younger members of a formation, which in previous reports on this area, has been called the Kitchener formation. In these ore deposits the pay-chutes are, in general, restricted to the massive and purer quartzites. Where the vein traverses the thinner, more argillaceous members, it is barren or filled with quartz containing small quantities of iron and copper sulphides. The members of the above sedimentary formation favourable for the deposition of silver-lead ores occur in greater abundance near the top of the formation, but are also present to some extent throughout its whole thickness.

## GENERAL GEOLOGY.

The great thickness and the homogeneous character of the sediments of the Purcell series have rendered difficult the attempt to correlate this series in East Kootenay with the apparently analagous series of the Boundary belt, although the two regions are in close proximity.

TABULAR DESCRIPTION OF FORMATIONS.

| | |
|---|---|
| Pleistocene and Recent | Unconsolidated gravels and sands. |
| Jurassic ? | Dyke intrusion ; aplite, lamprophyre and granite porphyry. |
| | Granite intrusion ; granite, granite porphyry. |
| Carboniferous— Mississippic | Wardner limestone. |
| Cambrian ? Purcell Series | (c) Thin-bedded grey to chocolate brown argillites and sandy shales with some quartzites and conglomerates. Thin bedded lava flows occur at various horizons. Estimated thickness 10,000 feet. |
| | (b) Light grey argillaceous quartzites and purer quartzites, estimated thickness 9,000 feet. |
| | (a) Rusty weathering heavy and thin bedded argillaceous quartzites, purer quartzites and slates. Numerous sills of gabbro occur at various horizons. Estimated thickness, 6,000 feet. |

PURCELL SERIES.

The oldest member of the Purcell series in East Kootenay consists of an alternating series of heavy-bedded and thin-bedded argillaceous quartzites and purer quartzites. The massive members are coarser in texture and grey to black on fresh fracture, and weather for the most part in grey tones, while the thinner-bedded, more argillaceous members, are a very dark grey on fresh fracture and weather a rusty brown, and being in great abundance, give the formation its typical rusty-red colour as a whole. This formation also contains the greater number of diorite sills and is the most favourable for ore deposition.

In the previous summary reports for 1909 and 1910,[1] the oldest member, as described this year, was correlated with the Kitchener, the succeeding member with the Creston, and the youngest member with the Moyie. This correlation was based solely on lithological characters, for the stratigraphic relations were obscured by heavy faulting and folding of the strata. In the lack of direct evidence to the contrary, the stratigraphical succession was supposed to be the same as found by R. A. Daly[2] along the International Boundary, *i.e.*, in ascending order, Creston, Kitchener, Moyie. This year a favourable section was found in which the strata were seen in their true relations. At this locality, the section, if the assumed correlation held true, was determined to be in ascending order, Kitchener, Creston, and Moyie.

As the stratigraphic succession in the Cranbrook map-area apparently does not correspond with that of Daly along the International Boundary, the term Kitchener has, therefore, been dropped from that pre-Creston formation in the former area. The Creston formation, however, appears to be identical in both areas, and there are no data yet available that would change the position of the Moyie. The three formations of the Cranbrook sheet in ascending order are pre-Creston, Creston, Moyie.

Lying conformably on the above series of rusty-weathering argillaceous quartzites, and passing into it by gradual transition, occurs a series of light grey argillaceous quartzites and purer quartzites, which is, on the whole, more massive than the older formation. The heavy massive beds are often separated by thin bands of argillite. The staple rock in this series is generally light grey on fresh fracture, and because it weathers grey it gives the whole formation a greyish-white appearance which is very distinctive in the field. This formation is correlated with the Creston formation of the Boundary Survey.

This series of grey weathering quartzites gradually passes upwards into a series of thin-bedded argillites and sandy shales with a few interbedded argillaceous quartzites and conglomerates. The shales are grey to chocolate-brown in colour, and hold abundant shallow water indications such as mud-cracks and ripple-marks. Litho-

[1] G.S.C. Summary Report, 1909, pp. 135-138.
G.S.C. " " 1910, pp. 130-134.

[2] Summary Report, Geol. Surv., Canada, 1904, pp. 91 A-100 A.

logically this group resembles the Moyie formation of the Boundary Survey, but does not correspond to it in stratigraphical position, since along the International Boundary the Kitchener formation intervenes between the Creston and Moyie.

*Purcell Sill Intrusion.*

The Purcell sills occur as tabular intrusive masses in the Purcell series, and are particularly numerous in the oldest subdivision of the series. They vary from a few feet in thickness in the area examined. The rock types vary from a very acid granite to a hyper-thene gabbro, and the relations of these types are now under investigation.

*Dyke Intrusives.*

Small aplitic and lamprophyric dykes are associated with the Purcell sills.

WARDNER LIMESTONE.

Down-faulted against the Purcell series in the Kootenay valley, in the neighbourhood of Wardner, is a block of limestone, Mississippian in age. It is mostly grey in colour, weathers a greyish-white and contains the following fossils, identified by Dr. E. Raymond.

*Camarophoria explanata*, (McChesney),
*Leiorhynchus*, sp. ind.
*Camarotœchia* cf. *C. metallica*, (White).
*Composita madisonensis*, (Girty),
*Cleiothyridina crassicardinalis*, (White),
*Spirifer* cf. *S. centronatus*, (Winchell),
*Productella cooperensis*, (Swallow).

*Granite Intrusion.*

Numerous small bodies of granite cut the Purcell series, but in no place was the granite found in contact with the Wardner limestone. The granite is lithologically similar to the Nelson granite and can probably be correlated with it.

*Dyke Intrusives.*

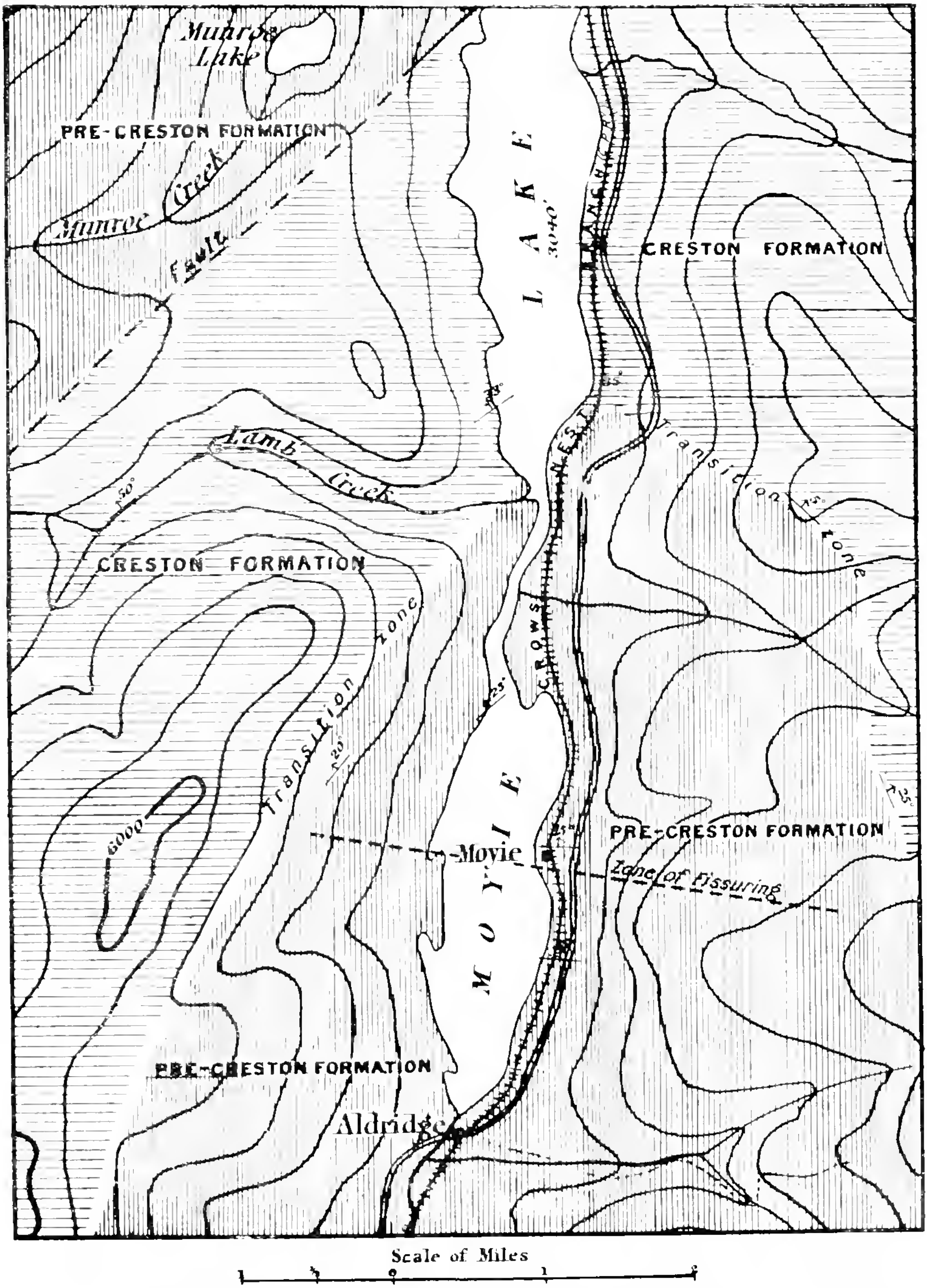
Cutting the granite and occurring as apophyses in the sediments are numerous small dykes of aplite and granite porphyry.

PLEISTOCENE DEPOSITS.

Covering the valley floors of all the master streams are deep deposits of stratified clays, sands, and gravels into which the rivers have entrenched themselves, leaving well-marked terraces along their courses.

ECONOMIC GEOLOGY.

The principal ore-bearing formation in East Kootenay is the oldest member of the Purcell series, called the Kitchener formation in previous reports of East Kootenay. The principal ore-bearing horizon is the upper part of this formation where the heavy-bedded quartzites occur in greater abundance. At this horizon are the Sullivan, North Star, Stemwinder, St. Eugene, Aurora, and Society Girl mines. There are two areas in the region examined which are of special importance, the Moyie and Kimberly districts.




DIAG. 8. Geological and structural relations of two formations of the Purcell series, near Moyie, B.C. Topography by J. McEvoy, 1912. Geology by S. J. Schofield, 1911.

### THE MOYIE AREA.

The Moyie area embraces the region around Lower Moyie lake. It is underlain by the Purcell series, which is here folded into a northerly-plunging anticline, whose axial part is made up of the oldest member of the Purcell series, while the radial parts consist of the grey-weathering argillaceous quartzites which lie conformably on the older formation. The field relations of these series and their distribution is shown on the accompanying cut. Crossing this anticline in an easterly direction is a very extensive zone of fissuring which dips about 70 degrees to the south.

There are two main fissures on both the east and west side of Lower Moyie lake, and it is probable that they occur underneath the lake. The general trend of the fissures is shown on the accompanying zinc cut. The walls bounding the main fissures show very little evidence of relative displacement, the greatest movement observed being 18 inches, although in such a homogeneous series of quartzites the detection of such movement might be difficult. In general, the pay-shoots are associated with the massive, purer quartzites which are less aluminous and more capable of forming an open fissure. The purer quartzites are also more easily replaced by the ore solution.

### *The Aurora Group of Claims.*

The Aurora group, operated by the Aurora Mining and Milling Company of Moyie, B.C., consists of five Crown-granted claims—the Aurora, Horse Shoe, Durang, Etna, and Portland, situated on the west side of Lower Moyie lake, opposite Moyie, B.C. The vein occurs on the east and west system of fissuring described in the general description of the district, and possibly on the southern of the two main fissures, which here has a general strike east and west, but varies as much as 15 degrees from this direction. The dip of the vein is 60 degrees to the south. The vein cuts across the oldest subdivision of the Purcell series, which here strikes northeast with a dip of 50° to the northwest.

The formation is made up of thin-bedded argillaceous quartzites (locally called slate) and massive purer quartzites, which here form the western limb of the northerly-plunging anticline described above. The vein has a maximum observed width of 6 feet, and consists of zinc blende and galena with very little gangue. Occasionally fragments of wall-rock are enclosed by the ore. In the report on the zinc resources of British Columbia, the following assay of the ore is quoted: gold. 0·02 ounce; silver, 7·3 ounce; lead, 21·5 per cent; zinc, 33 per cent. The ore, represented in the Aurora is also considered by the same commission to be the simplest to treat of any of the ores examined in their series of experiments.

Development on the property consists of about 1,500 feet of workings, mostly in the form of tunnels. Operations on this property are suspended, for at present there is no demand for zinc ore in British Columbia.

### *The Guindon Group of Claims.*

This group, consisting of the Guindon, Fereole, Alica, and St. Joseph fractions, is located in the territory adjoining the Aurora group to the north. The vein on which these claims are located is about 700 feet north of the Aurora vein and has an east and west strike with a dip of 60° to the south. The formation which the vein traverses is the oldest subdivision of the Purcell series, which here strikes northeast and dips 20° to the south. The vein is from 4 to 5 feet wide, and in one tunnel the ore was 18 inches in width and consisted of galena, zinc blende, and some pyrite. Development work consisted of a few short tunnels.

*The Cambrian and Mabelle Claims.*

The Cambrian and Mabelle Crown-granted claims, operated by the Cambrian Mining Company, Limited, of Moyie, B.C., embrace the territory between the St. Eugene Consolidated and the Aurora, and thus lie for the most part under the waters of Lower Moyie lake. The extensive zone of fissuring described in the general statement, and which occurs on both sides of the lake, is to be expected to occur in the intervening territory, and as the veins are mineralized in the St. Eugene Consolidated and in the Aurora, it is logical to expect that the Cambrian and Mabelle claims will also be productive. The sounding of the lake on the Cambrian and Mabelle claims revealed the maximum depth of water to be 140 feet, and in addition 90 feet of blue clay and hard-pan covers the bottom of the lake. This last information was supplied by Chas. A. MacKay, of Moyie, B.C., one of the directors of the Company.

*St. Eugene Consolidated Mining Company.*

The claims operated by this Company comprise an area of 520 acres, situated on the east side of Lower Moyie lake. The property contains two veins, having a general strike east and west with a dip of 70° to the south. The two veins are 600 feet apart on the 1,000 foot level, which is 1,000 feet above the level of the lake. They apparently converge downwards and to the west. Connecting the two main veins, at variable distances apart, is a series of important cross-veins, which meet the main veins, in general, at a small angle. Locally these cross-fissures are termed "avenues." The ore bodies are mainly confined to the fractured and folded area between the main veins, and in places large ore-chutes occur where the avenues meet the main veins, or close to this junction. Very little displacement was noticed along the main fissures, although slight folding or bending of the strata occurs in close proximity to these fissures. The country rocks consist of argillaceous quartzites, and purer heavy-bedded quartzites of the pre-Creston, the oldest subdivision of the Purcell series, which here form the axis and eastern limb of the anticline described above. The ore-bodies are associated with the massive purer quartzites of the above formation. The ore consists of galena, both fine and coarse-grained, associated in places with zinc blende. The gangue, which is small in amount, consists of garnet, anthophyllite (a variety of amphibole), and a little quartz, the latter mineral being very prominent where the vein pinches in the argillaceous quartzites. Locally the wall-rock in the immediate vicinity of the ore-bodies shows strong metamorphism in the development of garnet and anthophyllite.

*The Society Girl.*

This group comprises seven Crown-granted claims operated by the Society Girl Mining Company, Limited. They are situated about 2 miles east of Moyie at an elevation of about 5,000 feet, and adjoin the eastern boundary of the St. Eugene Consolidated. The formation, in which the deposit occurs, is the oldest known subdivision of the Purcell series, which here strikes north and south with a dip of 25° to the east and forms the eastern limb of the anticline described above. The vein, where examined, strikes N. 60° W. with a dip of 60° to the south, and appears to be in the great zone of fissuring which traverses the Moyie area. The vein is narrow where it traverses the thin-bedded argillaceous quartzites and widens out in the heavier-bedded quartzites.

The upper workings expose an oxidized ore-body consisting of cerussite and pyromorphite, both massive and in beautiful crystals. The pyromorphite is a yellowish green in colour and has been described both crystallographically and chemically by Bowles.[1] He gives the composition as $Pb_5\ Cl\ (PO_4)_3$..

The cerussite is white to colourless and occurs in tabular orthorhombic crystals either singly or as penetration twins. Massive cerussite is also present. The cerussite is often embedded in dense masses of limonite. The oxidized ore-zone is a rare occurrence in East Kootenay. The unoxidized or primary ore, consisting of galena and zinc blende with little or no gangue, is exposed in the lower tunnel which penetrates the ore-body 250 feet below the surface. At present the ore is hand-sorted and then sent to the smelter at Trail for treatment. For the year 1911 up to the end of September, the total output of the mine amounted to about 400 tons. The galena carries 1 ounce of silver to 4 per cent lead, while the oxidized ores carry 1 ounce silver to 5½ per cent of lead.

### THE KIMBERLEY AREA.

The area is situated near Kimberley, the terminus of the Canadian Pacific Railway branch line from Cranbrook to Kimberley, and includes the Sullivan, Stemwinder, North Star, and several minor properties. It is underlain by a series of argillaceous quartzites and purer heavy-bedded quartzites, which are identical in lithological and physical characters with those described in the Moyie district, and hence belong to the lowest known subdivision of the Purcell series. About one-half mile above Kimberley, on Mark creek, a few diorite sills are exposed in the valley walls.

#### *Sullivan Group.*

This group was discovered in 1895, and is located on Sullivan hill about 2½ miles by road north of Kimberley, at an elevation of about 4,600 feet above sea-level. The deposit lies in the lowest known subdivision of the Purcell series, which here strike about north and dip from 10° to 60° to the east. The country rocks consist of thin-bedded argillaceous quartzites and heavy-bedded, purer quartzites. The ore-body conforms in dip and strike with the quartzites and cannot be called a true fissure vein, but a replacement deposit in which the sulphides have replaced the fine-grained quartzites. The hanging and foot-walls are, in general, not well defined, but the ore gradually passes into the normal country rocks so that the distinction between country rock and ore is commercial rather than structural. Exceptions to this occur where the walls consist of the thin-bedded slaty quartzites which are evidently difficult to replace. In the upper workings, close-folding later than the ore deposition increases the apparent width of the deposit. On the 60 foot level the dip of the ore-body in places approximates 25°, and on the 100 foot level the dip increases to 70°, which is also the dip of the surrounding quartzites. As far as exploited, the maximum stope width is 120 feet and the maximum stope length 325 feet. There are nine levels, the deepest being 100 feet below the surface. The deposit is a lens-shaped mass striking about north and south with a dip to the east.

The ore-body is arranged in distinct zones which grade imperceptibly into each other. The centre of the body is occupied by a fine-grained mixture of galena and zinc blende in which masses of purer galena occur as lenses. The gangue in this inner zone is absent, except for a few well-formed crystals of pink garnets. This inner portion gradually passes exteriorly into a fine-grained mixture of pyrite, pyrrhotite, and zinc blende which contains as a gangue numerous crystals of a clear colourless garnet with some grains of anthophyllite and possibly diopside. The sulphides gradually diminish in amount and finally give way to a fine-grained chert which is present where the country rock is a heavy-bedded, purer quartzite, and is absent where a more argillaceous slaty member constitutes the wall-rock. No garnets

[1] Am. Jour. Sci., 4th Series, Vol. XXVIII, p. 40.

or anthophyllite are present in this zone. The chert gradually passes into the normal quartzite. The contact minerals occur only in the ore-body and are entirely lacking in the country rock surrounding the deposit. The presence of the minerals, garnet, and diopside, so characteristic of contact deposits, is not due to any intrusion of igneous material at present visible, for the nearest outcrop of granite is 4 miles away, near Wycliffe, on the St. Mary prairie. The presence of the minerals, garnet, pyroxene, and pyrrhotite warrants the conclusion that the Sullivan ore-body was formed under conditions of high temperature and pressure, and in origin was connected with some deep-seated intrusion of granite which has not yet been exposed by erosion in the neighbourhood of the Sullivan mine. The Stemwinder property, occurring in Mark creek and apparently in a lower horizon than the Sullivan, indicates that ore-bodies might be expected below the Sullivan deposit.

The ore is shipped to Trail for treatment and is melted without any preliminary concentration.

Development and constructional work is being rapidly pursued and a force of 100 men is employed.

### *The Stemwinder.*

The Stemwinder is situated about 1 mile northwest of Kimberley on Mark creek. The country rocks consist of argillaceous quartzites intruded by several sills of diorite. The ore-body is enclosed entirely by the quartzites and closely resembles the Sullivan deposit in its occurrence and mineralogy. The interior of the ore-body consists of a fine-grained mixture of galena and zinc blende passing exteriorly into a fine-grained mixture of pyrrhotite, pyrite, and zinc blende. This is succeeded by a cherty layer which in turn passes into normal quartzite. The amount of development so far accomplished was not sufficient to expose the relation of the ore-body, but it is evidently of large size. Three short tunnels and a shaft 75 feet deep open up the deposit. Experiments are in progress to determine the best methods for the treatment of this refractory ore.

# RECONNAISSANCE OF THE SHUSWAP LAKES AND VICINITY (SOUTH-CENTRAL BRITISH COLUMBIA).

(*Reginald A. Daly.*)

## INTRODUCTION.

The writer spent most of the season in a partial reconnaissance of the area (6,400 square miles) covered by the Shuswap sheet, which was engraved for the Survey in 1898 (Publication No. 604). That sheet was geologically coloured by George M. Dawson, who had combined the results of his own field work with that performed by McEvoy in his many arduous traverses of this district. No detailed report to accompany the map-sheet has been published. One object of the 1911 season was to collect facts which can be used in the future preparation of such a report.

The work was also planned to be part of that required in the development of a geological map and section, which is to extend along the main line of the Canadian Pacific railway from the Great Plains to the Pacific ocean. In connexion with the latter project the writer made traverses along the railway eastward and westward from the respective limits of the Shuswap sheet. The total length of the railway section traversed is 200 miles, extending from the summit of the Selkirks to the western end of Kamloops lake. Additional field work is required in the stretch from Revelstoke eastward; the structure section actually completed is 150 miles long, and lies between Revelstoke on the Columbia river and Savona on Kamloops lake.

The most important problems of the region concern the composition, structure, and stratigraphic relations of the Pre-Cambrian rocks, which cover a large part of the area mapped in the Shuswap sheet. A considerable part of the season was spent in an examination of the shores of the Shuswap lakes and of Adams lake, which occupy deep valleys sunk in the Pre-Cambrian terrane. Rock outcrops are there much more abundant than on the adjacent, densely-wooded mountains. Outside the railway section, about 200 miles of lake-shore traverse were run.

In the field the writer was efficiently assisted by Mr. N. L. Bowen.

## SYNOPSIS OF CONCLUSIONS.

The results which seem to be established are the following:—

(1.) Dawson's "Niskonlith series," outcropping in his original section across the Selkirk mountains, is not of Cambrian age as now defined, but represents the northern continuation of the "Beltian"[1] (pre-Olenellus part of the Belt terrane) rocks at the International Boundary. As suggested by Dawson, these rocks are to be correlated with the pre-Olenellus portion of the Bow River series of the Rocky mountains.

(2.) The "Niskonlith series," mapped in the Shuswap sheet area, is an entirely different, pre-Beltian as well as pre-Cambrian, group of sediments, which unconformably underlie the "Niskonlith series" of the Selkirk section.

(3.) The "Adams Lake series (volcanic)" which conformably overlies the thick limestones of Dawson's "Niskonlith series" of the Shuswap Lakes area, is also of pre-Beltian age.

(4.) The "Shuswap series" of the Shuswap lakes is not a distinct gneissic group unconformably underlying the "Niskonlith" sediments, but is the facies of those

[1] Systemic name suggested by C. D. Walcott in Smithsonian Miscellaneous Collections, Vol. 53, 1908, p. 169.

sediments where thermally metamorphosed and injected by pre-Beltian granites.

(5.) Since the sediments of the "Shuswap series" and "Ni-koulith series" and the basic volcanics of the "Adams Lake series" (as mapped by Dawson) are conformable throughout, it is proposed that the definition of "Shuswap series" be so enlarged that it shall include all these pre-Beltian rocks.

(6.) Though this Shuswap series is everywhere composed of typical crystalline schists (with crystalline limestones and quartzites), their regional metamorphism was not due to dynamic action. The writer agrees with Dawson in holding that this metamorphism was "static": the stress directing the recrystallization was induced by deep burial and dead-weight.

(7.) The Pre-Cambrian rocks are much less deformed (upturned) than the overlying Carboniferous or Triassic rocks. This fact illustrates the small depth of the earth-shell which underwent strong folding in post-Cambrian time.

(8.) The petrography of the pre-Beltian terrane (Shuswap series and granitic intrusions) strongly suggests that it furnished the greater part of the clastic material in the Rocky Mountain geosynclinal prism.

(9.) The observations regarding the post-Cambrian formations of the region studied, tend to confirm Dawson's conclusions, except that the Tertiary lavas and interbedded fresh-water sediments are believed to be of Oligocene age, rather than Miocene, as indicated on the engraved Shuswap and Kamloops sheets.

## Table of Formations.

The principal object of the summer's work was to collect facts bearing on the stratigraphy of the region. The results are definite as to the general succession of the rock formations. The following table, which bears some provisional names, gives the sequence actually determined.

| | | |
|---|---|---|
| *Pleistocene* | Thompson River silts. Glacial drift. | |
| | *—Unconformity—* | |
| *Oligocene* | Basic lava sand fresh-water sediments. | |
| | *—Unconformity—* | |
| *Probably late Jurassic* | Granite batholiths cutting the Nicola series. | |
| *Triassic (and Jurassic?)* | Nicola series: basic lavas, with ash-beds, sandstones, argillites, and rare limestone lenses. | |
| | *—Unconformity—* | |
| *Carboniferous* | Limestones, cherty quartzites, argillites, and basic volcanics. | |
| | *—Unconformity—* | |
| *Cambrian (?)* | Glacier quartzite division. | Selkirk series. |
| *"Beltian" (Pre-Cambrian)* | Albert Canyon division: argillities, carbonaceous limestones and quartzites. | Selkirk series. |
| | *—Unconformity—* | |
| *Pre-"Beltian" (Pre-Cambrian)* | Granite batholiths, sills, and dykes, cutting the Shuswap series. Shuswap series: limestones, metargillites (phyllites), mica schists, paragneisses, green schists, and greenstone. | |

## Shuswap Series.

### Composition.

The oldest rocks form a composite mass, which is known to be of very great thickness, though neither base nor top has been discovered. On the shores of Shuswap lake, from Sicamous to Cinnemousun narrows, a section was run, the statement of which will give an idea of the magnitude of this most ancient terrane yet recognized in British Columbia.

| | | Approximate thickness in feet. |
|---|---|---|
| | *Top of series not exposed.* | |
| | Green schists | 2,000+ |
| | Cinnemousun limestone | 600 |
| | Green schists | 1,000 |
| | Phyllites | 800 |
| | Limestone with phyllitic interbeds | 1,000 |
| | Phyllites | 600 |
| | Green schists | 6,000± |
| | Phyllitic schists | 6,500+ |
| | Sicamous limestone (phyllitic and carbonaceous) | 3,200 |
| | Phyllite | 300 |
| Thermally metamorphosed | Coarse mica schists | 1,500+ |
| | Massive calcareous quartzites with interbeds of mica schists | 3,000+ |
| | *Base concealed.* | |
| | Total | 26,500+ |

On Adams lake, green schists, corresponding in general horizon to those noted at the top of this column, are overlain by at least 2,000 feet of phyllitic schists. These are overlain, in ascending order, by 1,600 feet of massive limestone (marble), 800 feet of phyllite, 1,500 feet of phyllitic limestone, and an enormous mass of greenstone, with an apparent thickness of at least 10,000 feet. This greenstone is truncated by a large Pre-Cambrian batholith. The schistose rocks on Adams lake may be largely the same as those on Shuswap lake, being repeated in outcrop by normal faulting.

### RE-DEFINITION OF "SHUSWAP SERIES."

With the exception of the Sicamous limestone and the underlying formations, all of these rocks on both Shuswap and Adams lakes were mapped by Dawson as belonging to his (Cambrian) "Adams Lake series." He mapped the Sicamous limestone under the name, "Niskonlith series," and regarded it as likewise Cambrian in age.

The writer has been forced to different conclusions, which are based on studies more detailed than Dawson could make during his reconnaissance. Many other sections, besides those above noted, show that there is apparently perfect conformity throughout the whole series, from the lowest schists and quartzites to the top of the thick greenstone on Adams lake. All these rocks are not only Pre-Cambrian, but are also pre-"Beltian," to adopt Walcott's suggestion of a period name covering the time occupied in the deposition of the "Belt Terrane" sediments, of pre-Olenellus age.

Wherever exposed, the lower beds of this great series are intensely metamorphosed by batholiths of biotite granite or hornblende-biotite granite. At the roof or walls of each batholith the magma was forced into the highly fissile sediments, forming sills in such number and of such persistence as had never before been encountered in the writer's experience. The sills are often composed of the normal batholithic granite, but vast numbers of them are aplitic or pegmatitic. Very numerous dykes of similarly varying composition are likewise apophysal from the great magma chambers.

The thermal metamorphism of the sediments is roughly proportional to the number of these satellitic injections. The metargillites or phyllites have been converted into coarse, glittering muscovite-biotite schists or paragneisses; the calcareous beds into marbles, coarse crystalline limestones, or masses of lime-silicates. It was to these coarsely crystalline phases of the sediments, together with the intrusive sills, that Dawson originally gave the name "Shuswap series." At first he regarded the granite as in part the fused equivalent of these same sediments, but later became more and more convinced of its eruptive nature.

In view of the perfect conformity which seems to exist throughout the sediments and greenstones, the writer proposes that the name "Shuswap series" be extended to cover this whole group, together with any additional rocks which, in the future, may be found conformably below or above the formations here described. The "Adams Lake series" may accordingly be called the "Adams Lake greenstone," a member of the Shuswap series. The "Niskonlith series" of the Shuswap Lake region is the Sicamous limestone, another important member.

### ORIGIN OF THE GREENSTONES AND GREEN SCHISTS.

Dawson described the "Adams Lake series" as of volcanic origin. The description may be quite correct, but it is a remarkable fact that the present writer has found no clear evidence of an extrusive origin for greenstone or green schist, either in the field or in the study of many microscopic sections. Traces of porphyritic and granular structure have been found, but not one undoubted relic of pyroclastic, amygdaloid, or lava flow. It is certain only that the greenstones and green schists have been derived from highly uniform masses of basic eruptive rock, of basaltic, diabasic, or gabbroid composition. So far as the study has progressed, the writer is inclined to believe that some, perhaps much, of the greenstone is intrusive, as sills or irregular masses. Probably, however, the larger part is of extrusive origin.

### STATIC METAMORPHISM.

The difficulty in finding the exact origin of the green rocks is explained by their unusually thorough metamorphism; they are now chloritic and talc schists. Their fissility is usually extreme, so that it was often hard to secure a convenient specimen thick enough for thin-sectioning. Drastic recrystallization has also affected the sediments at every observed horizon. The effect has been to develop typical crystalline schists, indistinguishable from those so often produced in zones of intense deformation.

Yet it is clear that the general or regional metamorphism of the Shuswap series is not of dynamic origin. The full proof of this conclusion cannot be given in a summary report, but a few pertinent facts may be stated. With rare exceptions, bedding and schistosity are parallel in the Shuswap sediments. The average dip for an area of at least 800 square miles is very probably less than 45°. For several miles together, in well exposed areas, the dip ranges from 10° to 25°, while elsewhere the schistose sediments may be practically horizontal for considerable areas. In this case it is not possible to explain the low dips as those expected in a series of blocks dynamically metamorphosed by tangential thrust and then overthrown to recumbent positions. The crystallinity of the rock generally bears no relation to the angle of dip. The writer finds most satisfaction in adopting Dawson's view that the regional metamorphism is here simply due to deep burial under Pre-Cambrian sediments or volcanics. Deep burial of a surface rock means a raising of its temperature and, so long as the rock remains solid, it must undergo gravitational "stress." Recrystallization with the development of schistosity is hastened by the presence of water or other solvents. Since the lower beds of a great geosynclinal prism are nearly or quite horizontal, the dead-weight "stress" must produce schistosity sensibly parallel to the planes of stratification. This recrystallization is regional but is not connected with rock shearing as in the well-recognized type of dynamic metamorphism. Milch has given the name "*Belastungsmetamorphismus*" to such recrystallization under dead-weight stress. Probably Judd's word "static" is the best descriptive term in English.

Metamorphism of this kind is recorded in the flat schistosity of great areas of Pre-Cambrian rocks in the International Boundary section, in eastern Canada, in Greenland, in the German Grundgebirge, etc. The fact that it is not prominent anywhere in the relatively young Mesozoic geosynclinals, even 5 or 6 miles deep, suggests that possibly the earth's temperature gradient was steeper in the Pre-Cambrian than it has been in more recent time.

Locally superposed on the schistosity due to static metamorphism is that later produced, in certain zones, by dynamic metamorphism. The two are often easily distinguished in the field, and both can generally be distinguished from the primarily thermal metamorphism near the batholith contacts. In this field static metamorphism clearly dominates over the other two kinds.

### STRUCTURE OF THE SHUSWAP TERRANE.

Apart from local crumplings, systematic folding is extremely rare in this older Pre-Cambrian complex. The mass seems to have been deformed chiefly by normal faulting. Some of this deformation was already accomplished before the Beltian (Belt series of) sediments were deposited. The average strike of the Shuswap schists runs E.N.E.-W.S.W., that is, nearly at right angles to the N.W.-S.E. trend of the post-Triassic Cordillera. Only quite locally was the rock of the oldest visible terrane upturned so as to exhibit the typical Cordilleran strike.

A second important contrast to the younger formations of the region is implied in a foregoing paragraph. Unlike the Shuswap sediments, the Carboniferous and Triassic rocks almost always dip at high angles. For comparison an estimate was made of the average dips in three typical areas of about 100 square miles each, respectively underlain by Shuswap, Carboniferous, and Triassic rocks. The result is:—

| Terrane. | Average Dip. |
|---|---|
| Shuswap | 20° |
| Carboniferous | 75° |
| Triassic | 60° |

The conclusion seems to be that the deepest-lying terrane has been the least disturbed of the three; that the late Jurassic, Laramide, and mid-Tertiary folding took place in a relatively thin shell of the earth's crust. There is no evidence that the Pre-Cambrian terrane of the Shuswap area has ever been subjected to intense tangential stress. A similar condition is represented in the structure of the European Alps. Its repeated occurrence enforces belief in the importance of the fact for the general theory of mountain building. The earth-shell here subjected to orogenic folding is only a few miles in depth.

## SELKIRK SERIES.

### RELATION TO SHUSWAP SERIES.

The basal complex, including the Shuswap sediments and green schists, together with the numerous Pre-Cambrian sills, dykes, and batholiths, became moderately deformed and eroded. East of the Columbia river, at Revelstoke, its eroded surface was depressed and an enormous thickness of stratified rocks was piled upon it. These rocks compose most of the high Selkirks of the present day. Dawson divided them into an older "Niskonlith series" and a younger "Selkirk series," but recognized perfect conformity between the two series.[1] He regarded both series as of Cambrian age, having found unconformity between the "Niskonlith series" and the orthogneisses of the "Shuswap series" at Albert Canyon.

The writer has confirmed Dawson's discovery of that unconformity. Though the exposures of the "Niskonlith series" in the Selkirk range are unusually complete, not a single dyke or sill of aplite or granite could be found in those rocks either at or above the basal unconformity at Albert Canyon. The orthogneiss west of Albert Canyon and immediately below the plane of unconformity, is penetrated by such dykes and sills in great abundance. The Sicamous limestone, described and mapped by

[1] G. M. Dawson. Bulletin, Geological Society of America, Vol. ii, 1891, p. 168; Vol. xii, 1901, p. 66.

Dawson as the typical "Niskonlith" of the Shuswap lakes, is often traversed by sills and dykes of aplite, pegmatite, and granite (orthogneiss). That fact was apparently overlooked by Dawson in correlating these sediments of the Selkirks with the Sicamous limestone. As already implied, the "Niskonlith series" of the Selkirk range is a younger and quite different group of rocks from that of the "Niskonlith series" mapped in the Shuswap sheet area. This conclusion is sustained by the great lithological contrast of the two series, as well as by their structural relations.

Further, it was found, on the ground, that the name "Niskonlith" cannot be used appropriately for either of the groups of rock to which Dawson attached it. The belt of "Niskonlith" rocks, mapped by Dawson at Niskonlith lake, is narrow and poorly exposed, but it is almost certainly post-Cambrian in age. In fact, it probably represents the upper part of the Nicola series, and is thus of either Triassic or Jurassic date.

The writer believes it advisable to drop the name "Niskonlith series" as a designation for any of the rocks so named by Dawson.

### RE-DEFINITION OF SELKIRK SERIES.

On the other hand, Dawson's "Selkirk series" should also include all the sediments extending from the basal unconformity at Albert canyon to the base of the thick quartzites, which he originally includes in that series. For clearness in the present report, the Selkirk series, as exposed between Albert canyon and Rogers pass at the summit of the Selkirk range, is divided into two parts: the Glacier quartzite division (Dawson's original "Selkirk series") and the underlying Albert Canyon division (Dawson's "Niskonlith series").

A preliminary estimate of the thickness of the Albert Canyon division is 18,000.-20,000 feet, or more than the 15,000 feet which Dawson attributed to the "Niskonlith series." The basal member is not a conglomerate, but a quartzitic sandstone or arkose. This member is known to be more than 200 feet thick. Above it lies a vast thickness of argillaceous rock with subordinate interbeds of carbonaceous limestone and quartzite. These rocks have been statically metamorphosed and are now micaceous or phyllitic in largest part (metargillites, micaceous quartzites and limestones). They form a gigantic monocline of dark grey beds, dipping conformably under the white to light grey quartzites so wonderfully exposed around Glacier House.

The writer believes that Dawson's estimate of 25,000 feet for the thickness of those quartzites is justified as to order of magnitude, though the youngest beds were seen, this season, only at a distance.

### CORRELATION.

No fossils have yet been reported from either division of the Selkirk series. Many lithological and stratigraphical features agree in suggesting that the Albert Canyon division and the lower part of the Glacier division together represent the Pre-Cambrian "belt terrane" of the 49th Parallel section. There is no reason to doubt Dawson's correlation of the upper quartzites of the Selkirk series with the fossiliferous Cambrian rocks of the Rockies; following Dawson, the sediments now grouped as the Albert Canyon division are, for the present, best correlated with the pre-Olenellus portion of the Bow River series.

The new and old correlations of the Pre-Cambrian rocks are shown in the following table.

| | Shuswap Lakes Region (Columbia Mountain Range and Interior Plateaus). | Selkirk Range. |
|---|---|---|
| | **Correlation by Dawson.** | |
| *Cambrian* | Adams Lake series | Selkirk series. |
| *Cambrian* | Niskonlith series | Niskonlith series. |
| | —*Unconformity*— | —*Unconformity*— |
| *Pre-Cambrian* | Intrusive granites | Intrusive granites. |
| *(Archæan)* | Shuswap series | Shuswap series. |
| | **New Correlation.** | |
| *Cambrian (chiefly)* | Not known | Glacier division. } Selkirk series |
| *"Beltian"* | " | Albert Canyon division ("Niskonlith" of Dawson's Selkirk section). } Selkirk series |
| | | —*Unconformity*— |
| *Pre-"Beltian"* | Intrusive granites (orthogneisses) | Intrusive granites (orthogneisses). |
| *Pre-"Beltian"* | Shuswap series (includes rocks mapped on the Shuswap sheet as "Niskonlith" and "Adams Lake" series) | Shuswap series. |

## Use of the Term "Algonkian."

Once again the question arises as to the validity of the name "Algonkian." Though the Shuswap series and pre-"Beltian" intrusives form the Pre-Cambrian "Basement Complex" of British Columbia, it is clear that this complex is dominantly sedimentary and that "ordinary stratigraphic methods" can be applied to its elucidation. According to the vague criteria now employed for the separation of "Algonkian" and "Archæan," it becomes necessary to put the exceedingly thick Albert Canyon sediments and the exceedingly thick Shuswap series all in the "Algonkian." The "Algonkian period" thus comes to include the long interval represented in the unconformity at the base of the Albert Canyon strata. Yet this unconformity represents one of the most signal breaks in sedimentation which are registered in the Cordillera. The case is analogous to that in the east, where the "Algonkian" is made to include Keweenawan and Animikie and the underlying, spectacularly unconformable (lower) Huronian. Several influential authors have already placed the "Beltian" in the Algonkian: they must logically include in it also the huge Shuswap series. Is there any essential gain in thus throwing overboard "ordinary stratigraphic methods" in making stratigraphic classification? The writer believes that there is no gain in such procedure, but, on the other hand, that it would entail the certainty of serious, quite unnecessary confusion for future workers in Cordilleran geology.

### Source of Clastic Material in the Rocky Mountain Geosynclinal.

During the survey of the Cordilleran belt along the International Boundary, the writer came to the conclusion that the very thick Beltian-Cambrian fragmental rocks (Rocky Mountain geosynclinal) of the Selkirk, Purcell, and Rocky Mountain systems were chiefly derived from a great land-area lying west of the Columbia river at the 49th parallel. During last summer, strong evidence was secured that this ancient terrane was the southern continuation of the actual basal complex (Shuswap sediments and granitic intrusives) of the Shuswap Lakes region. The abundant large grains of microcline and microperthite in the Rocky Mountain geosynclinal are identical in microscopic habit with the feldspars of the extremely numerous, thick sills and dykes of coarse pegmatites cutting the Shuswap series. Most of the quartzites of the geosynclinal are not true sandstones, for their average grain is incomparably smaller than even the finest-grained sand, strictly so called. The geosynclinal quartzites are really consolidated quartz muds, with which essential amounts of minute microperthite and other alkaline feldspars are often mixed. The original quartz grains of these quartzites can be traced to the weathering of just such metargillites, phyllites, and greenstone schists as form colossal masses in the basal complex at the Shuswap lakes. In the thorough weathering of such rocks, the more soluble, finely-divided chlorite, uralite, talc, etc., are carried away in solution, while the relatively insoluble quartz is concentrated and washed into the sea as a highly siliceous mud. The minute particles of alkaline feldspar, also comparatively stable and insoluble, may be considered as having been derived from the simultaneous weathering of sill, dyke, and batholith in the Shuswap-orthogneiss terrane.

Though additional microscopic study of this problem is planned, the writer finds the foregoing explanation of these hitherto puzzling quartzites to be the best yet suggested by the facts. The question is important, as it relates to the origin of at least 20,000 feet of quartzites in the Rocky Mountain geosynclinal. Great as their volume is, there seems to have been ample areal extent and thickness in the older terrane to furnish the requisite amount of siliceous mud.

## Carboniferous Formations.

In the Shuswap Lakes area there seems to be no rock formation representative of the "Beltian," Cambrian, Ordovician, Silurian, or Devonian periods; that is, of the long interval during which the Rocky Mountain geosynclinal prism was being deposited. For most of that time the zone of shore-lines may have lain near the present divide of the Columbia Mountain range, west of Revelstoke. In that case, the absence of "Beltian" and older Palaeozoic sediments in the Shuswap region would be explained by failure of deposition. Yet it is quite possible that one or more of the periods mentioned saw deposition in the region and that erosion has since destroyed the sedimentary rocks so formed. Whatever the explanation, the Carboniferous (Pennsylvanian) is the next period known to be actually represented in the rocks of the Shuswap area, after the pre-Beltian granites were intruded into the Shuswap series.

The Carboniferous rocks have been described in detail by Dawson, especially in his Geological Survey report on the Kamloops sheet (1896). In 1911, the present writer began a revision of the complex structural geology of these rocks where mapped in the western part of the Shuswap sheet and the adjacent part of the Kamloops sheet area. Several collections of fossils were made from the thick limestones north of the Thompson river and east of Kamloops. The other chief rock-types of this rock series are noted in the foregoing general table of formations. The lithology and succession were found to be essentially as described by Dawson. The youngest member exposed (Marble Canyon limestone) is capped by an erosion surface, and the base of the Carboniferous is not exposed in any section traversed this season. Hence the whole thickness is unknown, but it is certainly great, and probably well over 10,000 feet.

## Nicola Series.

In all, about 25 miles of the railway section was run through the strongly deformed basaltic lavas (porphyrites) and subordinate sediments which Dawson grouped under the name "Nicola series." His description of the general lithology was, here too, found to be admirable; the account given in the Kamloops Sheet report applies well to the Nicola as it outcrops in the area of the Shuswap sheet. The lavas are extraordinarily massive and it is extremely difficult to read out the structure. So far, the writer has been baffled in the attempt to determine the total thickness or the exact succession. It is known, however, that the maximum thickness is greater than 4,000 feet.

The Nicola lavas rest unconformably on the Carboniferous limestone. They are overlain by at least 1,000 feet of hard sandstones and argillites, which are unfossiliferous and are possibly of Jurassic date. Where observed on the South Thompson river, these sediments are truncated by a Mesozoic granite batholith, so that their whole thickness is unknown.

Where discoverable, the dips of the Nicola rocks vary from 30° to 90° and, in this region, probably average more than 50°. The series has been deformed almost as much as the Carboniferous beds.

The writer was much struck with the close similarity of the Nicola rocks to the great mass of the complex Rossland group to the south. It would not be surprising if at least a large part of the latter group should some day be definitely referable to the Triassic.

### Mesozoic Batholiths.

Several large masses of biotite granite and hornblende-biotite granite cut the Triassic lavas or the Carboniferous sediments in the vicinity of the Shuswap lakes. These granites are generally somewhat strained but are seldom gneissic. Their field relations, field habit, and petrographic characters suggest that they were intruded at the same time as the great batholiths of the International Boundary belt, which are covered by lower Cretaceous sediments unconformably and are to be referred to the later Jurassic time of batholithic intrusion. It is possible that some of the granitic bodies cutting the Shuswap sediments are of the same age, but the evidence is clear as to the Pre-Cambrian date for nearly all of those intrusions where traversed last season.

### Oligocene Formations.

A beginning has been made on the petrographic and structural geology of the Tertiary lavas and interbedded fresh-water sediments, which cover such large areas in the area of the Kamloops and Shuswap sheets. The reader is referred to Dawson's Kamloops report for details. However, it should be pointed out that both the "upper Volcanic group" and the "lower Volcanic group" of Dawson's Kamloops sheet are very probably not Miocene in age, as there coloured, but Oligocene. In the field, the writer came to suspect that these thick basaltic formations were pre-Miocene, the chief reason being the strong upturning which the lavas have suffered. On his return to the east he found corroboration for this view in the palæontological studies of Lambe and Penhallow, who had published material dealing with the Tranquille beds, separating the upper Volcanic and lower Volcanic groups. Their results agreed in showing that the Tranquille beds are Oligocene. The field relations strongly uphold the view that the basalts of both the named groups, which are conformable to, and partly interbedded with, the Tranquille tuffs and sandstones, also date from the Oligocene.

### Glaciation.

Routine observations were made on the geology of the Pleistocene formations. The results are essentially like those published by Dawson in his Kamloops report and elsewhere. The imposing silt terraces of the South Thompson river early claimed attention, and the recent observations confirm Dawson's explanation of certain of the silts as deposits in temporary, ice-dammed lakes. The lake in the valley of the South Thompson must have been considerably more than 500 feet deep and at least 20 miles in length. The valley seems to have been dammed above by a large glacier terminating near Shuswap village, and below by a yet greater glacier coming out of the wide valley of the North Thompson. Remarkable deformation of similar silt-beds on the southern shore of Kamloops lake has been produced by an ice-sheet, which occupied that basin in late Pleistocene time and may have been the lower continuation of the North Thompson glacier itself.

Adams lake and, apparently, each of the larger divisions of Shuswap lake, are true rock basins, though Mara arm and Little Shuswap lake have become nearly barred off from the main Shuswap lake by the growing deltas of Eagle river and Adams river respectively. These valleys are fiord-like and the rock-basins doubtless originated in differential glacial erosion.

# GEOLOGY OF FIELD MAP-AREA, YOHO PARK, B.C.

(*John A. Allan.*)

## Introduction.

The field season of 1911 was spent in continuing the section begun last season in the Ice River district across the Rocky mountains, along the main line of the Canadian Pacific railway. The topographical map used was that issued in 1909 by the Department of the Interior on that portion of the Rocky mountains. It was enlarged to a scale of 1 mile to 1 inch for field use. The area mapped was about 300 square miles, including that portion examined in 1910. Only a few days were spent in the Ice River district in order to clear up some points of doubt. The whole area thus covered extends from the Continental divide west to Palliser, a distance of about 20 miles, and from the railway at the divide south 24 miles. It lies almost entirely within the Yoho Park. A section has been made across the area along the railway.

The last week of the season was spent in the Van Horne range as far as Mt. Hunter and Mt. King. A reconnaissance trip was made into the Beaverfoot range which is the most western range of the Rockies south of the railway. As it was not possible to use horses in much of the area, travel was necessarily slow.

A close study was made of all the deposits and occurrences of metalliferous and non-metalliferous products within the area. In this work I was most heartily assisted by those interested.

I am particularly grateful to Mr. H. H. Lavery, superintendent, and Mr. J. A. Thomson, manager, Mt. Stephen Mining Syndicate; Mr. R.' Kidney; Mr. Geo. Hunter, Park superintendent; Mr. W. T. Oke, Mr. W. Haygarth, and Mr. M. Dainard; to Mr. Kilpatrick, superintendent, and others of the Canadian Pacific railway for their information, assistance, and courtesy during the two seasons spent there.

Satisfactory and efficient assistance was rendered by Mr. Fred. J. Barlow. His previous acquaintance with the region was a material benefit in the technical work.

## Summary and Conclusions.

The area includes a very thick series of sedimentary rocks which ranges in age from lower Cambrian to Silurian. The Cambrian formations and, at least, the basal beds of the Ordovician are conformable upon one another. The softer and more thinly-bedded sediments have been folded and at a later period strongly sheared so that the cleavage planes cut across the previously formed folds. An irregular mass of alkaline magma has been intruded across and between the sediments. The main type of rock is nephelite syenite. The exact age of intrusion cannot be determined, but it is believed to be later than the folding and prior to the final movements which highly sheared the sediments.

Mineralization is wide-spread but the individual occurrences of ore are on a small scale. These small deposits can only be worked profitably when the cost of production and extraction can be reduced to a minimum.

## General Character of the District.

The area is extremely rugged and mountainous. The greatest average elevation, which is over 10,000 feet, is reached in the Bow range which forms the Continental watershed. There is a gradual downward slope in the whole system to the Columbia valley, with the exception of a few peaks in the Ottertail range,[1] of which Mt. Goodsir (11,676 feet) is the highest in this part of the Rocky mountains. The general appearance of the Bow range is quite distinct from those to the southwest. It is made up chiefly of heavy-bedded quartzites, limestones, and dolomites, mainly of lower and middle Cambrian age. The beds are lying nearly horizontal, and weather, in large part, into precipitous castellated cliffs which show up an "alcove" form of erosion in certain cliff-forming limestones and dolomites.

In contrast with the general appearance of the Bow range, there is the broad drainage area of the Ottertail valley to the southwest, which is floored by slates, shales, and argillites, all soft, highly cleaved, and weathering readily into rounded-topped ridges and broad talus slopes.

The Ottertail range contains a massive band of limestone which forms a precipitous cliff, frequently 2,000 feet high, along the southeast edge of the Ottertail valley. The broad Beaverfoot valley with a N.W.-S.E. trend, underlain by soft slates and argillites, separates the Beaverfoot range, which is the last range to the west, from the rest of the Mountain system. The Beaverfoot range has a very irregular zigzag summit made up of harder Ordovician and Silurian sediments.

The Van Horne range is the northwest continuation of the Beaverfoot and Ottertail ranges across the Kicking Horse valley.

The Kicking Horse river (Wapta[2]) forms the main traverse westward drainage of this portion of the Rocky mountains. It has its source in a broad saddle of the Kicking Horse pass, with an elevation of 5,329 feet. The westward slope from the pass is much steeper than that to the east. In a distance of about 8 miles the river drops 1,300 feet to an elevation of 4,064 feet at Field, and 1,100 feet of this drop occurs within 5 miles. The river is about 42 miles long and has a total fall of 2,750 feet. This valley in pre-Glacial time was drained to the southeast. The general character and uniformity of direction of the main tributaries were described in 1910.[3]

There is one main north and south depression in the area which is now occupied by Cataract Brook, McArthur Creek, and Moose Creek valleys.

## General Geology.

The thick sedimentary series in the area has been subdivided into various formations largely on fossil evidence, and in part on a lithological basis.

The beds below the graptolite shales, which are definitely Ordovician in age, were formerly divided into the Bow River group at the base and the Castle Mountain group above.[4]

These have been subdivided into formations by Walcott on purely fossil evidence and fully described in his Mt. Bosworth section.[5] The following local names were first given to various formations in this section—Sherbrooke, Paget, Bosworth, Eldon, Stephen, Cathedral, Mt. Whyte, St. Piran, Lake Louise, and Fairview.[6]

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[1] Summary Report, 1910, Geol. Survey, Canada, p. 136.

[2] Originally called 'Wapta' by the Stoney Indians.

[3] J. A. Allan. Geology of Ice River District: Summary Report, 1910, Geol. Survey, Canada, p. 136.

[4] R. G. McConnell. Ann. Rep. Part D, Geol. Survey, Canada, 1886, p. 15 D.

[5] C. D. Walcott. Cambrian Sections of the Cordilleran Area. Smithsonian Misc. Coll. Vol. 53, No. 5, 1908, p. 204.

[6] C. D. Walcott. Nomenclature of some Cambrian Cordilleran Formations. Smithsonian Misc. Coll. Vol. liii, No. 1, 1908, pp. 1-5.

The sedimentary series in the Ottertail range can be readily separated into three distinct formations, and since it has not been possible to correlate them with any others already recognized, they have been named by the writer in order to facilitate the description of each. The names are local and are taken from localities in which the beds are best exposed.

In the table the approximate thickness of each formation is given. There is a minimum thickness of 24,433 feet represented in this area. The thicknesses of the Halysites and Graptolite beds are those given by McConnell; the lower three formations have been measured and estimated by the writer; the remaining formations have been measured and estimated by Walcott and are well exposed in Mt. Bosworth.[1]

The igneous rocks have been described in summary for 1910,[2] but several types have since been determined.

[1] In Mt. Bosworth, upper Middle and lower Cambrian beds are exposed in a section. C. D. Walcott. Cambrian Sections of the Cordilleran area. Smithsonian Misc. Coll. Vol. liii, No. 5, 1908, p. 204.

[2] J. A. Allan. Geology of the Ice River District. Summary Report, 1910, p. 139.

## Table of Formations.

| System | Previous Classification. | Formation. | Approx. thickness feet. | Lithological characters. |
|---|---|---|---|---|
| Pleistocene and Recent | ............ | Fluviatile....... | ................ | Gravel, sand. |
| | | Lacustrine...... | ... .......... | Gravel, sand, clay, silt, conglomerate (stratified). |
| | | Glacial......... | ... .......... | Till. |

*Erosion Surface.*

| System | Previous Classification. | Formation. | Approx. thickness feet. | Lithological characters. |
|---|---|---|---|---|
| Silurian .... . . | Halysites beds.. | Halysites beds.. | 1,300+ | Greyish dolomites, white and brown quartzites. |
| Ordovician. .... | Graptolite shales | Graptolite shales | 1,500+ | Black and dark brown fissile shales. |
| | .............. | Goodsir formation. | 6,040+ | Cherts, cherty limestones, thin-bedded siliceous dolomites, grey dolomitic limestones, siliceous and calcareous slates and shales; weathering brown, purplish grey, light grey, light yellow, buff. |
| Upper Cambrian | .... .......... | Ottertail formation. | 1,725+ | Massive blue limestone with shaly bands. |
| | | Chancellor formation. | 2,500+ | Thin-bedded grey argillaceous and calcareous slates, weathering reddish, yellowish, and fawn; underlain by greyish calcareous meta-argillites, shales, and argillites highly cleaved and phyllitic; weathering greenish, greyish, reddish, yellowish, and buff. |
| | Castle Mt. Group | Sherbrooke[1]... | 1,375[2] | Grey, thin-bedded, cherty, oolitic limestones and arenaceous dolomitic limestones. |
| | | Paget ........ | 360+ | Massive bluish grey limestone with bands of oolitic dolomitic limestones. |
| | | Bosworth .... | 1,855+ | Massive grey, arenaceous, dolomitic limestone; weathering yellowish buff; underlain by thin-bedded dolomitic limestone with interbedded greenish siliceous shale weathering buff; arenaceous shale weathering buff, greenish, yellowish, deep red, and purplish. |
| Middle Cambrian. | .... .......... | Eldon ........ | 2,728 | Thin-bedded siliceous and dolomitic limestones, underlain by massive bedded arenaceous limestones, cliff-forming, weathering light grey to buff. |
| | | Stephen ...... | 640+ | Thin-bedded dark and bluish grey limestone interbedded with shale; with 150 feet of Ogygopsis shale in Mt. Stephen and 'Burgess shale' in Mt. Field. |
| | | Cathedral. ... | 1,595+ | Arenaceous dolomitic limestones; weathering grey and buff. |
| Lower Cambrian | .............. | Mt. Whyte... | 390 | Siliceous shale, sandstone, and thin-bedded limestone. |
| Base not exposed | Bow River Group. | St. Piran. .... | 2,600+[3] | Ferruginous quartzitic sandstone. |

Total thickness........ ........... 24,608 feet.

**Table of Formations**—*Concluded.*

IGNEOUS ROCKS.

| | | |
|---|---|---|
| Post-Cretaceous ?.... | Dyke intrusions..... | Camptonite, tinguaite, phonolite, ouachitite, etc. |
| | Alkaline intrusion... | Nephelite syenite, sodalite syenite, foyaite, urtite, jolite, theralite, essexite, jacupirangite, etc. |

NOTE—Colours in this table refer to the fresh rock unless specified.

[1] The remaining formations first named by: C. D. Walcott—Nomenclature of some Cambrian Cordilleran Formations. Smithsonian Misc. Coll. Vol. 53, No. 1; 1908, pp. 2-4.

[2] Thickness of formations determined by C. D. Walcott in Mt. Bosworth section—Smithsonian Misc. Coll. Vol. 53, No. 5; 1908, p. 216.

[3] Exposed above talus south of Lake O'Hara.

DESCRIPTION OF FORMATIONS.

*St. Piran and Mt. Whyte Formations.*

These formations consist essentially of quartzitic sandstones and siliceous shales. Some beds contain many annelid borings. There is a maximum thickness of almost 3,000 feet of these beds exposed in the Bow range above Lake O'Hara, but a much greater thickness has been examined by Walcott on the east side of the range at Lake Louise.

At the base of the north slope of Mt. Stephen about 600 feet of lower Cambrian quartizitic beds are exposed in a small anticline on both sides of the Kicking Horse valley.

*Cathedral, Stephen, and Eldon Formations.*

These occur only in the northeastern portion of the area mapped this summer, and consist largely of calcareous and dolomitic beds as shown in the table. They are characteristically developed in Mts. Stephen, Cathedral, Odaray and in the Bow range. The Eldon in particular forms steep castellated crags on the erosion surface which make the formation readily recognizable. Many of these beds are fossiliferous and it is in the Stephen formation that the "fossil bed," Ogygopsis shale of Mt. Stephen occurs, and the recently discovered fossil bed in the Burgess shale on Mt. Field.[1]

*Bosworth, Paget, and Sherbrooke Formations.*

These are best exposed in the Mt. Bosworth section, referred to above. It has not been possible to trace these formations to the southwest owing to a fault which crosses between Mt. Stephen and Mt. Dennis. The downthrow is on the southwest side, and beyond this break the beds are tightly folded and greatly metamorphosed so that fossils could not be found in them. This zone of highly sheared rocks occupies the great part of the Ottertail valley. The bedding of these rocks has become subordinate to the cleavage which has a general N.W.-S.E. trend. The beds are sometimes tightly folded and in other places are lying almost flat so that it is not possible to estimate the thickness represented in this zone. The folding is prior to the shearing.

*Chancellor Formation.*

This formation is well exposed in the Ice River valley and especially in the base of Chancellor peak. It consists of a thick series of grey meta-argillites, well cleaved along the bedding plane, weathering reddish, yellowish, and fawn. This series con-

[1] C. D. Walcott. Smithsonian Misc. Coll. Vol. 57, No. 3, 1911, p. 51

tains upper Cambrian fossils. It is the lowest formation exposed in the Ice River valley, where it has a measured thickness of 1,660 feet,[1] but on the northeast side of the Ottertail range it has an estimated thickness of over 2,500 feet exposed. In the Ottertail valley this formation can be traced down into highly sheared phyllitic slates and soft, calcareous argillites[2] in which the bedding becomes subordinate to the cleavage. This sheared zone which includes the whole of the Ottertail valley has been mentioned above. Fossils could not survive this intense alteration. Less altered rocks corresponding to this zone may be found to the northwest, but until such are examined it will not be possible to correlate these badly sheared rocks with those upper Cambrian formations to the northeast.

The Chancellor formation floors a part of the broad Beaverfoot valley, but becomes faulted off in the side of the Beaverfoot range. It also forms the lower end of the Van Horne range towards Mt. King and Mt. Hunter. The reddish weathering character of these beds in the range is typical of the formation. The top of the ridge on which Mt. Hunter is situated is composed of a band of massive bluish limestone with thin-bedded layers.[3] This band pitches to the southeast and disappears below the till-covered floor of the Beaverfoot valley about 2 miles above Wapta falls. Walcott found upper Cambrian fossils in this limestone at this point.

### *Ottertail Formation.*

This formation consists almost entirely of blue limestone, massive towards the top and rather thinly bedded towards the base. It has a measured thickness of 1,550 feet in the Ice River valley,[4] and in the Ottertail mountains overlooking the Ottertail valley it measured about 1,600 feet. In Limestone peak to the east of Moose Creek valley this formation is over 1,725 feet thick. Since this formation is especially well developed throughout the Ottertail range, forming a precipitous escarpment along the east side, and since it cannot be correlated with any of those previously named, it has been given a name.

A few fossils were collected from these beds but no good species have yet been determined which would definitely fix the age as upper Cambrian.

### *Goodsir Formation.*

This formation is best exposed in the upper part of Mt. Goodsir where it has a measured and estimated thickness of 6,040 feet.[5] It lies conformably on the Ottertail limestone and consists at the base of almost 3,000 feet of alternating hard and soft bands of argillaceous, calcareous, and siliceous bands of slate which weather light yellowish grey and buff. These beds are especially well exposed on the east side of Moose creek where they give a striped appearance to the mountain. In Mt. Goodsir they are more massive in composition. In the summary for 1910 this well banded series with a thickness of 2,975 feet was added to total thickness of sediments, but this series is only the more highly cleaved and metamorphosed beds of the Goodsir formation.[6]

The upper part of this formation consists of banded cherts, cherty limestones and dolomites, thin-bedded and very dense siliceous beds weathering into angular fragments.

Fossils have been found in the lower half of the formation. These have been determined by Walcott. He recognizes four new species which would place these beds in the Ordovician.[7] On both palæontologic and lithologic evidence the boundary

[1] J. A. Allan. Summary Report, 1910. Geol. Survey, Canada, p. 137
[2] R. G. McConnell. Ann. Rept., Part D, Geol. Survey, Canada, 1886, p. 25 D.
[3] R. G. McConnell. Ann. Rept., Part D, Geol. Survey, Canada, 1886, p. 39 D.
[4] J. A. Allan. Summary Report, 1910, Geol. Survey, Canada, p. 137 (No. 2 in table).
[5] J. A. Allan. Summary Report, 1910, Geol. Survey, Canada, p. 137 (No. 3 in table).
[6] J. A. Allan. Summary Report, 1910, Geol. Survey, Canada, p. 138 (No. 4 in table).
[7] C. D. Walcott. Cambro-Ordovician Boundary in British Columbia, etc.: Smithsonian Misc. Coll., Vol. 57, No. 7, 1912, p. 229.

between the Cambrian and the Ordovician in this district is placed at the top of the Ottertail limestone and at the base of the Goodsir formation.

No fossils have been found in the upper half of this formation although the beds have been examined to their highest horizon in the top of Mt. Goodsir.

### *Graptolite Shales.*[1]

These shales occur in the Beaverfoot range and are rich in graptolites. They are well exposed in a creek a few yards west of Glenogle station. The same band was found 15 miles to the southeast on the same range, with the beds dipping very steeply to northeast. They consist chiefly of very black fissile shales which weather into thin angular fragments. These Ordovician beds are faulted against the soft highly cleaved phyllitic slates which underlie the Beaverfoot valley.

### *Halysites Beds.*[2]

These beds consist of white and brown quartzites, brown siliceous shale, and grey dolomite. On account of the hardness of these beds they form the top of the Beaverfoot range. Certain beds are rich in corals, especially Halysites, which make them of Silurian age. The section through the Beaverfoot range has not yet been completed, so that the relation of these uppermost beds to one another has not been determined.

### *Pleistocene and Recent.*

The deposits of glacio-lacustrine origin may be noted here. On the retreat of the glacier from the Beaverfoot and Kicking Horse valleys a lake filled both of these depressions, into which the glacial detritus from the surrounding slopes was washed, together with material carried down by the remnant tongues of ice. This stratified gravel, sand, and silt form distinct terraces to an elevation of 4,650 feet. At Emerald, 3 miles below Field, there are five terraces noticeable.

In the upper part of Porcupine creek the gravels and sands have been cemented to a conglomerate. The present stream in one place has cut its course through the slates at the side of the old valley on account of the hardness of the conglomerate.

Fluviatile deposits cover the broad portions of the valley floors. In the Kicking Horse valley they form a flood plain 2 miles wide and in several places have aggraded the depressions left in the floor of the valley by the melting out of the ice.

## STRUCTURAL GEOLOGY.

There is a large fault with a north-south trend between Cathedral mountain and Mt. Stephen, with the downthrow in the latter. The displacement, which is over 1,500 feet, brings the lower Cambrian beds up against the middle Cambrian. This break continues to the south, passing between Mt. Duchesnay and Mt. Odaray. Another break with N.-S. trend cuts across the shoulder of Mt. Bosworth and follows south along Cataract valley.

At the south end of Lake McArthur the lower Cambrian beds to the east are faulted up against the middle Cambrian to the west. The displacement is over 800 feet.

A large break with N.W.-S.E. trend passes between Mt. Stephen and Mt. Dennis, the beds in the latter having slipped down. This break in Mt. Odaray has been offset by the Stephen-Cathedral fault which shows that there were at least two periods of faulting.

[1] R. G. McConnell. Ann. Rep. Geol. Survey, Canada, 1886, Part D, p. 22.
[2] R. G. McConnell. Ann. Rep. Geol. Survey, Canada, 1886, Part D, p. 21.

In the Van Horne range the southwest side of the Mt. Hunter ridge is bounded by a fault. Another break follows along the northeast side of the Beaverfoot range. There are several small faults, especially in the vicinity of the igneous mass.

All the main valleys are of pre-Glacial age widened and deepened by the action of the ice.

## Economic Geology.

There are several occurrences of ore in this part of the Rockies, but little development has been done on any of them. The Monarch mine on Mt. Stephen is the only one being operated at present. Most of the important prospects in the area have been examined and will be mentioned in this chapter. Other prospects and certain building and ornamental stones were described in the Summary for 1910.[1]

Argentiferous galena, sphalerite, and copper sulphides are the principal metalliferous ores.

The following table gives the results of assays made from some of the ores by Mr. H. A. Leverin, chemist for Mines Branch.

| — | Gold oz. | Silver oz. | Lead % | Zinc % | Copper % | Iron % |
|---|---|---|---|---|---|---|
| (1) Black Prince Mining claim (Mt. Field) | none. | 0·82 | 16·9 | 21·5 | | |
| (2) Waterloo Mining claim (Moose creek) | 0·5 | 2·90 | 3·69 | 16·10 | 1·59 | 27·30 |
| (3) Hercules Mining claim (Silver Slope creek) | trace. | 4·50 | 15·33 | 6·87 | 0·035 | |
| (4) Sunday Mining claim (Ottertail river) | " | 5·12 | 15·66 | 31·68 | 3·25 | |

### MONARCH MINE.

The location and general description of the mine were given in the Summary Report for 1910, page 142.

The mine is owned and operated by the Mt. Stephen Mining Syndicate of which Mr. J. A. Thomson is managing director, with office in Vancouver.

Mr. Harry Lavery is superintendent and has been employed by the Syndicate to erect a concentrating mill suitable for the treatment of the ore, and to develop the mine so that the ore can be produced economically. The location of the ore body in the precipitous cliff of the mountain, over 1,000 feet above the railway, and the old method of getting the ore down, made the cost of production very high.

On June 25, Mr. Lavery began work on the construction of a mill, which is located on the side of the railway at the base of the mountain. The mill and aerial tramway were completed in Janaury, 1912, and operations continued after that date.

It is a gravity concentrating mill 110 × 60 feet in 5 bents with room for enlargement. It has a capacity of 50 tons per day. The machinery used is a Blake crusher, 2 sets of rolls, trommels, Tamarack classifiers, Harz jigs, and Deister tables.

The power is supplied by a Pelton wheel under a head of 280 feet which will generate 140 H.P. The pipe line is 1,706 feet long and the pipe at the head is 12 inches in diameter, being gradually reduced to 8 inches at the wheel. The water is taken from the stream coming down between Mt. Stephen and Cathedral mountain.

The ore will be brought down from the mine by an aerial tram from an upper terminal in the face of the mountain above the mill. From this terminal a drift will be run for about 180 feet and a raise of 147 feet will connect with main tunnel of the mine, about 180 feet from its mouth.

The following mill-run was made: jig-cup producers gave 67 per cent lead, and 4 per cent zinc; table products ran 52 per cent zinc and 3·5 per cent lead; lead con-

[1] J. A. Allan, Ice River District, Summary Report, 1910, p. 141.

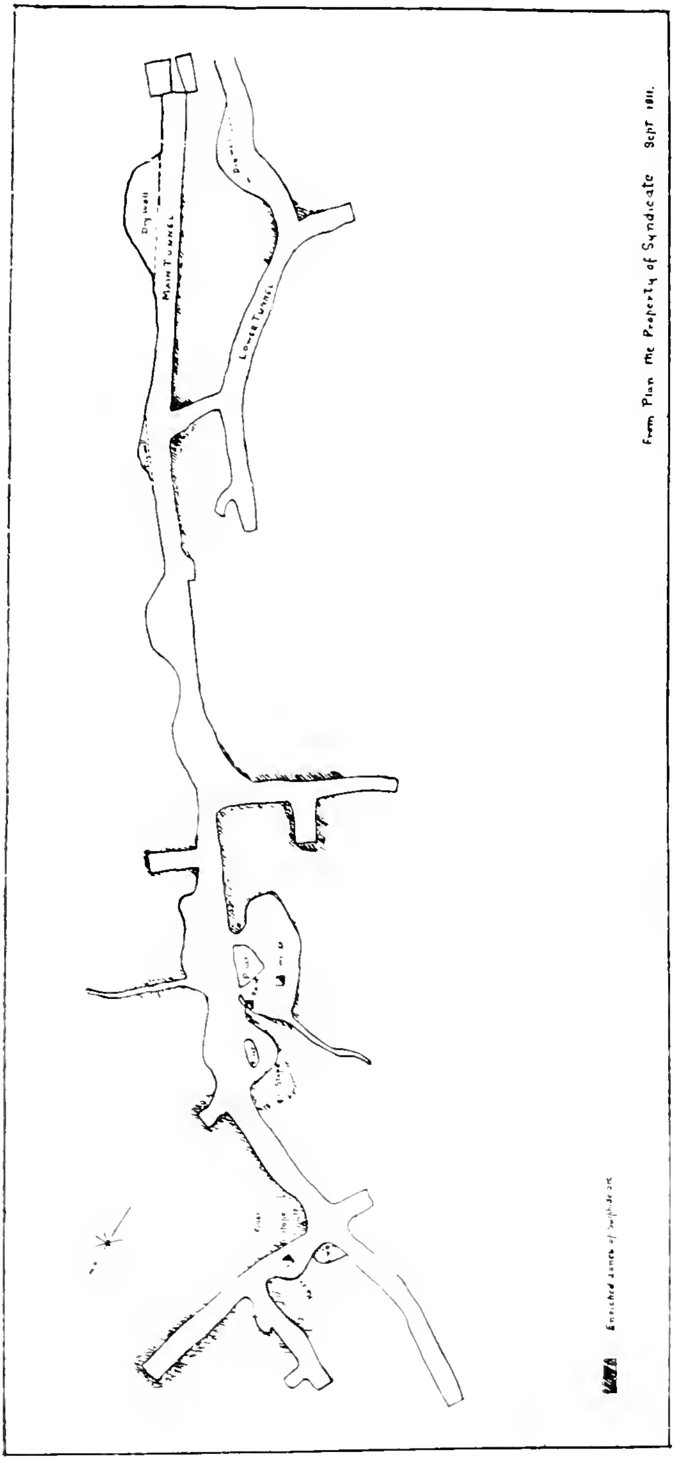



Fig. 7.—Plan of underground workings of Monarch mine.

centrate gave 76 per cent lead and 4 per cent zinc; tailings ran 0·6 per cent lead and 0·9 per cent zinc.

The accompanying plan shows the workings in the mine. The main tunnel is about 380 feet long and follows along a vertical fissure. There are several cross fissures, some of which are followed by drifts. The ore is always in or along the fissures. In some places the siliceous dolomitic limestone is highly fractured and crusted material is partly replaced by and cemented together with the lead and zinc ores. Pockets of almost pure galena or sometimes sphalerite are found along the cross fissures. The ore body is irregular and at the inner end of the workings is bending round to the south, following the fissure.

### BLACK PRINCE MINING CLAIM.

This claim is situated at an elevation of 5,050 feet on the south slope of Mt. Field. The mode of occurrence is quite similar to that in the Monarch mine on Mt. Stephen. The ore body lies along a fractured zone in a siliceous dolomite, and varies in width from a few inches to 6 feet. The ore minerals are galena, sphalerite with some pyrite and a very small amount of reddish coating on weathered surfaces which suggests mimetite. The ore solutions have replaced some of the country rock and have cemented the broken fragments together in the shear zone. The development, which has been done by W. T. Oke, shows that the ore body is somewhat irregular along the fissure, which contains a gouge clay, but the latest work shows up another pocket of galena ore in the end of the tunnel. An assay of the ore is given in the table, but is undoubtedly too high in zinc for an average sample.

## Prospects in the Ottertail Valley.

There are several small prospects in the valley of the Ottertail and its tributaries, Frenchman, Haskins, and Silver Slope creeks, which are the first three large creeks entering the Ottertail from the west side. Some development work has been done on these within the last decade. All the prospects occur in the highly cleaved slates of the Chancellor formation.

There is nothing being done with these various prospects at present. The Canadian Pacific railway crosses the mouth of the valley and a good trail extends 5 miles up Ottertail river.

Each of these prospects will be mentioned briefly.

### SILVER SLOPE CREEK GROUP.

This group consists of three claims, the Hercules, Phoenix, and the Tamarack mining claims. They are situated at the head of the southeast branch of Silver Slope creek. The workings are at elevation of 6,800 feet, which is the border of timber line. On the Hercules claim a tunnel 200 feet long crosses the beds which strike S. 65° E. and dip 40° to 45° S. These beds, dipping into the mountain, consist of reddish weathering slates of the Chancellor formation. The ore occurs as small lenses in a bed of limestone 6 feet thick, interbedded with the slates, partly recrystallized, and seamed with calcite stringers. On account of its hardness, this band stands out on the weathered surface. The ore minerals impregnating the limestone in irregular lenses and frequently in calcite stringers, are galena, sphalerite, and pyrite, with a small amount of chalcopyrite and probably argentite.

The tunnel was started 75 feet down the slope in order to strike the mineralized band at greater depth, but the end of the tunnel is still a few yards from where the ore should be reached. These claims were originally staked out and assessment work done by Messrs. W. T. Oke, T. Hebson, and Adams. Very large assay values have been reported from picked samples. An average sample, which the writer collected from the mineralized band of limestone, gave the results of No. 3 in the table of assays.

### HASKINS CREEK PROSPECT.

A prospect at the head of this creek was first worked several years ago by Messrs. Summers and Bullard. The workings have become filled up. The ore is largely chalcopyrite and pyrite associated with quartz as veins in slates.

### QUEBEC MINING CLAIM.

This claim is situated in Frenchman creek which is the first large creek entering the Ottertail river from the west and about 3 miles from the railway. This claim, together with the Ontario and the Empire, formed a group controlled by a syndicate. The workings on the Quebec are at elevation 4,625 feet or 900 feet above the railway. There are two tunnnels; the lower one is about 200 feet long and has a shaft about 60 feet deep at the inner end, the outer one is 175 feet long. The country rock is red weathering calcareous slates highly cleaved and cut by quartz-calcite veinlets. In these veinlets the ore minerals are galena, tetrahedrite, azurite, malachite, pyrite, and some arsenopyrite. No work has been done on the property for over twenty years, but when in operation, a tramway, with wooden rails, about 2 miles long was built from the workings down to near the railway, where it was intended that a spur should receive the ore. The ore was taken down in a car by gravity and the empty car hauled back by a mule. Only about 20 tons of ore were brought down when a forest fire destroyed a large part of the tramway, and development on the property was discontinued.

A large boulder very rich in similar ore minerals has been found on this slope in the woods which suggests some other occurrence of the ore in this slope of the range.

### ONTARIO MINING CLAIM.

This claim lies partly on the north side of the Ottertail river. A tunnel has been driven into the soft greenish slates and argillites on the north bank of the river, but has since been covered by talus.

### EMPIRE MINING CLAIM.

Very little development has been done on this claim. The exposure is about half a mile up the Ottertail river from the railway. The main tunnel has become closed up, but two small prospect holes show the greenish soft argillites and calcareous slates fissured, and these breaks filled with quartz calcite sericite which carry chalcopyrite, tetrahedrite, galena, and some bornite. The ore minerals sometimes occur in small pockets along fracture or between the veins and the highly cleaved slates. A vein 1 to 3 inches wide of pure galena was noted along a joint fracture, in which the galena showed evidences of having been intensely squeezed.

### SUNDAY MINING CLAIM.

This claim with two others, the Monday fraction and another fraction, form another group. Of these only the Sunday will be mentioned. The workings are situated opposite those of the Empire and consist of a shaft 100 feet deep, but now filled with water. The main tunnel is about 75 feet long and cuts across the strike of the soft greenish calcareous slates and argillites. The ore minerals are sphalerite, galena, pyrite, chalcopyrite, with a little tetrahedrite. The gangue minerals are fluorite and calcite, occurring as veins along and across the bedding of the slate and also in pockets along fractures or small faults. The fluorite varies from white to greenish blue colour; one pocket of this mineral is 1 foot in diameter. There is not enough of this mineral to give it an economic value. Sphalerite is frequently associated with the fluorite. Ore minerals can be readily separated from the gangue. A small amount of development work was done during the past summer. Assay No. (4) in the table was made from an average sample collected from the veins containing the ore.

WATERLOO MINING CLAIM.

This prospect is situated at an elevation of 7,100 feet, near the head of Moose Creek valley, and was described in Summary Report for 1910.[1] The ore minerals are sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, and pyrite in a gangue of quartz and calcite, which occur as segregations in or along fault planes in a mica porphyry sheet lying almost conformable with the bedding of the siliceous limestones.

A representative ore sample taken from this prospect by the writer gave assay No. (2) in the table of assays.

## Other Prospects.

In Porcupine creek considerable prospecting has been done. About 3 miles up the valley at an elevation of 4,300 feet small fractures in a dolomitic slate are filled with vein material, 1 to 6 inches wide, consisting of fluorite, ferruginous dolomite (ankerite), muscovite, and some lepidomelane. The ore minerals are argentiferous galena and pyrites; these occur segregated in the gangue.

In Mt. Field a short tunnel has been driven along a quartz vein 2 to 4 feet wide, which follows the strike of the ferruginous quartz interbedded with soft, chloritic slates. The ore minerals are chalcopyrite, tetrahedrite, malachite, and azurite. These minerals occur both in the vein and along its sides.

On the south slope of Mt. Stephen at an elevation of 7,200 feet mining locations have been made on quartz veins along fissures in dolomitic limestone. Chalcopyrite and the carbonates are the essential ore minerals.

MERCURY.

Native quicksilver is reported to have been found in the gravels of the Kicking Horse valley in the vicinity of Field. This metal was first found by Mr. Flindt in a water pipe in the Mount Stephen Hotel, which must have come from the source of the water supply in the southwest slope of Mt. Stephen. Some of this material was sent to the Survey office. At a later date five samples of gravel were collected by Mr. C. E. Cartwright, consulting engineer, Vancouver, from the flood gravels within 2 miles of Field, and were panned by Mr. C. M. Bryant, Vancouver, with the result that a trace of quicksilver was found in three out of the five samples. Mr. Busteed, general superintendent Canadian Pacific Railway Company in Vancouver, also stated that he obtained quicksilver by panning the gravels "from the edge of the river a few hundred feet below the bridge," opposite Field station, from a depth of about 2 feet below the surface, "where the high water had cut down about that depth."

These facts seem to show that the quicksilver does occur disseminated through even the surface gravels in the floor of the Kicking Horse valley and that its source must be in some of the surrounding mountains. Two claims have been staked out

[1] J. A. Allan, Summary Report, 1910, Geol. Survey, Canada, p. 141.

on the talus on the southwest slope of Mt. Stephen about the intake of the water supply for the hotel. A considerable amount of work was done in an attempt to locate the source of the mercury, but without results.

Some time was spent by the writer at the beginning of the field season in examining the rocks in Mt. Stephen, Cathedral, Field, and the Yoho valley. The most likely rock was assayed for mercury, but no trace of this mineral was found. Nevertheless, it seems possible that some compounds of this metal may occur even within these mountains which may have given rise to the native quicksilver now found in the gravels of the Kicking Horse valley.

Cinnabar is reported to have been found several years ago in a massive limestone ridge on the north side of the valley between Emerald creek and the Amiskwi river. It was also found in a calcite vein close to Glenogle station in the lower Kicking Horse canyon.[1]

### MARBLE.

Within the past year claims have been staked for marble in the Yoho valley. A cross-section of this band of marble is exposed at the switchback on the Yoho road, 2 miles from the mouth of that river. At this point it has a thickness between 350 and 400 feet. The rock is a dolomitic marble and varies largely in both colour and texture. In colour it is dark grey, mottled grey with white spots or vice versa, light grey, white with greyish bands a fraction of an inch in width, and pure white. These last two types occur towards the top of the band and are of the most economic importance. The rock takes a smooth polish, the grained material can be readily carved and will take a sharp edge. This band of marble extends along the eastward slope of Mt. Ogden which makes the quantity very large.

The exposed surface of the marble is badly fractured so that it would be hard to get large blocks of the material, but this fractured zone may not be very deep. The presence of small cavities in certain layers is also detrimental to the value of the marble. Pyrite is only sparsely scattered through certain layers which might be avoided in quarrying.

No development has yet been done on the property. The beds are lying almost horizontal with a maximum dip of 12 degrees. The railway is less than 2 miles distant and on the same elevation.

### GRAVEL.

There is an extensive deposit of stratified glacial gravels more than 100 feet thick in the valley of the Kicking Horse river between Field and Ottertail. At Emerald, 3 miles below Field, the Canadian Pacific Railway Company have installed a washing plant in which the clayey material is washed from the gravels, giving a clean product which is used for ballast.

### CLAY.

A small deposit of clay of glacio-lacustrine origin occurs in the Yoho valley about 3 miles from its mouth. It is yellowish in colour when wet and much lighter in colour when dry. The lime content is high in it and the finest powder is gritty. This material might be manufactured into an earthenware or a variety of pottery.

At the town of Field there is a colluvial clay of indefinite extent, washed down from the talus slope of shales and argillites between Mt. Stephen and Mt. Dennis.

Another small lake deposit of glacial clay or silt occurs near the head of Ice River valley at the base of Chancellor peak. The clay is light buff in colour and highly calcareous. Tests on this silt prove it to be of very low grade and of little or no economic importance.

[1] R. G. McConnell. Annual Report, 1886, Part D, p. 41.

## CAMBRIAN OF THE KICKING HORSE VALLEY, B.C.

*(Charles D. Walcott.)*

In continuation of the field work of the season of 1910, a camp was established on the north side of Burgess pass, 3,000 feet above Field, a trail was built up to the fossil bed on the west slope of the ridge between Mount Wapta and Mount Field, and the systematic quarrying and collecting of fossils continued from July 20 until September 9. A section of the Burgess formation in which the now celebrated fossil bed occurs, was measured as follows:—

### SECTION OF BURGESS SHALE OF THE STEPHEN FORMATION.

*Typical Locality.*—East side of Burgess pass on west slope of Mount Field, facing towards Mount Burgess and Emerald lake, B.C., Canada.

The Burgess[1] shale is overlain by massive bedded arenaceous limestones of the Eldon formation.[2]

| | Feet. | Inches. |
|---|---|---|
| *a.* Greenish coloured argillaceous shales ........................ | 6 | |
| Annelid trails. | | |
| *b.* Grey arenaceous limestone ........................ | 3·6 | |
| *c.* Bluish-black and grey finely arenaceous shale and thin layers of grey, rough sandstone in massive layers ........................ | 24·6 | |
| *d.* Grey arenaceous magnesium limestone in massive beds, that break up into thin irregular layers. Some of the thin layers weather buff and others dirty-grey, passing gradually into more and more shaly beds of bluish-grey colour and buff weathering ........................ | 22 | |
| *Fauna.*—Fragments of fossils and trails. | | |
| *e.* Coarse highly arenaceous limestone ........................ | 4 | |
| *f.* Grey siliceous shale in beds 2 to 4 feet thick, weathering greyish-buff, and banded ........................ | 42 | |
| *Fauna.*—Fragments of trilobites. | | |
| *g.* Finer grained shales than in *f.* and with thin layers of grey siliceous, slightly calcareous, shale ........................ | 80 | |
| *Fauna.*—Large and varied. Locality $\frac{(35\,k)}{10}$ | | |

Among the species identified are the following:—

Sponges—
*Vauxia gracilenta*, n. g. and n. sp.

Annelida—
*Banffia constricta* Walcott.
*Pollingeria grandis* Walcott.
*Ottoia prolifica* Walcott.

Brachiopoda—
*Micromitra (Iphidella) pannula* (White).
*Nisusia alberta* Walcott.

Pteropoda—
*Hyolithes carinatus* Matthew.

[1] Smithsonian Misc. Coll., Vol. 57, 1911, p. 51.
[2] Idem, Vol. 53, 1908, p. 3. Idem, 1910, p. 208

Crustacea—

*Opabinia ? media Walcott.*
*Yohoia plena* Walcott.
*Burgessia bella* Walcott.
*Bidentia difficilis* Walcott.
*Carnarvonia venosa* Walcott.

| | Feet. |
|---|---|
| *h.* Bluish-grey, fine, strong, arenaceous and siliceous shale. About 90 feet down the shales became thinner and darker........ | 228 |
| *Fauna.*—Between 30 and 40 feet from the base the Phyllopod fauna occurs in great abundance. The described species are listed on page 190. | |
| Total thickness of Burgess shale............... ........... | 420 |

Below, the Stephen[1] formation continues downward as a thin-bedded bluish limestone.

*Detailed section of the Phyllopod bed that occurs between 30 and 40 feet from the base in the lower part of h.*

The Phyllopod bed is overlain by a bed of slightly arenaceous shale of a bluish-dirty-grey colour. This shale weathers on exposed edges to a yellowish ochre-brown colour, and serves to mark the upper horizon of the Phyllopod bed. At the fossil quarry it has a thickness of 19 inches.

| | Inches. |
|---|---|
| 1. Bluish-grey shale with partings of dirty brownish-grey shale...... | 21 |
| 2. Dirty-grey earthy shale ................. .......................... | 8 |
| 3. Thick layers 3 to 4 inches in thickness, of bluish-grey very compact hard siliceous shale........... ........... ........... ........ | 12 |
| 4. Dirty-grey shale................. ................. ...................... | 2 |
| 5. Bluish-grey, tough, brittle layer of siliceous shale.................... | 2 |
| *Fauna.*—Medusæ, Holothurians, Annelids, Crustaceans. | |
| 6. Bluish-grey compact shale that splits on partings, finally on lines of bedding.......... ............. .......... ............. ........ | 8 |
| 7. Alternating dirty-grey and bluish-grey shale........................ | 9 |
| *Fauna.*—This is the great *Hymenocaris perfecta* bed, and also contains many Annelids, Sponges, and Crustaceans. | |
| 8. Same as 6. | |
| 9. Dirty-grey earthy shale ..................... ......................... | 2 |
| 10. Solid bed of bluish-grey hard compact shale that splits more or less evenly parallel with the bedding of the layers.............. | 16 |
| *Fauna.*—Sponges, Annelids, Pteropods, Crustaceans. | |
| 11. Dirty grey earthy shale............ ................................. | 1·5 |
| 12. Very fine bluish-grey compact shale................................. | 1·5 |
| *Fauna.*—*Marrella splendens* layer. | |
| Total thickness ............. ................. ................ | 7 feet 7 inches. |

Below 12 the shales are more or less irregular, arenaceous, and not favourable for the preservation of fossils.

The layers at the fossil bed have a very gentle dip to the eastward. A short distance to the westward they dip abruptly downward and disappear beneath the debris slope.

The fossil bed is limited in extent by a fault on the north that has brought the Eldon limestone down against them, and by shearing and breaking a short distance to the south. The fossil quarry is now 65 feet in length on the steep slope of the ridge, with a floor extending back into the ridge 10 feet, and a vertical wall on the back side of from 10 to 12 feet. About 150 cubic yards of the shale have been quarried

[1] Smithsonian Misc. Coll. Vol. 53, 1908, p. 3. Idem, 1910, p. 209.

and split up. The fossils are scattered more or less irregularly, and are rarely very abundant, with the exception of a few species.

The fauna thus far described from this remarkable deposit is as follows:—

BURGESS SHALE FAUNA.

Annelida.[1]

*Amiskwia sagittiformis.*
*Miskoia preciosa.*
*Aysheaia pedunculata.*
*Canadia spinosa.*
*Canadia setigera.*
*Canadia sparsa.*
*Canadia dubia.*
*Canadia irregularis.*
*Selkirkia major* (Walcott).
*Selkirkia fragilis.*
*Selkirkia gracilis.*
*Wiwaxia corrugata* (Matthew).
*Pollingeria grandis.*
*Worthenella cambria.*
*Ottoia prolifica.*
*Ottoia minor.*
*Ottoia tenuis.*
*Banffia constricta.*
*Pikaia gracilens.*
*Œsia disjuncta.*

Holothurians.[2]

*Eldonia ludwigi.*
*Laggania cambria.*
*Louisella pedunculata.*
*Mackenzia costalis.*

Medusæ[2] (Scyphomedusæ).

*Peytoia nathorsti.*

Crustacea (Branchiopoda[3]).

*Opabinia regalis.*
*Opabinia ? media.*
*Leanchoilia superlata.*
*Habelia optata.*
*Emeraldella brocki.*
*Yohoia tenuis.*
*Bidentia difficilis.*
*Molaria spinifera.*
*Nathorstia transitans.*
*Naraoia compacta.*
*Marrella splendens.*
*Burgessia bella.*
*Anomalocaris gigantea.*

Crustacea (Malacostraca).

*Waptia fieldensis.*
*Hymenocaris perfecta.*
*Hymenocaris ? circularis.*
*Hymenocaris obliqua.*
*Hymenocaris ovalis.*
*Hymenocaris ? parva.*
*Hurdia victoria.*
*Hurdia triangulata.*
*Fieldia lanceolata.*
*Carnarvonia venosa.*
*Tuzoia retifera.*
*Odaraia alata.*

Crustacea (Trilobita[4]).

*Mollisonia symmetrica.*
*Mollisonia gracilis.*
*Mollisonia ? rara.*
*Tontoia kwaguntensis.*

Crustacea (Merostomata[5]).

*Sidneyia inexpectans.*
*Amiella ornata.*

The Burgess shale undulates with more or less sharp anticlines and synclines across the broad pass and disappears beneath the mass of limestones of Mount Burgess. With the exception of the localities on the western slope of Mount Field and

[1] Smithsonian Misc. Coll. Vol. 57, No. 5.
[2] Idem, No. 3.
[3] Idem, No. 6.
[4] Smithsonian Misc. Coll. Vol. 57, No. 6.
[5] Idem, No. 2.

its north ridge, no distinguishable fossils were fonnd in the shale. The Burgess shale is a part of the Stephen formation which is exposed on the northwest slope of Mount Stephen, above Field.

*Van Horne Range*.—A reconnaissance made in the vicinity of Leanchoil station, about 18 miles sonthwest of Field, resulted in the discovery of Cambrian fossils in the railway cut just east of Leanchoil station; also at Wapta falls, southwest of Leanchoil. The finding of these fossils in eastward dipping beds is important, as it proves that Mr. McConnell's impression of the structure of the Van Horne range and the Ottertail range just to the south of the Canadian Pacific Railway track, as a broad synclinal, was essentially correct.

From the northern slope of Mount Vaux the synclinal nature of the Van Horne range was very clear.

The limestones of the southwest ridge of Mount Hunter strike to the northwest and appear to be above the fossil-bearing rock just east of Leanchoil.

Traces of fossils of apparently Cambrian age were found in Hoodoo canyon, between Chancellor peak and Mount Vaux. I noted in this canyon large light-grey quartzite sandstone boulders, with many vertical annelid (*Scolithus*) borings filled with white quartz. The borings were more irregular than those of *Scolithus linearis,* and are from 5 to 10 millimetres in diameter. The only other recognizable fossil is a small species of *Acrotreta* that occurs in a dark bluish-grey limestone.

On September 14 I camped on Amiskwi pass and found in the nearly horizontal limestone layers on the northwest side of the pass, traces of upper Cambrian trilobites that probably belonged to the lower thin-bedded limestones of the Bosworth formation.

All field work was suspended after September 20, owing to a heavy fall of snow.

# GEOLOGY OF BLAIRMORE MAP AREA, ALBERTA.

*(W. W. Leach.)*

During the season of 1911 only two months, September and October, were spent in the field.

## Location and Area.

The district under examination is situated in the eastern or Alberta entrance to the Crowsnest pass and is one of great importance on account of the extensive coal mining operations being there carried on. The map, now being compiled, will cover an area 17 by 12 miles in extent and will be published on a scale of 1 mile to 1 inch. The towns of Blairmore and Frank on the Crows Nest branch of the Canadian Pacific railway are situated near the centre of the map area sheet.

## Previous Work.

Dr. Dawson in 1883-4 traversed the Crowsnest pass and in a general way outlined the chief geological features (see Report on the Bow and Belly Rivers region 1882-3, and Report on a portion of the Rocky mountains, Vol. I. 1885). In the year 1902 the writer spent the summer in this district, the results obtained, together with a sketch map, being published in the Summary Report for 1902. In 1903 Messrs. Brock and McConnell wrote a special report on "The Great Landslide at Frank, Alberta," issued by the Department of the Interior, Part VIII, Annual Report 1903.

## Summary and Conclusions.

As the time available for field work was very limited it was considered advisable to devote the greater part of it to measuring as accurately as possible a section across the whole of the strata represented in the area so that the relative positions of any characteristic beds, which might be used as horizon markers, could be determined. As several faults of great throw are present and the rocks are often severely folded it will be seen that this is a matter of much importance in determining the available amount of coal present.

The main structural features of the district to the west of Blairmore are a number of great step faults with persistent easterly downthrow, which bring the coal-bearing horizon to the surface at several places. The line of faulting in nearly all cases follows closely the strike of the beds. To the east of Blairmore the strata have been subjected to much folding, complicated by a number of faults.

The strike of the beds is approximately north and south so that the railway crosses it nearly at right angles and many active mining camps have sprung up in the vicinity of the various outcrops of the coal-bearing strata.

The class of the coal produced here is essentially of the steaming and coking variety and is much used for railway purposes, while a large number of coke ovens are either in commission or under construction.

Near Burmis station, at the eastern edge of the map sheet, a very extensive fault with easterly downthrow cuts off the Kootenay coal-bearing formation, the Burmis outcrop being the last one to the east.

The most prominent horizon markers noted in the field are: a massive, very hard cherty conglomerate at the base of the Dakota formation and immediately overlying the coal-bearing beds; a thin bed of bluish, shaly limestone, associated with seal-brown weathering calcareous sandstones, and occupying a middle position in the Dakota formation; the volcanic breccias and ash beds overlying the Dakota and overlain by the Benton shales, and a bed of very hard, siliceous light-weathering sandstone, about 20 feet thick, which occurs about 500 feet above the base of the Benton shales.

The similarity in general appearance of the Benton and the Fernie shales is apt to lead to confusion when, by faulting, they are brought into juxtaposition.

## Topography.

The Crowsnest river crosses the map sheet diagonally with a course approximately northwest and southeast and occupies a wide terraced valley with a comparatively light gradient, thus affording an easy route for the railway to the summit of the Crowsnest pass in which it takes its rise.

In the area to the west of Blairmore, to which last season's operations were confined, all the principal streams entering the river with the exception of York creek follow generally the strike of the rocks and have, in consequence, north and south courses; York creek, however, cuts across the strike nearly at right angles. The crests of the ridges, intervening between the streams, as a rule follow the outcrop of some of the harder beds, while the valleys in many cases are underlain by the softer shales. The higher points of the ridges rarely exceed 7,000 feet in elevation while the river valley is comparatively high, the elevation of Blairmore station being 4,226, so that the maximum difference of relief seldom reaches 3,000 feet.

## General Geology.

### TABLE OF FORMATIONS.

| | |
|---|---|
| Quaternary | Glacial and river drift. |
| Cretaceous | (1) Allison Creek Sandstone (Belly River ?)<br>(2) Benton-Niobrara.<br>(3) Crowsnest Volcanics.<br>(4) Dakota (?)<br>(5) Kootenay. |
| Jurassic | Fernie Shales. |
| Devono-Carboniferous. | |

### DESCRIPTION OF FORMATIONS.

*Devono-Carboniferous.*—The Palæozoic rocks included in this area consist almost entirely of massive limestone with some thin beds of quartzite and calcareous sandstone towards the top. They form the backbone of the Livingstone range and of Bluff and Turtle mountains, but have not as yet been studied in detail and no attempt has been made to ascertain the total thickness of these rocks represented here.

*Fernie Shales.*—These rocks overlie the Palæozoic limestones apparently conformably and as their name implies, consist largely of very fissile shales, usually dark grey in colour, but also contain a few thin arenaceous bands and some more massive beds of clay shale. The line of demarcation between these shales and the overlying Kootenay formation is not very sharply drawn, but may be assumed to be at the base of the lowest heavy bed of sandstone underlying the coal seams.

Owing to the soft character of these beds very few natural exposures are to be seen. Almost invariably they occupy valleys or depressions and are heavily drift-covered; the harder sandstones of the Kootenay and the massive Carboniferous limestone usually forming the ridges on either side.

South of the railway opposite Blairmore, the Fernie shales are exposed in two pits which have been opened for the purpose of obtaining shale which is used in the manufacture of cement nearby. A section measured there from the topmost exposure of the Palæozoic rocks to the base of the lowest outcrop of Kootenay sandstone showed a maximum thickness of Fernie shales of 750 feet. A great part of the ground at that point is covered so that it is possible that this thickness is too great.

On York creek, a short way below the fan-house of the International Coal Company, the Fernie shales are again exposed to some extent. There, however, the base of the beds is not seen, being cut off by a great fault, and the shales themselves are tremendously crumpled rendering it impossible to obtain even an approximate idea of their thickness. No fossils were found in these rocks in this district, but from fossil evidence gathered elsewhere they have been determined to be of Jurassic age.

*Kootenay.*—This formation is of the greatest commercial importance containing, as it does, all the coal seams now being exploited in this district. It is composed of an uppermost bed of hard cherty conglomerate in a siliceous matrix, massive, moderately hard, dark-coloured sandstones, thin-bedded dark sandstones, grey, black, and carbonaceous shales and a number of coal seams. The following section was measured on York creek near the fan-house of the International Coal and Coke Company:— (Descending order.)

| | | Feet. |
|---|---|---|
| 1. | Hard, siliceous, cherty conglomerate | 19 |
| 2. | Hard, dark grey, thin-bedded sandstone | 12 |
| 3. | Partly covered, shaly sandstone and dark shale | 36 |
| 4. | *Coal* | 16 |
| 5. | Carbonaceous shale, thin beds of shaly sandstone and two thin coal seams (8 inches and 14 inches) | 30 |
| 6. | *Coal* | 10 |
| 7. | Thin-bedded shaly sandstone and grey and carbonaceous shale | 55 |
| 8. | Grey and brown shale | 20 |
| 9. | Hard, siliceous dark grey sandstone | 38 |
| 10. | Partly covered, carbonaceous shale, thin beds of shaly sandstone, and thin seams of coal (a 3 foot seam 50 feet from top) | 165 |
| 11. | *Coal* | 8 |
| 12. | Massive, rather coarse, greenish sandstone | 41 |
| 13. | Covered | 40 |
| 14. | Greenish, crumbly, thin-bedded sandstone | 75 |
| | Total | 565 |
| | Total coal | 38 feet 10 inches. |

The last sandstone bed is underlain conformably by the Fernie shale. This section is not complete and as the beds are in places locally crumpled may be considered as subject to revision.

Elsewhere in the field a coal seam was noted underlying the hard, thin-bedded sandstone immediately below the conglomerate (No. 2 of section); it was not seen at this point but the outcrop may be drift covered. It is generally rather irregular in character and is locally known as No. 1 seam.

A large proportion of the coal mined at Coleman and Blairmore is from the 16 foot seam (No. 4 of section), known as No. 2.

From Turtle mountain westward along the valley of Crowsnest river, the Kootenay rocks outcrop in three roughly parallel bands due to two large faults. The most easterly outcrop is at Blairmore, the second about three-fourths of a mile farther west, and the third at the western end of the town of Coleman.

A section of part of the Kootenay formation, including the principal coal seams, compiled by the West Canadian Collieries from information obtained in a short tunnel and a number of open-cuts in the first, or Blairmore outcrop, about 1½ miles north of that town, is as follows:—(Descending order.)

| | | Feet. | Inches. |
|---|---|---|---|
| 1. | Conglomerate | 27 | |
| 2. | *Coal* | 10 | |
| 3. | Sandstone and shale | 53 | |
| 4. | Conglomerate | 8 | |
| 5. | *Coal* | 17 | |
| 6. | Shale | 1 | 6 |
| 7. | *Coal* | 3 | 6 |
| 8. | Sandstone | 24 | |
| 9. | *Coal* | 3 | 6 |
| 10. | Sandstone | 42 | |
| 11. | *Coal* | 17 | |
| 12. | Sandstone and shale | 65 | |
| 13. | *Coal* | 6 | |
| 14. | Shale | | |
| | Total | 277 | 6 |
| | Total coal | 57 | 0 |

The 17 foot seam or No. 2 (No. 5 of section) is probably the same as that now being mined by the West Canadian Collieries at Blairmore on the south side of the river.

An incomplete section measured near the Blairmore mine showed a total thickness of Kootenay rocks of about 610 feet.

On the second outcrop (three-fourths of a mile west of Blairmore), but little work has been done and that merely surface prospecting, No. 1 seam underlying the conglomerate having been stripped at one point just south of the railway. The fault which brings the Kootenay rocks to the surface here apparently lies very close to the east of the conglomerate outcrop, and it is possible that the lower seams are cut off and never reach the surface here.

To the north of the railway along the strike of the strata the Kootenay rocks are not seen, the fault evidently cutting the strike of the beds at a narrow angle in such a manner that the overlying Dakota beds outcrop on either side of it.

The third or Coleman outcrop is very persistent and regular and has been traced, and the coal seams uncovered, for long distances both to the north and south of the railway. The McGillivray Creek Coal and Coke Company and the International Coal and Coke Company are operating mines on this outcrop on the north and south sides of the valley respectively. The York Creek section given above was measured on the Coleman outcrop where cut by York creek about 2 miles south of the town of Coleman.

The age of the Kootenay formation has been determined by fossil evidence (chiefly plants), to be lower Cretaceous with the possibility that some of the lower beds should be included in the Jurassic. No fossils have been as yet determined from the area under consideration; the nearest locality where any have been obtained being the South Fork of the Oldman river (about 10 miles southeast of Blairmore), where Dr. Dawson collected some fossil plants among which Sir J. W. Dawson recognized Podozamites lanceolatus (Linde) and Zamites Montana (Dn.). (See Annual Report, Vol. I, p. 58 B).

*Dakota (?).*—This formation overlies the Kootenay without any evidence of unconformity unless the conglomerate at the top of the Kootenay should mark a short cessation of deposition at that period.

The Dakota consists essentially of sandstones, varying greatly in colour and texture, with one thin bed of bluish shaly limestone towards the middle of the series, which, on account of its persistent nature, serves as a most useful horizon-marker.

The formation as a whole appears to show marked differences in total thickness within comparatively short distances, as the following measured sections will indicate.

(1.) Section measured from top of Kootenay conglomerate at second outcrop, three-fourths of a mile west of Blairmore station to first outcrop of volcanics on York creek near dam site =2,200 feet.

(2.) From top of Kootenay conglomerate near fan-house on York creek to base of volcanics at Forks of York creek =2,500 feet.

(3.) From top of Kootenay conglomerate on north end of McGillivray ridge to base of volcanics on Ma butte=2,865 feet.

(4.) From top of Kootenay beds at Coleman along road to base of volcanics in railway cut=2,810 feet.

The most complete section was that measured near Ma butte and is as follows:—(Ascending order.)

| | | Feet. |
|---|---|---|
| 1. | Yellowish-weathering, soft shaly light-greenish sandstone with some irregular, thin, harder beds | 550 |
| 2. | Moderately hard greenish sandstone | 15 |
| 3. | Shaly light-greenish sandstone | 35 |
| 4. | Moderately hard greenish sandstone | 12 |
| 5. | Shaly, light-greenish sandstone | 340 |
| 6. | Massive, hard, coarse-grained, light-grey sandstone | 16 |
| 7. | Shaly light-greenish sandstone | 190 |
| 8. | Bluish shaly limestone | 14 |
| 9. | Covered | 20 |
| 10. | Massive, seal-brown-weathering calcareous sandstone, dark greenish grey on fresh fracture, alternating with shaly, dark green sandstone | 226 |
| 11. | Hard, rather thin-bedded, coarse-grained, greenish sandstone with obscure plant impressions | 40 |
| 12. | Mostly covered, a few exposures dark-greenish, shaly sandstone and some thin beds of seal-brown-weathering calcareous sandstone | 370 |
| 13. | Generally dark, bottle-green, very crumbly, shaly sandstone with irregular patches of claret-coloured argillaceous sandstone and a few thin beds of seal-brown-weathering calcareous sandstone. | 510 |
| 14. | Dark, fine-grained cherty conglomerate | 8 |
| 15. | Dark, bottle-green crumbly sandstone with irregular claret-coloured patches | 370 |
| 16. | Hard-massive, light-grey sandstone | 65 |
| 17. | Dark green, crumbly sandstone with irregular dark red patches.. | 84 |
| | Total.. | 2,865 |

Generally speaking the lower beds up to the limestone are light in colour, usually greenish in tint and weathering yellowish. These are followed by several hundred feet of strata in which calcareous beds predominate, while the upper members are dark in colour, green being the prevailing tint although the irregular dark red patches are very noticeable. They are almost always soft and readily-weathering, breaking up into small angular fragments.

The conglomerate noted here is not very persistent, being missing in the other measured sections, although on York creek a prominent outcrop of conglomerate was seen, but relatively much lower down in the section. On the east flank of McGillivray ridge a thin bed of volcanic material was noticed, consisting of ash rock and agglomerate about 12 feet in thickness and occupying a position about 250 feet above the limestone bed. This was not seen elsewhere.

No recognizable fossil forms were observed in these rocks, but obscure plant impressions are frequent, and on York creek, near the top of the formation, two small streaks of coaly material were seen. Dr. Dawson collected a number of fossil plants from similar beds on the northwest branch of the Oldman river. He estimated the zone at which they occurred to be about 400 feet below the Crowsnest volcanics.

The following species were recognized by Sir Wm. Dawson:—

*Alnites insignis ?*, Dn.
*Platanus affinis*, Lesq.
*Macclintockia Cretacea*, Heer.
*Laurophyllum debile*, Dn.
*Aralia*, sp.
*Paliurus montanus*, Dn.
*Juglandites Cretacea*, Dn.

(*See* Annual Report, Vol. I, page 88 B.)

*Crowsnest Volcanics.*—These rocks consist of an important intercalation of volcanic breccias, tuffs, and flows, varying in colour from purplish to greenish-grey, and in texture from coarse agglomerates to fine-grained ash beds. These rocks were in 1905 microscopically and chemically examined by Mr. C. W. Knight, and from about sixty specimens he distinguished four predominant rock types, viz: augite-trachyte breccia, tinguaite, andesite tuff, and analcite-trachyte tuff.[1]

At one point where these rocks cross the Crowsnest valley near Coleman, Dr. Dawson noted "small segregations of copper pyrites forming scattered granules in some of the agglomerates."[2]

These rocks cross the valley of the Crowsnest river at two points, the most easterly being about 2½ miles west of Blairmore, and the second about 1 mile west of Coleman. At the first of these outcrops a total thickness of 440 feet was measured, while to the west of Coleman they reach a thickness of 1,150 feet.

It appears that the volcanics reach their greatest thickness about 2 miles to the east of Crowsnest mountain, thinning out rapidly to the eastward. They have been traced in a north and south direction for over 45 miles, but at both extremities are only a few feet thick.

On account of their superior hardness and homogeneity these rocks usually outcrop on the crests of comparatively high north and south ridges, and have been found especially useful in working out the structural features of the area.

*Benton Niobrara.*—The volcanics are overlain conformably by a great thickness of shales. It seems probable that these are referable to the Benton formation, possibly including rocks of Niobrara age towards the top. This series consists almost entirely of shales, but includes at least two sandstone beds. The lower of these occurs about 250 feet above the volcanics, is about 12 feet thick, dark-coloured, thin-bedded, and often shows ripple markings, and secondary quartz developed along jointage planes. The upper sandstone bed is found about 220 feet above the first; it is a notable horizon-marker, being apparently very persistent throughout the area, and by reason of its superior hardness is often found outcropping when the softer shales on either side are completely drift-covered. This bed is usually from 15 to 20 feet thick, is very siliceous and hard, and, although generally dark grey on fresh fractures, weathers to light-whitish tints.

From the volcanics to the first sandstone the beds are composed of fissile, dark grey shales with a few thin dark arenaceous beds. Between the sandstones the shales are generally somewhat sandy, often rusty-weathering and showing sparsely scattered clay ironstone nodules. The upper sandstone bed is overlaid by dark sandy shales and shaly sandstones for 150 feet, which are succeeded by dark rusty-weathering sandy shales and grey nodular clay shales.

On account of their soft, readily weathering nature these rocks are seldom well exposed, and where seen frequently show considerable minor folding and crumpling;

[1] See "Analcite-trachyte Tuffs and Breccias from Southwest Alberta": C. W. Knight, Canadian Record of Science, Vol. IX, No. 5.
[2] See Annual Report, Vol. I, page 69 B.

in consequence any estimate of their thickness must necessarily be approximate only. It seems probable, however, that they are at least 2,750 feet thick and possibly several hundred feet more.

The best section available of these beds is seen on York creek, but even there exposures are few especially towards the top of the formation. On Pelletier creek the lower members of the series are well seen in many places.

A number of fossils were found at various exposures on York and Pelletier creeks; of these Dr. Raymond has identified:—

*Scaphites ventricosus*, Meek and Hayden.
*Inoceramus labiatus*, Schlotheim.

On the northwest branch of the Oldman river, Dr. Dawson collected a number of fossils from this formation, the following of which were identified by Dr. Whiteaves:—

*Pholadomya papyracea.*
*Scaphites Warreni.*
*Scaphites vermiformis ?.*[1]

*Allison Creek Sandstones.*—A series of sandstones succeeded the dark shales apparently conformably; they are generally soft, of pale greenish to yellowish shades, weather to light colours, and are rather coarse in texture. The lower beds of this series are well seen on York creek, about half a mile below the fan-house, where about 250 feet are exposed; above this point they are cut off by a large fault.

On McGillivray ridge a measured section showed 1,900 feet of these rocks, when they are again interrupted by faulting.

The sandstones are somewhat similar in appearance to the lower members of the Dakota, but differ from the latter by being usually of lighter colours, more massive, and in not so readily disintegrating into crumbly angular fragments.

It is possible that these beds are equivalent to the Belly River series, but as no fossils have as yet been found it was decided to use the above name provisionally.

## Structural Geology.

From Turtle mountain westward the rocks almost everywhere dip to the west, at angles varying from 30 to 70 degrees, except in a few instances where the soft shales of the Kootenay and Benton formations were seen locally crumpled. As before mentioned the coal measures, and the other formations in part, have been repeated three times between Turtle mountain and the western boundary of the area. The repetition is due to two very extensive faults, the most easterly, which may be termed the Blairmore fault, crosses the valley about half a mile west of Blairmore station while the second or Coleman fault passes through the town of that name.

The strike of both faults follows that of the rocks closely, although at times cutting the latter at very small angles. The dip of the fault plane has in neither case been clearly seen; at several points on the Blairmore fault it seemed to be nearly vertical and similar conditions were noted in several minor faults. Assuming that the dip of the fault planes in both the large faults is vertical the throw of the Blairmore fault must be close to 2,000 feet and that of the Coleman fault over 8,000 feet; the downthrow being in each case to the east.

The topography of the country does not appear to be materially affected by the faulting, but depends on the nature of the rocks, the alternating ridges and valleys following approximately the strike of the harder and softer rocks respectively. In many cases the crests of the higher ridges are composed of either the volcanic rocks

[1] See Annual Report, Vol. I, page 89 B.

or the hard cherty conglomerate forming the upper bed of the Kootenay formation, while some of the valleys, notably the upper end of Blairmore Creek valley, follow the strike of the soft Benton shales.

## ECONOMIC GEOLOGY.

Coal mining is by far the most important industry in this district, but until the map is completed and the structure more fully worked out, it is impossible to even approximately estimate the amount of available coal. Three companies are operating to the west of Turtle mountain. The West Canadian Collieries at Blairmore, and the McGillivray Creek Coal and Coke Company and the International Coal and Coke Company at Coleman, while considerable prospecting has been undertaken by the Head syndicate on the Coleman outcrop where it crosses the headwaters of the South fork of the Oldman river.

At Blairmore the Rocky Mountain Cement Company is utilizing the Carboniferous limestone and the Fernie shales in the manufacture of cement; both materials are quarried in open pits and transported to the plant by aerial trams. During 1910 the output of cement from this plant exceeded 60,000 barrels, the daily capacity being about 500 barrels.

### BURMIS IRON ORE.

At the end of the season a hurried visit was made to a number of iron claims in the vicinity of Burmis station, about 9 miles east of Blairmore. These claims have been prospected by means of open-cuts and a short tunnel along a line extending for about 8 miles northwards from a point near Burmis station; most of the prospecting, however, having been done near the northern extremity of this line on the headwaters of Cow creek.

The iron-bearing beds occur interbedded with a series of soft, rather coarse, light-coloured sandstones which outcrop along the foothills 2 or 3 miles east of the Livingstone range. This range is composed of Palæozoic limestone with a narrow belt of the coal-bearing Kootenay formation, evidently with a faulted contact, lying along its eastern flanks. The sandstone series containing the iron-bearing beds apparently forms part of the upper Cretaceous group which extends eastward towards the prairie, but as no fossils were found and its stratigraphical relations not seen, its proper horizon is not known. It is evident, however, that the great fault noticed in the Crowsnest valley near Burmis must extend northward, a short distance east of the Livingstone range, and with its eastern downthrow brings together the Kootenay rocks and the upper Cretaceous.

On the most northerly claims, where most work has been done, there are at least three iron-bearing beds contained in a thickness of not more than 250 feet of strata; the rocks here, however, are rather severely folded, causing difficulty in identifying the beds on which the various openings have been made.

In the valley of a small creek, rising in the Livingstone range, three distinct beds were seen, on the middle one of which a tunnel about 100 feet in length has been driven with a cross-cut 34 feet long, driven to the west, at the end. The tunnel and the first 20 feet of the cross-cut are in ore, but unfortunately this work was done on the axis of a synclinal fold with gentle dip on its easterly limb and slightly overturned to the west, the result being that at the tunnel entrance the ore is lying almost flat while at the end of the cross-cut it is standing vertical. The ore is also somewhat fractured, is much slickensided, and shows considerable calcite developed along fracture planes. It is impossible at this point to gain a fair idea of the size or quality of the deposit. About 200 yards to the south of the tunnel an open-cut on the same bed also near the axis of the syncline shows it to be 8½ feet thick and fairly uniform in character.

Another open-cut about one-half mile south of the tunnel exposes a second bed which is probably below the first and is here 10½ feet thick. The strata at this point are nearly horizontal, dipping from 5 to 8 degrees to the west; and the ore appears to be of a very uniform nature. A sample taken across the bed in this cut was analysed by the Mines Branch with the following results:—

| | |
|---|---|
| Fe (metallic) | 39·80 per cent. |
| $SiO_2$ | 18·33 " |
| CaO | 2·21 " |
| MgO | 2·25 " |
| $TiO_2$ | 5·56 " |
| P | 0·073 " |
| S | trace. |

The writer was informed that there are a number of other openings both to the north and south of this point, but none of these were examined with the exception of a couple of small cuts, about 1 mile north of Burmis, where two beds of iron ore were seen. The ore, where stripped, was found to be dipping with practically the same angle as the slope of the hill so that it was difficult to measure the thickness of the beds, the larger bed showing about 5 feet and the smaller 3 feet of ore with the top in neither case clearly defined.

A sample of the smaller and richer-looking bed was taken and analysed by the Mines Branch, the results being as follows:—

| | |
|---|---|
| Fe (metallic) | 55·50 per cent. |
| $SiO_2$ | 12·53 " |
| CaO | 2·78 " |
| MgO | 0·52 " |
| $TiO_2$ | 5·74 " |
| P | 0 10 " |
| S | trace. |

It would appear that this deposit consists of a number of beds of indurated black magnetic sand, probably in the form of an ancient shore concentration. Under the microscope the ore was seen to be composed of more or less rounded particles of magnetite, quartz, and augite with a little secondary calcite, apparently derived from plagioclase, the whole being cemented with iron oxide. It is possible that the titanium dioxide shown in the above analyses may be due, at least in part, to the presence of sphene or rutile; if this is the case a product might be obtained by some method of magnetic concentration, sufficiently free from titanium to be of commercial value. Experiments are now being conducted in order to ascertain the nature of the titaniferous minerals present in the ore.

# I.

# GEOLOGY OF ROCHE MIETTE MAP-AREA, JASPER PARK, ALBERTA.

(*D. B. Dowling.*)

## Introduction.

The activity in prospecting for coal in the Yellow Head Pass region, noted in the Summary Report for 1910, was continued during the past summer and has resulted in the establishment of a shipping mine—the Jasper Park collieries. Coal seams were also found east of Brulé lake at no great distance from the Grand Trunk Pacific, so that when there is a railway on each bank of the Athabaska four coal-mining centres will probably be actively engaged in producing coal. That is, a mine or mines on each side of Brulé lake and others farther westward on either bank of the Athabaska, above Fiddle creek, will furnish coal to the Canadian Northern and the Grand Trunk Pacific railways.

The energies of the party during 1911 were expended mainly on the mapping of the above-mentioned areas of economic importance. The previous season having been devoted, in the main, to mapping the southern portion of the coal area west of Fiddle creek, therefore the continuation of this area north of the Athabaska and those areas to the east of the first range received more particular attention this season.

The topographic details secured, consist of various traverses of roads and streams made to supplement the photographic records obtained while extending the triangulation inaugurated last year. The photographic work was carried out by L. H. Gass and A. J. Merrill, and the triangulation and angular measurements were by S. E. Slipper and E. H. Orser. Traverses were made by all the members of the party as opportunity arose, and it is a pleasure to record the cheerful and energetic assistance rendered.

## Summary and Conclusions.

The coal-bearing Kootanie formation, of lower Cretaceous age, forms two coal areas, each of which extends in a general N.W.-S.E. direction on both sides of the valley of the Athabaska. One of these coal areas is situated east of the first range of the Rockies and crosses the Athabaska in the neighbourhood of Brulé lake. The second lies to the west of the first, inside of the first range of the Rockies.

The lower Cretaceous rocks brought up in the eastern coal area, east of the first range of the Rocky mountains, form an anticlinal ridge. There is evidence that Devono-Carboniferous rocks were overthrust from the west for a short distance on these Cretaceous beds. The anticline reached its maximum uplift in the hill known as Folding mountain, and the denuded northern end of the hill shows that the Carboniferous limestones form its axis, while overlying coal-bearing Cretaceous beds are present only as an encircling band. A part of the eastern limb of the anticline is available as a coal-mining area, and probably also a part of the western which, however, may be either much crumpled or overridden by the Devono-Carboniferous. South from this point of maximum upthrust, the elevation of the outer range decreases and it seems probable that the Kootanie rocks will be found exposed in several of the ridges which form the continuation of the Folding Mountain anticline. Northward the anticline is very hard to follow since, where it crosses the Athabaska valley, erosion has been heavy and the strata are largely hidden by detrital matter. In the hills to the north and west of Brulé lake, the anticlinal axis, along which outcrop the coal-bearing beds of the upper part of the Kootanie, is seen in close proximity to the first range where it is very evident that the western limb of the Cretaceous anticline passes beneath the Devono-Carboniferous limestones of the first range. These Cretaceous beds may also be seen beneath the same limestones on the south side of the river in Drystone creek.

The coal area inside the first range crosses the Athabaska from the valley of Moose creek on the north and follows south along the east face of the range which terminates at the river in Roche Miette. The southern part is divided along its length by a broken anticline which shows in places older strata. The eastern portion is probably a narrow basin in which only the lowest seams are likely present. The western part, which is a monoclinal block for part of its length, presents more favourable conditions for mining from the edge of the valley by tunnels along the seams. Three workable seams of steam coal in beds of 5, 10, and 13 feet, respectively, have been prospected at the Jasper Park collieries situated in this western portion.

North of the Athabaska the eastern trough narrows, finally disappears, and at about 4 miles from the river the basin may be said to be unbroken except for folds in the measures toward the western edge. At the canyon on Moose creek, half a mile below the crossing of the 6th principal meridian, a small seam of coal is found below a conglomerate band. Above the canyon, at a point 3 miles up stream, five workable seams have been discovered, for which details are given later.

## Topography.

The general structure of the Rocky mountains from the International Boundary north to the Saskatchewan river is that of a series of westerly dipping fault blocks of similar strata resting against each other. A repetition of form and of strata, and a continuity in the ranges, therefore, obtains, but in going northward, more diversity in the form of the blocks is noticeable. The uniform westerly dip and the regular repetition of beds is to a great extent replaced by folding of the strata, while a greater variety in the outline of ridges is apparent. This departure from the regularity of form that holds in the south, is exemplified in the district visited this summer. This district forms a part of the outer ranges of the Rocky mountains, and is crossed in an east-west direction by the deeply eroded valley of the Athabaska river, into which drain several streams flowing between the tilted and folded blocks of strata that form the ranges.

One mountain chain occurring in the southwestern part of the district, seems to be quite persistent although its general direction is deflected at the Athabaska. A flat-topped, cliff-sided point on this range, south of the Athabaska, has long borne the name Roche Miette and forms one of the most striking features in the landscape. Between this range and the foothills, the mountains, largely owing to their geological structures, are more irregular.

In the northern portion of the map-area, the outer ridges are the upturned edges of the harder beds of a wide fault block. At the Athabaska river, this block shows signs of longitudinal folds and breaks, which, farther south, have prevented any continuity of the ranges. One short ridge south of the Athabaska, occupying a position in advance of the mountains, is plainly caused by a simple fold, and the arch so formed—a short ridge of limestone exposed by the erosion of the softer rocks of the original surface—bears the descriptive name, Folding mountain.

The foothills near the Athabaska valley are not prominent and to the south are somewhat irregular especially near the mountains; to the north the ridges have steep faces towards the mountains and long easy slopes northeastward.

The drainage channels that are cut through the mountains or foothills in many instances seem to owe their origin to breaks in the upthrusted blocks.

The stream occupying the Athabaska valley above Brulé lake is, for some distance, depositing considerable fine-grained material along its bed, and its present meandering course by many channels, through a swampy flat with the evidence of discarded channels, seems to indicate that it has partially filled a former lake which extended from Brulé lake to Jasper lake, and that possibly the present shallow basins may eventually become silted up. The presence at Brulé lake of lake deposits at elevations of 100 feet above the present water level tends to show that probably the outlet has been lowered.

Gravel terraces similar to those in the Saskatchewan and Bow valleys are found at elevations up to 300 feet above the present river. These probably belong to the same period as the transported deposits known as the Saskatchewan gravels.

The tributary streams entering on each side are moving a large amount of gravel into the Athabaska valley and in almost every case show a steady growth of fan deposit near the mouth. Thus at the mouth of Fiddle creek, the steeper grade of the tributary stream has enabled it to move material toward the Athabaska river that could not be removed by the current of that stream. Consequently the river has been forced over against the rocky walls of the ridges on the north side. At the mouth of Moose creek a smaller collection of river-borne material forms a flat fan, which occupies a part of the river flat. This appears to be due to the activity of the current of Moose creek and its growth shows a corresponding influence in deflecting the course of the river away from the north bank. The large tributaries, such as Rocky and Stone Indian rivers, which enter the Athabaska from both north and south, may have been the cause of the formation of Jasper lake, by moving material into the valley and thus forming an obstruction partially damming back the water. Brulé lake, although it seems to be silting up, has no doubt also been lowered by the erosion of the barrier at the outlet. This barrier consists of tilted beds of Cretaceous sandstone that, separated by shale, form a succession of hard ribs. The channel which is being cut through them from Brulé lake to the mouth of Prairie creek, although it has a fairly uniform and heavy gradient, is still in process of erosion where it crosses each of the ribs. The gradient of the channel through this barrier steepens perceptibly a short distance below the lake, and there are several rapids. None of them, however, are at the outlet, so that the erosion, still going on, does not immediately threaten the existence of the lake.

## Forest.

The largest extent of green forest, containing timber of marketable size, occupies a triangular area of country lying to the east of Brulé lake. Other fairly large areas of unburned timber are found within the mountains, on the flat lands through which wind the many channels of the Athabaska river. Another area of green forest extends in patches from the head of Drystone and Prairie creeks to the western sources of McLeod river. Although throughout the district there are, here and there, small patches of living trees, the greater part of the original forest has been burnt. This burnt forest, however, remains standing, or when fallen, decays very slowly and is free from borers. There is thus a large quantity of material in a dry state that should not be allowed to rot or by subsequent burning further destroy the soil and seedlings already springing up. The measures to be taken to remove this material which is an eyesore and an obstacle to travel through the country may be successfully arrived at. In the vicinity of the mines, much of it can be used as lagging and in timbering.

## National Park.

The facility with which the mountains can be reached since the construction of the Grand Trunk Pacific railway to the mouth of Miette river, offers great inducement to those seeking change for health or recreation, and the adaptability of this area for health and pleasure resorts may be noticed. The scenery of Jasper park is pleasing, since the valley of the Athabaska which is wide and well furnished with lake-like stretches of water, forms a contrasting foreground to the mountain peaks and ranges on either side. The outer ranges, while not grand masses, are sufficiently high to afford difficulties in mountain climbing, besides which they offer in their folded strata, studies in the great processes of mountain building and evidences of the mighty forces of nature. The approach to the mountains by way of the Athabaska valley offers ever-changing scenic views of river stretches and wooded hills, above which can be seen the rugged ridges of the outer range. The upper waters of the Athabaska have their origin in the main range and in this, at no great distance from the railway, some of the highest peaks in the Canadian Rockies are to be found.

A new town, Fitzhugh, is now being laid out at the mouth of Miette river, a few miles above the site of Wm. Henry's old trading post, and from it the adventurous have choice of many high peaks. The picturesque Maligne lake, the description of which is from the pen of Mrs. Schaffer, the first lady, and possibly the first explorer, to describe its valley,[1] is within a distance of less than two days' travel from the town. A survey of its waters was made this season by Mrs. Schaffer, and will no doubt appear in one of the geographical magazines.

Another townsite is being surveyed at Fiddle creek, and it is also the location for a large hotel selected by the Grand Trunk Pacific Railway Company under the shoulder of Roche Perdrix, commonly called Fiddle mountain. From this point it is proposed to construct a road to the hot springs, a distance of about 7 miles up Fiddle creek, passing through a very rough canyon. The waters of the springs, of which there are several in a group, vary in temperature—the highest observed being 127 F.—and give off a decided sulphurous smell. The medicinal value of the springs has been tested by the workmen on the railway construction with favourable results to alleviate rheumatic attacks induced by exposure and hard labour.

## Transportation.

Trains on the Grand Trunk Pacific railway are run west as far as Fitzhugh, near the mouth of Miette creek and the site of Henry House. Progress is being made on the construction of the line through the pass, but on Miette creek this is retarded by considerable rock-cutting. The difficulty in the construction of the piers for the bridge across the Athabaska caused considerable delay and a temporary structure was ultimately used. The Canadian Northern Railway Company is also actively engaged in the construction of a through line to the Pacific coast, and the section from Edmonton to the mountains will probably be completed during 1912. This road passes through the park on the northern and western side of the Athabaska. The coal areas on both sides of the river have thus excellent shipping facilities in two directions—eastward to the network of railways traversing Alberta and Saskatchewan, and westward through British Columbia to possible smelters requiring coke.

## General Geology.

The section of the consolidated rocks of this district includes a sequence of beds from the middle Cretaceous downward to and including argillites, sandstones, and limestones of Cambrian age. The crests of mountain ridges are almost wholly of the harder members of this series, namely the heavy limestone beds referred to the Carboniferous and Devonian. Among the formations so far recognized are certain thin-bedded, shaly sandstones found between the red beds of the Triassic and the limestones of the Carboniferous, to which in the absence of fossils, either a Permian or upper Carboniferous age might be assigned. There is also a series of shales between the Devonian and Cambrian rocks in which no fossils have been found. These are provisionally referred to the Silurian but may be lower Devonian.

[1] Bull. Geol. Soc. Phila. Vol. VII, No. 3, 1909.

TABLE OF FORMATIONS.

| | |
|---|---|
| Recent | River deposits. |
| Pleistocene | Boulder clays. |
| " | Cemented gravels (similar to Saskatchewan gravels). |
| Cretaceous | In the disturbed area of the foothills, beds of the Edmonton series are found. In the mountains the lower part of the Cretaceous is exposed. |
| Jurassic | Shales and sandstones. |
| Triassic and Permian | Red and yellow sandy shales and yellowish sandy dolomites. |
| Carboniferous | Limestones and shales in thick beds. |
| Devonian | Heavy bedded limestones. |
| Silurian (?) | Shaly limestones. |
| Cambrian | Yellow sandy limestones and reddish argilites. |

## CRETACEOUS.

### *Kootanie Formation.*

The beds of this formation are the highest of the Cretaceous exposed within the mountains at this latitude and are the coal-bearing beds of the foothills and mountain areas. They are of fresh-water origin, though salt water deposits are not entirely absent. Plant remains are to be found throughout the whole thickness of the measures. A small collection of plants was brought from these beds on one of the branches of McLeod river from the Nikanassin basin. The species represented as determined by Dr. Knowlton include the following:—

*Podozamites Lanceolatus,* (L. and H.) Nahorst.
*Sequoia Reichenbachii,* (Geinitz) Heer.
*Sequoia Smittiana ?,* Heer.
*Oleandra gramniæfolia,* Knowlton.
*Zamites acutipennis,* Heer.
*Asplenium Dicksonianum,* Heer (of Dawson).

From the shales above a coal seam at Folding mountain, Mr. W. J. Wilson and Dr. Knowlton recognize the following forms:—

*Sequoia Reichenbachii,* (Geinitz) Heer, and *Sphenolipidum Kurrianum,* Heer.

The sections as found south of the Athabaska, when compared with those of the Bighorn basin, are found to be somewhat similar, having in each a conglomerate band beneath the productive part of the coal measures. North and east the principal apparent change is the introduction of beds of conglomerate in the upper or coal-bearing portions.

A varying amount of the Cretaceous is exposed within the mountains. Since it is not certain that the top of the Kootanie is present, an estimate of the total thickness is not possible.

## JURASSIC.

### *Fernie Shales.*

The best exposures of these beds occur on Fiddle creek below the mouth of Sulphur creek, and consist of black shales, among which sandstone beds are distributed. These sandstone beds contain marine shells. In the first rib of sandstone below the plant-bearing beds of the Cretaceous, and separated from them by 100 feet of shales, forms similar to *Arctica (Cyprina) occidentalis* and *Nemodon sulcatinus* were found. The first of these is recorded by Dr. Whiteaves from the lower shales of Queen Charlotte islands, and regarded as Jurassic. The second is probably one of the forms from the same horizon described under the name *Arca* (Nemodon).

Below and separated from these sandstones by approximately 100 feet of dark shales, lies a second sandstone rib. In this, specimens of *Gryphaea planoconvexa*, *Ostrea strigicula*, and a species of *Terebratulina* were found. Of these Mr. Raymond says: "The fossils and their mode of occurrence strongly suggest the Ellis formation of Montana and the Yellowstone National park." The Ellis formation has been considered as Jurassic, and this, therefore, furnishes the first correlation between the Fernie shale horizon and the Jurassic of Montana, although previous to this the Jurassic age of the Fernie shale and the lower shales of Queen Charlotte islands has been admitted.

### TRIASSIC AND PERMIAN.

In the Cascade basin the beds included in the above were the Upper Banff shale and the Rocky Mountain quartzite. Here a subdivision has not as yet been made. The series consist of reddish shales and dolomites resting on yellow to brown shales and sandstones or quartzites. No fossils have been collected from any of the beds, but the presence of Triassic rocks in the mountains along the Brazeau has been established by the finding of fossils of the Monotis type. The Monotis beds on Peace river to the north are also included in the Triassic.

### PALÆOZOIC.

#### *Carboniferous.*

Immediately beneath the thin bedded brownish quartzites and shales there are two heavy limestone formations separated by thinner bedded limestones and dark shales, which occupy positions similar to the Upper and Lower Banff limestones. The Lower Banff shale, which in the south separates these limestones, is here of somewhat similar character, but occupies a much greater thickness in the section. From the upper limestone band a few fossils were collected, but their determination is only provisional, and detailed study and comparison with those from Banff may alter the list considerably.

The thickness of the two limestone bands, with intervening shales, approximates only about 3,000 feet, which even with the addition of the shales below would be thinner than the Banff section.

#### *Devonian.*

The rocks of Roche Miette show a heavy limestone bed of a somewhat yellowish weathering appearance superimposed on shales and sandy limestones, the lowest of which represent horizons below the Devonian. It is probable that the same heavy limestone is repeated in the cliffs on the west side of Brulé lake. The Roche Miette limestone is thus similar to the Intermediate beds of the Bow River section. From the lowest part of this limestone Mr. McEvoy collected the following[1]:—

*Atrypa reticularis*, (Linne).
*Dyphyphyllum*, sp.
*Cyrtina*, sp.
*Spirifer* (or *Spiriferina*), sp.
Casts of elongated spiral gasteropod.

[1] Ann. Rep. Geol. Survey, Vol. XI, p. 29 D.

Our collection from Mr. Raymond's list includes:—

*Syringopora*, sp.
*Favosites* cf. *F. digitalus*, Rominger.

These are from the loose material on the face of the limestone.

From the summit and in thinner beds than the mass of the heavy limestone band, the forms found are:—

*Proetus*, sp. ind.
*Schuchertella*, sp. ind.
*Cyrtina*, sp. ind.
*Atrypa reticularis* (Linne) var.
*Gypidula* cf. *G. comis*, Hall.
Fish tooth.

Mr. L. M. Lambe has furnished the following description of the fish tooth mentioned in the above list:—

"The small, anterior, detached fish tooth, labelled 'summit of Roche Miette, Alberta, D. B. Dowling, 1911,' is apparently referable to the genus Helodus, Agassiz, of the Palæozoic selachian family Cochliodontidae.

"The specimen was embedded in bluish-grey limestone holding many fragments of crinoid stems. It is transversely elongated and arched, and rises in the centre to a rounded prominence. Its measurements are: diameters, 12·7 mm. by 4·6 mm., max. height, 4 mm. The surface of the crown is smooth and exhibits numerous minute punctæ.

"Detached teeth which have been referred to this genus occur in the Chemung (upper Devonian) of Pennsylvania. Over a dozen species have been described from the Subcarboniferous of the central States (Iowa, Indiana, etc.), and the genus is sparingly represented in the Coal Measures of Illinois. The Carboniferous Limestone series of Great Britain has furnished material for a number of specific forms.

"As the fish tooth from the summit of Roche Miette is not apparently referable to any known species of the genus to which it is considered to belong, and as this genus ranges from the Chemung up into the Coal Measures, there is no evidence supplied by the tooth in question as to the exact age of the limestone beds in which it was found, whether they are uppermost Devonian or belong to a rather higher horizon.

"A portion of another fish tooth, labelled 'Falls, north side of Athabaska river, Brulé lake, Dowling, 1911,' is preserved in a piece of limestone similar to that from Roche Miette, and also holding numerous remains of crinoid rings in a like state of preservation. This locality is within 6 miles of Roche Miette.

"The second specimen is incomplete and consists of a portion of a flat-pavement tooth. The part preserved is four-sided with two rounded angles, one of the sides being the line of fracture. It measures 9 mm. in length and breadth. The surface is smooth and polished, and, as in the Roche Miette tooth, punctæ are present. At the unbroken end the bony base projects beyond the margin of the upper polished surface.

"Traquair has shown that in a connected dental series of the Cochliodont sharks there is a great variation, according to location, in individual teeth, in both shape and size. It is, therefore, probable that this second specimen belongs to the species represented by the Roche Miette tooth."

The limits of the Devonian can scarcely be defined as yet without further collection of fossils and study, but it seems to include the shale band above the limestone as well as the thin-bedded limestone beneath. An approximate thickness of 3,000 feet will probably include all that is definitely Devonian.

### *Silurian (?).*

As there is no marked unconformity in the series down to the lowest rocks found, namely, the middle Cambrian, there is, therefore, a series of shaly beds which may be grouped under the above head. The only fossils found were in beds 200 feet above the Cambrian, and of these Dr. Shimer says:—

*Upper Part of Yellow Bed, Roche Miette.—Stromatopora (Syringostroma)* sp. (Genus characteristic of the Devonian). "From the known distribution of the species . . . the age of the beds containing these forms should be lowest Devonian or possibly Silurian."

### *Cambrian.*

Near the base of the series which forms the mass of Roche Miette a distinct yellow band is exposed near the fault line which separates the lower rocks from the Cretaceous. Along the range to the south, a few hundred feet of lower beds intervene, but this yellow band is very near the base of the limestone series as exposed in the outer ranges. The evidence of age is given by Mr. Raymond as:—

*Crepicephalus* cf. *C. iowensis*, (Owen).
*Ptychoparia affinis*, Walcott.
*Ptychoparia* cf. *P. wisconsonensis*, Owen.
*Dicellomus*, sp. ind.

"These species indicate a horizon about the same as the upper part of the Gallatin limestone of Montana which Dr. Walcott has referred to the upper part of the middle Cambrian. The fauna is also similar to that of the upper middle Cambrian of the upper Mississippi valley, and not of the same type as the middle Cambrian at Mount Stephen and elsewhere."

## Economic Geology.

### cement and lime.

The wide use of cement in the building industry in Alberta, has led to the construction of cement works on both branches of the Canadian Pacific railway near the mountains, since the necessary calcareous material is found only in very small amounts in the rocks of the plains. Calcareous deposits in the form of marl beds have been found in the vicinity of the Grand Trunk Pacific railway west of Edson. The foundations of cement works in the vicinity have already been laid and it is probable that the manufacture of cement will be assured in a few years.

It is also probable that the limestone and shale of the outer ranges of the mountains may be used for a similar purpose.

Locations for the quarrying of limestone, presumably for lime manufacture, have been applied for on both sides of the Athabaska valley—on the western slope of Roche Miette and the same beds on the slope of Roche Ronde.

### iron ore.

Some of the shale bands which separate the limestone formations contain a small amount of iron oxide. The greatest impregnation noticed is to be found in a series of siliceous shales between the limestone and the overlying coal-bearing rocks. As red bands, these rocks have been traced northward from the Kananaskis river, and their increased thickness and extent increases the probability of finding in them mineable bodies of iron ore, though, as a rule, these would be of low grade. Samples of thin beds of richly impregnated rocks which looked promising were brought in by assistants on the party from the slopes of the hills east of Moose creek. These appear to have been obtained from rocks just below the red band and may be the result of infiltration from the beds above.

COAL.

The rocks of the Kootanie, which is in general a sandstone and shale formation, contain coal seams. These rocks, previous to the formation of the Rocky mountains, were deeply buried, but are now found outcropping in the valleys of the outer ranges, having been elevated along with the great blocks of the underlying limestones. In the foothills, they are occasionally found in advance of the first range. The uplift necessary to bring these beds to the present surface was accompanied by the formation, to the east, of a wide syncline in the rocks of the plains. This basin, at the latitude of Edmonton, is wide, but farther south narrows, and the dip of the beds on either limb of the syncline steepens perceptibly. Near the Athabaska an anticline or elliptical dome, showing by denudation a central axis of limestone, has formed in front of the first range. Beds of coal and the lower part of the coal-bearing series thus outcrop in elliptical form round the exposed limestone mass (Folding mountain), but portions on the west side may be entirely over-ridden by the limestone of the first range. North of Brulé lake, the anticline in the Kootanie beds appears to be a continuation from Folding mountain, and coal seams have been exposed by prospecting on both sides of the axis.

### *Coal Areas.*

*Scovil Creek.*—Mention was made last year of the finding of coal on this creek. The claim known as the Keywood location covers a width of a mile on the creek. The original outcrop of coal was near the summit of the anticline, so that the seam has an exposure of a short distance only on the side of the valley. The part on the eastern slope of the anticline is the most promising for mining, as the thickness is 9 feet 6 inches and the dip is only 25° northeast. Some prospecting has been done on the slope of the hills toward Brulé lake. One hole was found in which a 12 foot seam had been uncovered. The outcrop shows many dirty streaks in the coal and a portion only may be good mining coal. This portion is an upper seam and is separated apparently from the one on the gully by a band of conglomerate. On this same creek, but above the apex of the anticline, some prospecting has been done on the westerly-dipping beds by Mr. Bartholemew, who has secured a lease on property west of the Keywood claim. Two seams showing cross-faulting have been located. The upper one is very dirty and has hardly enough coal to mine. The lower one is about 5 feet in width and is of a very fair grade of coal. Mr. Bartholemew's sample analysed by Mr. J. O'Sullivan, Vancouver, June 20, 1911, gives:—

| | |
|---|---|
| Moisture | 0·5 |
| Volatile matter | 19·0 |
| Fixed carbon | 73·5 |
| Ash | 6·0 |
| Sulphur | 1·0 |
| | 100·0 |

This shows the result of greater pressure on the beds in that it has more fixed carbon than the Keywood 9½ foot seam. No prospecting has been done between this 5 foot seam and the one down stream on the Keywood claim on account of the indefinite nature of the boundary between the claims. Northward, several leases have been applied for, and there is every prospect that mineable seams will be found, since the foothills on the west side of Solomon creek, which comes from the northwest in a large valley, are composed of the Kootanie rocks.

*North End of Folding Mountain.*—Prospecting on the lower beds of the coal-bearing Kootanie rocks, lying on the east flank of Folding mountain, was inaugurated in 1910 by Mr. McEvoy for the Northern Alberta Coal Syndicate. The operations during the past season have proved the presence of a seam of coal about 11 feet in thickness crossing the southern part of section 29 and the northern part of section 21, township 29, range 27, west of 5th. It was discovered on the east flank of Folding mountain in a gully near the eastern edge of northwest quarter, section 21, and traced for a fourth of a mile to the northern slope. At a distance of about a mile and at a much lower elevation, or near the foot of the slope of Folding mountain, a similar seam, believed by Mr. McEvoy to be above the first, was found by trenching across the measures. The section or the distances between the seams thus found in the vicinity of the boundary between the southeast and southwest quarters of section 29, ending at the southern boundary of the section, is given in the following in descending order:—

| | |
|---|---|
| Sandstone. | |
| Highest coal seam—*Coal* | 2 feet |
| Clay | 4 " |
| Sandstone. | |
| Trenching showing shale and sandstone | 153 " |
| *Coal* | 4 " |
| Trenching showing shale and sandstone | 258 " |
| *Coal* | 11 feet 3 inches |
| Trenching showing shale and sandstone | 340 " |
| Wedge of coal 6 feet at surface pinching out with depth | 6 " |
| Partly trenched, shale, etc. | 460 " |
| Small showing of coal dust. | |
| Sandstones in heavy bed forming rib on side of mountain | 50 " |
| | 1,288 feet. |

In this section, the rocks strike N. 69° W. astronomic and dip S. 65° to 80°. The dip will probably increase with depth and change to the northward. Of the two seams with 11 and 4 feet of coal, respectively, the prospecting has been confined to a small shaft on the 4 foot seam and a tunnel run from a suitable tipple level on the strike of the 11 foot seam. The tunnel had reached a distance of 100 feet from the entry where the seam was of fairly solid coal with a few dirty streaks which raised the ash of the sample taken across the seam. The analysis shows this coal to be slightly softer, containing about 3 per cent more volatile matter than that of the tunnel seam at the Jasper collieries. It is, however, not quite as bituminous as the upper seam at the above locality by about 3 per cent less volatile matter, but has strongly marked coking qualities.

Attempts have been made at tracing the measures westward toward Brulé lake, but the surface deposits proved very thick and of a sandy nature, thus allowing the contained water to accumulate in the pits. The addition of pumping appliances is required.

*West Fork McLeod.*—South of Folding mountain the Kootanie measures are exposed in front of the first range. Considerable prospecting has been done in this area on the exposed coal seams, but its development must await the building of railway connexion with the main lines to the north. This amounts to a probable distance of 25 miles. The locality was not visited, but the following information is given by Mr. Jas. McEvoy, a former member of the staff, who was in charge of the prospecting work.

The section on the south branch of this stream shows beds dipping north 20° east at an angle of 70°. The section there shown in decending order is:—

| | | |
|---|---|---|
| Shale | 200 feet. | |
| Sandstone | 120 " | |
| *Coal* | 2 to 3 " | |
| Sandstone and shale | 75 " | |
| *Coal* | 8 " | 6 inches. |
| Sandstone and shale | 115 " | |
| *Coal* | 4 " | |
| Shale | 7 " | |
| *Coal* | 28 " | |

The two lower seams from the prospecting samples taken across the seams show the customary amount of ash for surface samples, which is principally in the broken and softer parts of the seam and is attributable partly to impurities filtered from the surface. A specimen of lump coal from the 8½ foot seam, assayed as follows (Thos. Heys and Son, of Toronto, assayers):—

| | |
|---|---|
| Moisture | 0·54 |
| Volatile | 25·28 |
| Fixed carbon | 69·95 |
| Ash | 4·23 |
| | 100·00 |

It is predicted that an average of 600 feet vertically may be mined above the entry on the coal seams in the valley of the creeks.

## The Mountain Coal Basins.

Within the outer ranges strips of the lower Cretaceous rocks have been preserved on the lower edges of some of the fault blocks and form the rocks through which some of the lateral streams have eroded channels. There are several valleys in which possibly the lower part of the Cretaceous may still remain, but as a coal formation the most important is the Cretaceous block which is found in the valley of Moose creek and southward in front or to the northeast of Roche Miette, along the west side of the valley of Fiddle creek. The coal-bearing beds are in the upper part of the Kootanie series, and remnants of this part are found both in the centre of the valley and in contact with the next succeeding fault block. The fault line, which is the western boundary of the coal area, is generally concealed by detritus, but its approximate position is indicated by changes in the dip of the beds and by local folding.

Owing to a differential uplift of the western edge of the coal measures, and to a deformation of the block by anticlinal folding, the southern end of the block is raised and the beds containing the workable seams have been eroded. Continuing south this elevation results in the cutting away almost entirely of the rocks of the lower part or non-productive portion of the Kootanie formation, so that only a very narrow band, if any, remains to form a connexion with the Nikanassin basin to the south. The measures containing mineable coal seams extend south from the Athabaska to about Sulphur creek. Northward they extend up the valley of Moose creek, and are reported as continuous to the headwaters of streams running to Smoky river, thus forming a trough that extends some considerable distance north.

The southern part of this basin is divided into two parts by an anticlinal fold along its length. At the south end, the coal areas are separated by faulting as well, but this gradually disappears northward. The eastern part is mainly in trough form, while the western, although composed of westerly dipping beds, may, in the vicinity of the major fault, which terminates the western extension of the measures, be greatly modified by foldings from the monoclinal form. It is a wedge-shaped block, narrow to the south but broadening northward, the rocks dipping toward the southwest at fairly constant angles which vary from 50° to 70° in different parts of the field. This part occupies the western edge of the fault block of which it is an upper member and is partly overridden by rocks of the next range.

The measures near the western fault are sometimes upturned and folded back, especially the highest beds at the fault contact. Those near the fault and lower in the series, and consequently seen at lower elevations, are overridden by the limestone and show less folding. The strong ribs of sandstone and the rib of conglomerate near the base of the productive coal measures form prominent ridges that show a continuity arguing well for the condition of the coal in their proximity; the lower seams, therefore, at least for this block, should be mineable southward to Villeneuve creek. Northward the block appears to widen, and should be from that fact of greater value as a coal field, since higher beds may be exposed and a greater number of seams found.

The eastern part of the coal field is in the form of a trough, the southern end of which is elevated and south of Villeneuve creek eroded away. On that creek the trough is too shallow to warrant the expectation of finding in it mineable coal seams, but on Morris creek it is much wider and the beds of the eastern limb of the syncline are not so much disturbed as those of the western limb. The inference from the exposed part of the section is that the upturn on the west was accompanied by faulting and that this fault line which separated the two coal areas reached nearly to the Athabaska valley. The section on Villeneuve creek shows an upturn of the beds on the western limb of the syncline, but after a short interval of concealed beds, lower sandstones are found dipping to the west in conformity with those of the block next the mountains. This indicates a displacement by faulting. On Morris creek there is an apparent trough, but at the point of reversal of dip, which should be the centre of the trough, the beds on the east belong at least 1,200 feet higher in the section than those on the west. There is here probably a break in the western limb and a push up of the block on the west; the amount of displacement is evidently greater than 1,200 feet.

The surface drainage north of Morris creek runs to the Athabaska, and the rocks exposed are lower down in the series than those of Morris creek. The only exposure there along the eastern edge of the western block is on Mountain creek, quite near the probable line of break, and shows sandstones containing a 9 foot seam of coal lying almost horizontal, and evidently from the attitude of the neighbouring beds forming the centre of a syncline. Near the Athabaska, the eastern block is traced only by the sandstone ridges of its eastern margin which are almost vertical. The outcrop of the rocks on the western side is concealed so that the structure is inferred from the outcrops on the opposite side of the river. The western block is traced by sandstone ridges almost to the Athabaska, where two coal seams are being mined at present. The conglomerate bed is exposed in Mountain creek, and is crossed by the stream near the edge of the terrace where the erosion of the softer beds above it has formed a fall into a narrow canyon. The erosive action of the water on the face of the conglomerate wall has hollowed out a basin at its foot and local usage has given it the descriptive name Punchbowl fall.

North of the Athabaska, the break in the centre of the eastern basin is not very evident, and the anticline on the eastern edge of the western block is plainly seen on the side of the valley, where the conglomerate stands out prominently. The double fold that is thus shown narrows down in going northward and disappears on Moose creek within 5 miles of the Athabaska valley. North of this the field is practically a continuation of the western block, and is a modified monocline. The modification is in the introduction of a second anticlinal fold which is found to the west of the first and near the fault line that limits the field in that direction. The effect of this second fold is not noticed in the beds 6 miles north but may be present on the western side of the valley.

### Western Block.

*Villeneuve Creek.*—The lower shales and sandstones of the Kootanie appear by the sections on this creek to contain very little coal, thin streaks only being observed from the bottom sandstone almost up to the conglomerate bed. Some coal dust, occurring below this conglomerate, may indicate a small seam but its thickness cannot be very great. Above the conglomerate, the beds show the following section:—

| Measures. | Feet. | Remarks. |
|---|---|---|
| *Coal* clear seam. | 10 | |
| Sandstones | 250 | |
| *Coal* | 12 | Sample and analysis. |
| Sandstones, some shale. | 350 | |
| *Coal* thin streaks | | |
| Sandstones | 100 | |
| *Coal* | 5 | Analysis by F. G. Wait.<br>Moisture 2·37<br>Volatile 22·38<br>Fixed carbon 68·58<br>Ash 6·67<br>100·00 |
| Sandstones and shales | 250 | |
| Conglomerate | 30 | |

*Morris Creek.*—On Morris creek, the first western branch of Fiddle creek, the following section is given but it is only approximate, the distances being estimated by pacing.

| | | | |
|---|---|---|---|
| Heavy sandstone bed— | | | |
| *Coal* | 3 feet | 10 inches. | Coal 10 feet 11 inches sample and analysis. |
| Shale | 0 " | 6 " | |
| *Coal* | 7 " | 1 " | |
| Sandstone | 150 " | 0 " | |
| Sandstone and shale | 100 " | 0 " | |
| *Coal* | 9 feet | 7 inches. | Analysis by F. G. Wait.<br>Moisture 1·34<br>Volatile 22·91<br>Fixed carbon. 68·51<br>Ash 7·24<br>100·00 |
| Sandstone | 350 feet | 0 inches. | |
| *Coal* | 5 " | 6 " | |
| Sandstone | 2 " | 0 " | |
| *Coal* | 3 " | 0 " | |
| Sandstone and shale | 300 " | 0 " | |
| Conglomerate. | | | |

*Mountain Creek.*—Below a point where several streams coming from the eastern face of Roche Miette unite to form this brook, an exposure of a seam in a shallow syncline shows 9 feet of coal. This may be in the bent-over eastern edge of the western block. In the gorge somewhat higher up the stream, the beds have a regular dip for a short distance of about 42° southwest. In these a seam showing 5 feet 7 inches of coal has been uncovered. Neither of these seams has been traced toward the Athabaska. The sandstone ridge between them continues to the vicinity of the river, and the supposition is that the larger is one of the seams at the Jasper collieries, which is found just below this sandstone ridge. This has been traced along the face of the ridge for about a mile, but not to Mountain creek. The mining on this seam is by level entry near the Athabaska, at the surface level of the gravel terrace, and later from tipple level above the tracks of the Grand Trunk Pacific. The seam dips 56° to the southwest and is here about 500 feet horizontally west of the conglomerate outcrop. This is a distance representing about 414 feet of beds. The section at the tunnel shows a slight thickening of the lower coal in going to the southeast, but will average somewhat as follows:—

| | |
|---|---|
| Coal | 9 feet 6 inches. |
| Sandstone | 1 to 2 feet. |
| Coal | 3 to 4 feet. |

Another seam apparently about 13 feet thick has been located 1,050 feet southwest of the tunnel. It is an upper seam, apparently 870 feet above the tunnel seam.

It is possible that other seams that are indicated in the sections on the creeks to the south may also occur here; if this is found to be so, it will add materially to the value of the mine.

*North Bank of the Athabaska.*—In the portion next the Athabaska river, the exposures of sandstone and conglomerate are confined mostly to the lower part of the formation. On the western limb of the anticline, five seams of coal above the conglomerate have been found. One which appears to be the continuation of one of the big seams at the Jasper Park collieries, has an outcrop exposure of 11 feet 7 inches of coal, and below this and between it and the conglomerate a 5 foot seam is reported.

In a gully which joins Moose creek from the west near the 6th meridian, there are several exposures of conglomerate, and it is suggested that these may not represent one bed, but three distinct horizons with 2,000 feet between the two lower and 1,000 between the upper ones. It is at present impossible to verify owing to portions being concealed, but that it is possible is proved by the section of MacVicar creek which shows three conglomerate beds. The section thus interpreted would give over 3,000 feet of measures above the lowest conglomerate and would possibly contain several coal seams.

The section up this gully from the lowest conglomerate includes a trough one-fourth mile wide at Moose creek, in which the conglomerate forms the east and west sides. The western side then turns abruptly down to the west, and 3,000 feet up the gully a 10 foot bed of conglomerate dips 67° S.W. At 4,300 feet an 18 foot bed of conglomerate dips 42° S.W. but comes up again at 4,500 feet dipping 64° S.E. This bed then passes over an anticlinal fold and is seen again at 5,600 feet, dipping 82° S.W. The beds above this conglomerate are exposed for 175 feet and contain at 103 feet from the conglomerate, the first exposed seam of coal on the creek. The following section occurs there:—

| | | | | | |
|---|---|---|---|---|---|
| *Coal* | 0 | feet | 6 | inches. |
| Shale | 0 | " | 6 | " |
| Sandstone | 4 | " | 0 | " |
| Shale | 3 | " | 0 | " |
| *Coal* | 1 | " | 5 | " |
| Shale | 2 | " | 0 | " |
| *Coal* | 5 | " | 6 | " |
| Sandstone | 4 | " | 0 | " |
| *Coal* | 0 | " | 8 | " |
| Shale | 1 | " | 0 | " |
| *Coal* | 3 | " | 4 | " |

Measures to conglomerate 103·0.

The upper part of the valley is eroded diagonally across the measures and at a distance of 6 miles above the 6th meridian is in the upper measures. The only exposure of coal on this part of the creek is of a seam which is above the lowest conglomerate and near the northwest end of the eastern trough. It seems to be in a disturbed portion of the area, but will probably be found in a less disturbed place. The section here shows about 5 feet of clean coal as below:—

Shale roof—

| | | | |
|---|---|---|---|
| *Clean coal* | 2 feet | 5 inches. |
| *Dirty coal* | 1 " | 0 " |
| Broken coal and shale | 1 " | 7 " |
| Shale | 0 " | 7 " |
| *Coal* | 5 " | 2 " |
| Sandstone | 0 " | 6 " |
| Shaly coal | 2 " | 4 " |
| | 13 feet | 7 inches. |

Samples from the top and middle portions, analysed by Mr. Wait of the Mines Branch, give the following results:—

| | |
|---|---|
| Moisture | 2·29 |
| Volatile combustible | 19·63 |
| Fixed carbon | 66·08 |
| Ash | 12·00 |
| | 100·00 |

The upper part of the valley being eroded mostly in the upper beds of the Kootanie, the hills forming its northeastern sides are of the westward-dipping beds of the coal measures. Although little prospecting has been done, Mr. MacVicar has furnished the following information relative to a section across this block in a gully from the east. Ascending this gully from Moose creek three bands of conglomerate are passed, and except for minor variations, the strike of the beds is quite uniform. The dip increases in the lower members of the section or toward the east side of the valley. Exposures between the two lower conglomerate beds seem to be few and no coal seams are recorded. From Moose creek to the second conglomerate, a very good section showing all the changes in character of the beds has been measured. A summary of this section is introduced here, beginning at the first exposure from Moose creek, the highest beds seen.

Section on MacVicar Creek—(In descending order.)

| | | | |
|---|---|---|---|
| Shale | 200 feet | 0 inches | |
| Sandstone and shale | 236 " | 0 " | |
| *Coal* seam 1 | 5 " | 9 " | |
| Shale and concealed | 85 " | 0 " | |
| Coal and shale | 5 " | 0 " | |
| *Coal* | 1 " | 4 " | |
| Shale | 101 " | 6 " | |
| *Coal* seam 2 | 6 " | 10 " | Strike N. 40° W. mag., dip 53° S.W. |
| Shale | 69 " | 3 " | |
| *Coal* seam C | 14 " | 8 " | Strike N. 30° W. mag., dip 68° S.W. |
| Concealed shale and sandstone | 163 " | 0 " | |
| Conglomerate | 45 " | 6 " | |
| *Coal* seam B | 5 " | 6 " | Strike N. 49° W., dip 69° S.W. |
| Sandstone and shale | 333 " | 6 " | |
| *Coal* seam A | 6 | 2 " | Strike N. 34° W. mag., dip 76° S.W. |
| Shale and sandstone | 272 " | 2 " | |
| *Coal* seam 3 | 5 " | 8 " | Strike N. 47° W. mag. dip 77 to 89 S.W. |
| Sandstone with 4 thin coal seam | 92 " | 6 " | |
| Sandstones | 136 " | 7 " | |
| Conglomerate | 40 " | 0 " | |
| Concealed measures estimated at | 2,000 " | 0 " | |
| To conglomerate. | | | |
| | 3,878 | 11 | |

Details of seams in above section.

*Seam No. 1—*

Sandstone hanging wall.

| | | |
|---|---|---|
| Shale | 0 foot | 4 inches. |
| *Coal* | 0 " | 7 " |
| Shale | 0 " | 4 " |
| *Coal* | 1 " | 6 " |
| Shale and coal | 0 " | 9 " |
| *Coal* | 2 " | 3 " |
| | 5 feet | 9 inches. |

*Coal seam No. 2.*

Shale hanging wall.

| | | | | |
|---|---|---|---|---|
| *Coal* | 0 | feet | 4 | inches. |
| Shale | 0 | " | 9 | " |
| *Coal* | 2 | " | 2 | " |
| Shale | 0 | " | 3 | " |
| *Coal* | 3 | " | 4 | " |
| | 6 | " | 10 | " |
| Coal | 5 | " | 10 | " |

*Coal seam C.*

Shale hanging wall.

| | | | | |
|---|---|---|---|---|
| *Coal* | 3 | feet | 6 | inches. |
| Shale | 0 | " | 9 | " |
| *Coal* | 0 | " | 3 | " |
| Shale | 0 | " | 2 | " |
| *Coal* | 0 | " | 3 | " |
| Shale | 0 | " | 4 | " |
| *Coal* | 4 | " | 0 | " |
| Shale | 0 | " | 11 | " |
| *Coal* and shale | 2 | " | 3 | " |
| *Coal* | 2 | " | 3 | " |

Sample. Analysis by Mr. Wait.

| | |
|---|---|
| Moisture | 8·78 |
| Volatile | 31·83 |
| Fixed carbon | 47·16 |
| Ash | 12·23 |
| | 100·00 |

*Coal seam B.*

Conglomerate hanging wall.—

| | | | | |
|---|---|---|---|---|
| *Coal* | 0 | feet | 5 | inches. |
| Shale | 0 | " | 3 | " |
| *Coal* | 0 | " | 6 | " |
| Shale | 0 | " | 5 | " |
| *Coal* | 0 | " | 4 | " |
| Shale | 0 | " | 4 | " |
| *Coal* | 1 | " | 7 | " |
| Shale | 0 | " | 5 | " |
| *Coal* | 1 | " | 3 | " |

Sample from coal excluding shale.
Analysis by F. G. Wait.—

| | |
|---|---|
| Moisture | 2·67 |
| Volatile | 21·05 |
| Fixed carbon | 72·42 |
| Ash | 3·86 |
| | 100·00 |

*Coal seam A.*

Sandstone and shale roof—

| | | | | |
|---|---|---|---|---|
| *Coal* (dirty) | 0 | feet | 10 | inches. |
| Shale | 0 | " | 2 | " |
| *Coal* | 0 | " | 4 | " |
| Shale | 0 | " | 2 | " |
| *Coal* | 0 | " | 10 | " |
| Shale | 0 | " | 3 | " |
| *Coal* (dirty) | 0 | " | 6 | " |
| *Coal* (clean) | 0 | " | 5 | " |
| *Coal* (dirty) | 0 | " | 2 | " |
| *Coal* (clean) | 0 | " | 11 | " |
| Shale | 0 | " | 2 | " |
| *Coal* | 1 | " | 5 | " |
| | 6 | " | 2 | " |

Coal sample, probably from this seam, sent by Mr. MacVicar. Analysis by F. G. Wait.

| | |
|---|---|
| Moisture | 4·10 |
| Volatile combustible | 22·28 |
| Fixed carbon | 58·04 |
| Ash | 15·58 |
| | 100·00 |

*Seam 3—*

Shale hanging wall—

| | | | | |
|---|---|---|---|---|
| *Coal* | 1 | foot | 1 | inch |
| Clay | 0 | feet | $0\frac{1}{4}$ | inches. |
| *Coal* | 4 | " | 3 | " |
| Clay | 0 | " | $0\frac{1}{2}$ | " |
| *Coal* | 0 | " | 2 | " |
| Clay | 0 | " | 2 | " |
| | 5 | feet | $8\frac{3}{4}$ | inches. |

*Eastern Trough.*

The southern limit of the eastern trough, considered from the point of view of its value as a coal-mining area, will be found to be between Morris and Villeneuve creeks, since, on the latter, only the lower part of the coal-bearing beds remain, the bottom of the trough passing probably less than 800 feet below the trench cut by the creek. On Morris creek, the trough is much deeper, and the measures, consequently, in greater thickness, so that the coal seams near the conglomerate, although probably folded at the bottom of the trough or near the fault line, may prove of value. On this creek in the same trough, and on the eastern side, a seam was observed standing at a high angle and having a thickness of 13 feet 6 inches. This thickness includes many partings of clay and shale which may render a part of the seam unfit for mining. On the western side of the basin, a small seam was also noted but it did not appear to be important.

Northwest toward the Athabaska there are exposures of the sandstones and of the conglomerate ridge of the eastern edge of this trough only, so that its depth or western edge can only be inferred by comparing the sections on Morris creek with those on the north bank of the river. One coal seam, at some distance above the conglomerate, has been found on a small eastern branch of Mountain creek, and although nearly vertical seems to belong to the eastern limb of the syncline. Its thickness is about 5 feet 2 inches.

North of the Athabaska, the trough narrows and it is probable that the seams above the conglomerate may prove to be of little value. There are also probabilities that below the conglomerate some of the indications of coal seen farther south may here develop sufficient thickness to be mineable. One such exposure is noted up Moose creek where the stream breaks through the conglomerate ridge. A small seam of coal 2 feet thick is found just below the bed of conglomerate, and at a point 40 feet below this another measuring 4 feet in thickness is found. This contains the hardest coal in the district. A sample of the whole seam, as analysed by Mr. Wait, shows the following:—

| | |
|---|---|
| Moisture | 0·71 |
| Volatile combustible | 15·92 |
| Fixed carbon | 71·07 |
| Ash | 12·30 |
| | 100·0 |

In the laboratory it gives a firm coke, so that this is still a coal of the bituminous class.

## Character of Coal.

The resemblance and behaviour of the coal of this district to that from the Crowsnest pass has been remarked and confirmed by the mechanical department of the Grand Trunk Pacific railway. It is slower-burning than the Ohio coals used in the eastern section of the railway, and its use requires different methods of firing. Experiments in a small way show that it is practically all coking, so that when a demand for coke in northern British Columbia is made the supply may be drawn not only from this district but from the nearby fields on the eastern slope of the Rocky mountains. As was expected, variations have been found in the coals of the different seams showing a slight increase in fixed carbon in the lower seams, and in the areas within the mountains a slightly higher fixed carbon percentage over coals from outside. Thus, in the area inside the mountain, three examples show this general rule.

| | For dry and clean coal. | |
|---|---|---|
| | Fixed carbon. | Volatile. |
| 13 foot seam at collieries | 74·21 | 25·79 |
| Tunnel seam | 78·46 | 21·34 |
| 4 foot seam below conglomerate | 81·69 | 18·31 |

Comparison between seams in the foothill areas and those within the mountains is difficult, but it may be assumed that the seams already discovered outside the first range are as low in the formation as those inside, and the analyses show this coal to contain about the same volatile combustible matter as the higher seams in the western fields.

Samples from the outcrop exposures are sure to give misleading analyses, since the alteration by exposure seems here to be greater than farther south. Thus the outcrop sample of the seam at Jasper collieries would indicate a coal bordering on the sub-bituminous class. Reference to this is made in the Summary Report for 1910, and analyses were given. A summary of these for the tunnel seam is interesting, as the workings are now far in from the surface.

| | For clean dry coal. | |
|---|---|---|
| | Fixed carbon. | Volatile. |
| Surface outcrop. | 68·66 | 31·34 |
| Thirty feet from surface | 78·46 | 21·34 |
| Nineteen hundred feet on entry, 250 feet from surface | 78·83 | 21·17 |

In several seams there is a streak of dark soft coal and shale that is high in ash and requires to be mined out. In the tunnel seam the upper part contains the most ash, but by careful mining and picking this can be reduced in the commercial product and need not exceed about 7 per cent, though in practice it probably runs to 10. The samples from the seam at Folding mountain and from the Jasper collieries give the same ash content, and it is quite probable that if a streak is wasted in each a clean coal will result.

DEVELOPMENT WORK.

The prospecting which was noted last year was continued during the past season with renewed vigour. On the west of Brulé lake, little was done in development work, but several parties were engaged in tracing the measures northwestward to streams flowing to Solomon creek, and it seems probable that the northern extension of the Scovil Creek measures will become utilized after the Canadian Northern railway is built. A large party was employed south of Brulé lake tracing seams and testing them by tunnels near Folding mountain. On Moose creek, the seams on the headwaters were found and sampled, but little development work was done.

The greatest activity was confined to the south side of the river, where at the Jasper collieries every effort was made to be ready to ship some coal as soon as the railway could be connected by a spur with the temporary tipple. The first carload was delivered to the railway company in the last week of September. By November

13 the output was 130 tons per day, and this was increased by December 16 to 275 tons. The latest returns, to March, 1912, give 400 tons per day with a maximum of 490. All the works and shipping facilities are temporary, the permanent tipple and main entry requiring to be located after careful survey. In the meantime, the temporary works do not interfere with this installation, and the present entry 240 feet above the permanent entry will be required for ventilation, timber, etc. The situation at the mine at present is as follows: the line of the Grand Trunk Pacific, on the south side of the Athabaska, skirts the foot of a gravel-faced terrace rising about 270 feet above the tracks. From the brow of the terrace there is a gentle rise to the foot of a sandstone ridge up which the stope steepens. Along the eastern face of the ridge a coal seam has been traced. An entry on this coal seam, with only grade enough for drainage, has been effected by a tunnel along its strike from the terrace level. This has been extended into the hill somewhat over 2,000 feet, obtaining a vertical depth of over 200 feet. Mining above the entry has been started at this point, and a small output to the amount stated above has been made from this block of coal. The cars are loaded in the tunnel at chutes and drawn by horse to the top of the terrace and then lowered by cable and hoisting engine on an outside slope to a temporary tipple at the siding. An inside slope on the seam is in progress to reach the level of the permanent entry, which will be about 240 feet below the present one, and will enter the hill from a point near the permanent tipple. The seam dips at about 56° from the horizontal. The system of mining will depend greatly on local conditions. There should be for some time a large supply of coal above this entry and the mining and haulage should be done at low cost.

## II

## NOTES ON COAL OCCURRENCES AND THE PROGRESS OF DEVELOPMENT WORK IN ALBERTA AND SASKATCHEWAN.

### Coal Area West of Brazeau Range.

Notice of the discovery of this area of coal-bearing rocks was published in the Summary Report of this department for 1909, page 147. No prospecting had apparently been done toward the discovery of workable seams of coal until the summer of 1911, when a party under the direction of Mr. Norman Fraser spent a short time in the search. Three seams were uncovered, one of which is of workable thickness, being reported as having nearly 14 feet of coal. This has been traced southeastward from Mire creek, over a ridge, having an elevation of 1,500 feet almost to the Saskatchewan. As the dip of the beds is not at a high angle, there will be a large tonnage of coal above the entry level, which may be made from either the Mire creek or Saskatchewan valleys. The character of the coal as reported from analyses will be slightly lower in fixed carbon than that of the Bighorn basin, but one having good coking qualities.

On the main Brazeau river, the continuation of the measures of the Bighorn basin have been found, and several seams opened. The principal one is reported as having about 20 feet of coal. As the locality was not visited by any of our parties, more definite information cannot be given.

### Kananaskis River, Branch of Lusk Creek.

Development work on the continuation of the measures of the Cascade basin, southward on Kananaskis river, has not been very actively prosecuted this year, as the building of a railway is necessary before mining operations can be resumed. On the head-waters of this stream and east of Tombstone mountain, a narrow strip of the coal-bearing rocks is found high above the Kananaskis valley. Some claims or leases have been applied for but access to the area may be difficult.

In the foothills east of Kananaskis river, the crest of an anticline running northwest from Moose mountain is dissected by streams draining east to Jumpingpound creek and west to Lusk creek, a branch of Kananaskis river. At the apex of this anticline some of the dissecting streams have cut through the soft beds of the Colorado group of the Cretaceous, and one or two through to the heavy conglomerate bed at the top of the Kootanie. The nearest of these exposures to the existing railway lines is on an east branch of Lusk creek. A prospecting party located a camp in this valley, and by means of a hand diamond drill was piercing the upper part of the Kootanie. That this method was inadequate is shown by the fact that the drill hole reached a depth of only 175 feet and went through the upper part of the sandstone. As the hole was near a fault or break which runs along the valley, the water forced downward through the drill did not return, so that though small seams of fractured coal may have been pierced in that distance, the existence of such was not proved. It is probable that better facilities for testing the measures will be installed.

## Edmonton Coals, West of Edmonton.

The coal horizon which underlies the city of Edmonton is being mined only on the outskirts of the town since the possible damage to property by the sinking of the surface is becoming too great. Attempts at reaching the horizon at points available for shipment are being made. Progress has been made on the sinking of shafts at Saint Albert, on the Canadian Northern railway, about 6 miles northwest, and the coal will be raised about 250 feet to the surface. The seam, as tested by boring, is reported to be 7 feet. Farther west, the coal of the top of the Edmonton formation outcrops at the surface near Wabamun lake, and mining on it has been commenced in the vicinity of the Grand Trunk Pacific railway. A shaft at Gainsford had this summer about reached a seam which is stated to be 10 feet in thickness. Near Pembina river, several shafts have been put down to the seams that are found in the banks of the river, and it is expected that coal will be mined there shortly. Farther west the coal horizons are again brought to the surface in the edge of the disturbed belt of the foothills, and from the thickness and number of the seams it is probable that the coal seams represent the same horizon as that of the upper part of the Edmonton formation. An uplifted block of these rocks is found on the head-waters of the Embarras river and southeast to the Pembina. On the Embarras head-waters, the Yellowhead Pass Coal and Coke Company is preparing to mine from several seams as soon as the railway branch is completed from the Grand Trunk Pacific. This is reported as being constructed at the present time a distance south of 30 miles. This line will also pass near mines operated by the Pacific Pass Coal Fields, Limited, whose holdings extend to the Pembina river.

## Eastern Outcrop of Edmonton Coal Formation.

The report on the Edmonton coal-field (No. 1115) contains notes on localities south and east of Edmonton, at which the same coal horizon has been discovered and in many places mined. These include Tofield, Round Hill, Bawlf, Camrose, Battle River, Red Willow Creek, Paint Earth Creek, and the Kneehill country west of Red Deer river.

## GRAND TRUNK RAILWAY EAST FROM EDMONTON.

### TOFIELD.

The exposures of the Edmonton coal measures on the Grand Trunk Pacific extend eastward past Beaver lake. In this vicinity coal is being mined and quarried. Just south of the town of Tofield, a flat-lying seam about 9 feet in thickness is found having from 15 to 20 feet of cover, consisting mostly of sandy shales with a few streaks of hardened sand approaching sandstone. This is now being mined by stripping (two companies operating steam excavators), and the exposed coal quarried and loaded either on railway cars or on wagons. Drilling at the town, which is below the level of the coal seam, has resulted in the finding of another seam at a horizon approximately 200 feet below the surface seam. This would appear to be the lowest seam in the Edmonton measures. An analysis of both seams shows them to be excellent fuels of the sub-bituminous class. The surface seam does not appear to have suffered to as great extent as has been reported from weathering due to its thin covering. Small areas of the exposed coal show the upper surface somewhat decomposed, but the main part of the bed may be taken as having the following characters. Analysis of sample from 9 foot seam, Tofield Coal Company:—

| | |
|---|---|
| Moisture | 15·55 |
| Volatile hydrocarbons | 35·09 |
| Fixed carbon | 44·30 |
| Ash | 5·06 |
| | 100·00 |

The sample reported to have come from the bore-hole 200 feet below is slightly more compact, but is apparently of much the same grade of fuel as that at the surface. Analysis:—

| | |
|---|---|
| Moisture | 11·12 |
| Volatile hydrocarbon | 37·88 |
| Fixed carbon | 42·81 |
| Ash | 8·19 |

## CANADIAN PACIFIC RAILWAY BRANCHES.

The various eastern branches from the Calgary and Edmonton line cross the eastern part of the coal field underlain by the Edmonton formation. On the Wetaskiwin branch, coal mines have been opened near Camrose and another near Bawlf.

### THE BAWLF COLLIERIES.

This is on sec. 10, tp. 46, R. 18, west of the 4th meridian. The coal is under a thick cover of sandstone and should be easily mined on account of the solid nature of the roof. At a depth of 140 feet, a seam of 10 feet is found. Beneath this, separated by 10 to 15 feet of sandstone, lies another seam of 6 feet. Shafts were completed and hoisting machinery installed and the mine opened in 1910.

The extension of the Canadian Pacific Railway branch east from Lacombe has opened for settlement a large area east of Sullivan lake, and a prosperous town, Castor, is now built at the crossing of Beaverdam creek. The influx of settlers and the establishment of a town at this point have created a demand for coal, and the coal seam that here underlies the town at a depth of only a few feet, is being mined by two companies operating on either side of the town.

CASTOR COAL COMPANY.

Sec. 3. tp. 38, R. 14, west of the 4th meridian.

At the outcrop of the seam in a small coulée on legal subdivision 2, near the railway, some coal is being mined by stripping, but as the cover is increasing by a westward dip in the coal, mining by tunnel will follow shortly. The seam is 6 feet 2 inches with a parting of 1 inch clay, 29 inches below the top. A sample from the tunnel 57 feet from the outcrop gives the following analysis, according to Mr. Wait:—

| | |
|---|---|
| Moisture | 25·89 |
| Volatile | 34·13 |
| Fixed carbon | 35·31 |
| Ash | 4·67 |
| | 100·00 |

On subdivision 9, the first opening or mine was made on this seam. The coal shows a thickness of 6 feet 6 inches at the eastern part of the mine, and increases westward to 7 feet 6 inches. This part of the property has a cover above the coal of 6 to 9 feet, and it is proposed to strip this for about 30 acres. The coal under this light cover shows a slight deterioration in the upper part of the seam, but samples from the lower part show very little, and the coal is in fact of the same grade as that of the former sample from the tunnel. Analysis of sample from old mine by F. G. Wait, Mines Branch:—

| | |
|---|---|
| Moisture | 24·75 |
| Volatile | 33·94 |
| Fixed carbon | 36·33 |
| Ash | 4·98 |
| | 100·00 |

On subdivision 8 and 9, the cover runs to 30 feet and the coal seam from 8 to 9 feet, as reported from borings.

A spur from the railway is graded through the western and northern part of the property, and two entries will be run north and south through from subdivision 9 to entry No. 1 on subdivision 2. The western part of the property will probably be mined by shaft at the railway.

THE BATTLE AXE MINE.

Southeast ¼ sec. 26, tp. 37, R. 14, west of the 4th meridian.

The seam on this area varies from 6 feet to 4 feet, with considerable less cover than on the property to the north of the town. It is quite probable that this could be more economically stripped than mined.

This coal horizon has been traced southward by the settlers for 60 miles from Castor, and at the following localities the thickness and cover over the coal is given as reported below:—

At Garden Plains on sec. 1, tp. 34, R. 14, west of the 4th meridian, the seam is 4 feet, with cover ranging from 5 to 10 feet. It has also been found on sec. 8, tp. 32, R. 13, but thickness is not known. Colonel Walker's mine on Berry creek, or between Berry creek and Bull Pound creek, seems to be on the top of a hill. The coal may thus be restricted to an irregular oval-shaped area, but should be repeated west. The locality is southeast ¼, sec. 19, tp. 29, R. 12, west of the 4th meridian. The south half of this ¼ section is under lease to W. Oscar. The seam is reported at 11 feet with 8 or 10 feet of cover.

In the same locality, 8 miles south on sec. 12, tp. 29, R. 13, west of the 4th meridian, 8 feet of coal is reported with light cover, and another report is to the effect that midway between these above exposures, the seam has been found.

What might be termed a stripping area is thus pretty well defined along the eastern outcrop of the Edmonton measures reaching from Tofield in township 50 to the Berry Creek locality in township 29, a distance of 132 miles, with a seam having a maximum thickness of 11 feet and a general average of 8 feet, but in places as thin as 4 feet. The amount of domestic fuel easily obtained in large measure by stripping is thus seen to be enormous.

### Northern Extension of Medicine Hat Area.

On the Red Deer river, the Lethbridge seam was mapped by G. M. Dawson as outcropping on the banks for many miles below the mouth of Bull Pound creek. Last year, a mine was opened at Fieldholme, on secs. 6 and 7, tp. 23, R. 14, west of the 4th meridian, with a coal seam of 5 feet 6 inches.

### Mannville.

The northern portion of the exposed coal-bearing rocks belonging to the Belly River formation, or the continuation of the coal-bearing beds of Medicine Hat and Lethbridge, is exposed northward to the valley of Vermilion river north of Mannville, Alta., a station on the Canadian Northern railway. Small seams of coal are reported at several localities. A few inches of coal occur on sec. 13, tp. 52, R. 10, west of the 4th meridian, and probably the same seam reappears at Spruce Bridge, a point about 2 miles upstream.

An occurrence most likely to be a mineable seam is found in the valley of Vermilion river, on the farm of W. H. Warwood, on sec. 16, tp. 51, R. 9, west of the 4th meridian about 6 miles from Mannville. A well at Mr. Warwood's house went through a seam of coal at a depth of 17 feet, which, by general report, had a thickness of 5 feet. An abundant flow of water which occurred at a depth of 14 feet from the surface would make mining difficult, but if the seam were persistent, points farther from the creek might be found that would not be so troubled by the drainage. Samples of the coal were picked out of the excavated material and show that it is a lignite holding a large percentage of water. Analysis made by Mr. F. G. Wait, Mines Branch, of loose pieces from well, give:—

| | |
|---|---|
| Moisture | 27·47 |
| Volatile combustible | 30·26 |
| Fixed carbon | 28·98 |
| Ash | 13·29 |
| | 100·00 |

### Brock, Saskatchewan.

Another locality in the northern extension of the Belly River beds at which coal is found, is in the vicinity of Brock, about 100 miles southwest of Saskatoon. This is a station on the Calgary-Saskatoon branch of the Canadian Northern railway, and is the nearest present exposure of coal to this important Saskatchewan town. The discovery was made while drilling a well on sec. 22, tp. 28, R. 20, west of the 3rd meridian. The district is rolling, and the well which was put down on the top of a hill pierced the coal seam at a depth of 130 feet. To the northwest a dry coulée crosses the section and it is probable that the seam lies beneath the bed of this valley, and could be reached at a much less depth. An open shaft 6 feet square was dug on the hilltop to a depth of 140 feet and stood untimbered and dry. Last winter several tons of the coal were raised by block and tackle, but at the time of my visit, July 19, 1911, some of the wall of the shaft had fallen in, concealing the greater part of the seam. Information given by Mr. McKay, manager, Northern Crown Bank, is to the effect that the seam is nearly 10 feet thick on one side, but can be averaged as having about 7 feet of coal.

The upper part of the seam is mostly dust and black dirt, but 2 feet in the middle is solid coal. From a sackful of the extracted coal, samples that would be representative of the mass, including the dirty part as well, were taken and gave the following analysis:—

| | |
|---|---|
| Moisture | 25·70 |
| Volatile | 26·95 |
| Fixed carbon | 28·42 |
| Ash | 18·93 |
| | 100·00 |

It is quite evident that if only samples of the solid coal were taken the ash content would be much reduced. The locality is in the unforested area, and this field, although of about the grade of the Souris coal, would be valuable to the surrounding district. Mining would be expensive on account of lack of timber, but as the country is dry there seems to be no great need for expense in drainage, and the roof, although of clay, stands up well. The untimbered pit had no water in it and the walls stood remarkably well; but without a casing of boards it would seem to be a menace to those attempting further development.

## Boring at Egg Lake, near Morinville.

The operations of the American Canadian Oil and Gas Company have been concentrated in an effort to pierce the Cretaceous beds to the depth of the tar-bearing sands. This has been a work of patient drilling, and a depth of 3,340 feet is now reported to have been reached (December, 1911). The well was visited September 30, and operations were suspended long enough to have the depth of the well measured and samples of the sludge examined. At that date, the depth from the floor of the drilling-shed was ascertained to be 3,305 feet 7½ inches.

The drill was in very hard sandstone, but the casing was not down to this hard rock, consequently some of the shale from the walls was found in the sludge. Besides very finely pulverized shale, the sludge contained small particles of sandstone and a few pieces of coal, which would tend to establish the Dakota age of this sandstone. When the water was removed from the material brought up, the whole mass bubbled up like yeast, and a large number of bubbles showed the iridescence, called by the drillers, "colours of oil." A few small specks of brown oily matter were found in the washed material. This gives great hope to the drillers that the top of the tar sands has been reached.

In the Athabaska valley, the tar sands are resting on the Devonian, the supposed source of the oil. In the foothills other formations, not of an absorbent nature, intervene, so that there is a limit to the western extension of the productive part of the Dakota. The presence of even a small amount of oily matter in what seems here to be the Dakota formation, shows that the western limit has hardly yet been reached, and there is great hope of ultimate success in the boring operations. The indications of oil are reported as becoming more promising. Some delay caused by caving in the lower part of the hole is reported, and the casing will necessarily have to be put down to the top of the sandstone.

# I.

# REPORT ON PROGRESS OF INVESTIGATION OF CLAY RESOURCES.

*Heinrich Ries.*

## INTRODUCTORY.

During the summer of 1911 I spent about three months in the field. Up to the middle of July, Mr. Joseph Keele was associated with me, but from that time on, with the exception of a few days in September, we were working separately in order to cover more ground.

The main object of this year's work was to fill out the gaps left in last season's work in the western provinces, in the region west of Winnipeg.

Most of the localities visited, therefore, had not been heretofore examined. In a few cases certain districts were revisited in order to find out what developments had taken place in the intervening twelve months.

A summary of the past season's work must, therefore, be a somewhat detached set of statements.

## GREAT PLAINS REGION.

In our report for last year particular attention was called to the shale deposits of the Great Plains region. These included the Pierre, Niobrara, Belly River, Laramie, Edmonton, and Tertiary. Of these the Pierre and the Niobrara shales are each worked only at one locality.

### PIERRE SHALES.

The general character of these was referred to in last year's report, and their rather low plasticity in the unweathered condition was referred to. They also burn to a rather porous body. The area around LaRivière was visited this year, and this is the only point at which the Pierre shales are worked, there being abundant exposures of the material.

The plant in operation there was erected for making pressed brick, and was first equipped with a dry-press machine; but this being unsatisfactory, a semi-plastic process was employed. The plant is still in the experimental stage. It is probable that better results will be obtained by mixing some surface clay with the shale, and our tests of last winter demonstrated this.

### NIOBRARA SHALES.

These are worked at Leary, Man., and were described in last year's report. No deposits of this age were visited by myself this season, but Mr. Keele examined some north of Regina. They are more promising than the Pierre shales, being more plastic and burning to a denser body. These show an extraordinary tensile strength.

### BELLY RIVER SHALES.

This represents, perhaps, the most extensive series of shale deposits in the Great Plains area, and a number of samples of these were tested for last year's report.

Attention was also called to their use by the sewer-pipe works of the Alberta Clay Products Company of Medicine Hat, and the Red Cliff Brick Works. The supply for the former was being obtained from a ridge along Bullshead creek, near Coleridge, and, although only a small excavation had been made, the opinion was then expressed that the different types of shale found there occurred in lenses. A re-examination this year, when more extensive quarrying had been done, showed that this theory was correct. One bed for example, as the so-called fireclay seam, which showed up last year with a thickness of about 6 feet, has thinned out to a few inches in less than 50 feet. The shales now being obtained at Coleridge appear to work well for fireproting and pressed brick, but they cause considerable trouble by cracking when worked up for sewer-pipe. Efforts are, therefore, being made to obtain a pipe-clay from some other locality, and at the time of our visit favourable preliminary tests had been made with a clay from west of Calgary.

We also made an examination of the Bullshead Creek valley for a distance of several miles up stream, and beginning at a point about 4 miles above the Coleridge bank.

Both sides of the valley here showed numerous shale exposures, interbedded with sandstone beds. The shales varied from very sandy to smooth fine-grained ones, and some of the lenses showed a maximum thickness of 30 feet. To the southward, or up the valley, the shales appeared to pass into sandstones.

The tests on the samples from this valley are now in progress and will soon be available.

Reference was made last year to the exposure of Belly River shales, along the Belly river near Lethbridge, but there are a number of other points along the stream where these are exposed, although many of them are at present located too far from the railway to be of commercial value.

A new district visited this season was that north of Taber, Alberta, where the Belly river flows about 2 miles north of the town.

An opportunity of examining the shales is afforded by the numerous small lignite mines which are in operation and have openings on the side slopes of the river valley.

The shales of this locality are similarly variable to those near Coleridge, but gypsiferous ones appear to be more abundant. However, a moderate amount of gypsum grains need not necessarily interfere with their workability.

Only one attempt has been made to work the shales near Taber, and this was done in the crudest way at a small yard located on the river bank. The poor results obtained were due to the methods rather than to the material.

Samples were taken for testing from several points along the river, and of the shale from above and below the coal in the shaft of the Rock Springs mine of the Superior Coal Company, northwest of Taber. The following two analyses were supplied by the Company, No. 1 being the top clay and No. 2 the bottom clay.

| | I. | II. |
|---|---|---|
| Silica | 63·2 | 68·4 |
| Alumina | 19·2 | 18·0 |
| Ferric oxide | 5·4 | 4·0 |
| Lime | 0·6 | 0·4 |
| Magnesia | 1·2 | 1·0 |
| Loss on ignition | 9·0 | 7·7 |
| | 98·6 | 99·5 |

A well was being sunk at Taber in the summer of 1911 with the hope of striking gas, and at the time of my visit had reached a depth of 1,500 feet. The cores showed a series of shale beds, some of them quite smooth, and occasional layers of sandstone. A 4 foot layer of coal was struck at 70 feet, and a 2 foot 8 inch bed at 370 feet.

At 670 feet the drillers struck a strong flow of water, yielding 950 gallons per hour. At 620 feet there was a slight flow of gas.

Shale exposures are also to be found on the banks of the Belly river near Bow island. It was hoped that shale beds might be found in the horseshoe bend of the river south of Bassano, but the cutting, though deep, is in glacial drift.

### LARAMIE.

Several days were given to an examination of the district along the new branch of the Canadian Pacific railway from Weyburn to Forward and Ogema. It was hoped that we might find a southern extension of the white-clay formation of the Dirt hills, but owing to the heavy mantle of Pleistocene clays, no Laramie material was found.

Twelve miles south of Forward, at Stowe on the Souris river, there are small exposures of greyish-white plastic clay, and brown and bluish smooth shales, all probably of Cretaceous age.

Since a branch line of the Canadian Northern passes this point, these shales are worth looking into in greater detail. There is the possibility, however, that they may contain too frequently interbedded sandstones, although it is not safe to say this without further prospecting.

The Pleistocene surface loams and stony clays form a somewhat heavy mantle throughout this region.

It is interesting to note that the refractory clays of the Dirt Hills region, which have remained so long unnoticed, are beginning to excite considerable interest, due, in part, to the attention given them in the Geological Survey work. One plant will shortly be established there, and two others are contemplated.

### EDMONTON FORMATION.

This formation was referred to in last year's report, and attention called to the fact that the shales of the upper beds of Edmonton might be developed for brick manufacture. A plant has since been started near Strathcona and is employing these shales for dry-press brick manufacture. The shale being used underlies those which we sampled and tested last year. It is red-burning, but further tests are not yet available.

One of the best series of shale exposures found in Alberta, is that seen along the Pembina and Lobstick rivers west and northwest of Entwhistle on the Grand Trunk Pacific. These outcrop in considerable thickness, are favourably located for working, and some of them, at least, appear to be favourably constituted for making vitrified structural wares.

Since coal has been found in borings at no great distance below the surface, the necessary fuel for burning these shales could be easily obtained. The shale formation extends east of Entwhistle, but no shale outcrops are visible along the railway.

### TERTIARY SHALES.

Those near Brickburn, west of Calgary, were referred to in last year's report, and the suggestion made that further prospecting to the eastward of the brick pits might show other beds containing fewer sandstone layers. Developments made at this point since then have demonstrated the presence of some very promising shale beds in the escarpment east of the brickyard, and some of the material has been shipped to Medicine Hat for sewer-pipe manufacture. The shale that has been shipped from here to Medicine Hat, is from a lower bed than that used for brick at the Brickburn yard and is of appreciably higher refractoriness, standing cone 3 to 4.

A more careful examination was made of the shale sections along the Bow river between Morley and Cochrane, which resulted in the collection of samples for testing from the section west of Mitford. The shales occurring there appear to be promising.

When a branch line of the Canadian Pacific railway from Langdon, on the main line east of Calgary, is extended to Carbon, the shale deposits exposed along the Red Deer river will become available, but there are no shale exposures along the present line from Langdon northward.

### OTHER LOCALITIES.

At Red Deer two yards manufacturing common brick were in operation last year, both of them using surface clays. One of these has recently been reorganized and it is proposed to use a mixture of local surface clay and the shale which outcrops along the river just above the railway bridge. This was tested last winter. A search was made along the Red Deer river south of Red Deer, but only glacial clays were found.

At Medicine Hat the stiff-mud yard of Purmal and Pruitt, which had been destroyed by fire, is again in operation, but Hofmann's yard, 2 miles east of town, is not running.

The Acme Brick Company, 7 miles north of Edmonton, has been remodeling its plant and introducing a patent system of drying and burning.

The clay pit at these works presents a rather unique section.

The upper clay is a tough laminated material, and is underlain by 12 to 15 feet of a dense sandy clay containing layers of gypsum rosettes.

### Mountain Region.

Shale exposures are abundant in the valley between Fernie and Coal Creek mines, as well as in the valley in which Morrissey lies, but they are all too hard and siliceous to work up into a plastic mass. Those near Morrissey are slightly less siliceous than those near Coal creek.

This then still leaves the shales near Blairmore and Coleman as the most promising thus far tried along the Crows Nest Pass line. Those at Blairmore are still being worked for dry-press brick, but give some trouble in burning. They are not adapted to a stiff-mud process because of their low plasticity.

Attempts are still being made to exploit as a fireclay proposition some streaks of talcose schist in quartzite, which occur about 9 miles south of Elko along the Great Northern railway. Tests made by us on this show that it is not even refractory.

An examination was also made this year of clays in the Columbia River valley north and south of Golden. There is no reason why deposits of clay should not be found underlying the flood plain of Columbia river. Near Golden there is a considerable area underlain by this clay, which may be of value for brick manufacture. It is very plastic in the field.

Pockets of tough silty clay are also found in the glacial drift bordering the valley, but little can be expected of them.

In the Nicola valley there was found a most extensive deposit of plastic laminated clay, evidently a lake deposit, which may prove useful for brick and tile-making. It can be traced almost continuously from Merritt to Nicola.

The Tertiary coals of the Nicola valley, which are being worked at Merritt, are interbedded with sandstones and siliceous shales. The latter are not very promising, but some are being tried. West of Quilchena the coaly shales are overlain by that peculiar type of clay known as Bentonite, which is found in such abundance in the state of Wyoming. The Bentonite bed is at least 6 feet in thickness.

### Vancouver Island.

The shales of the Nanaimo coal basin were also examined this year. Most of them appear rather siliceous, but some near East Wellington have given satisfactory results in a preliminary trial on the stiff-mud machine.

ONTARIO AND QUEBEC.

Towards the end of the season some days were spent in examining certain feldspar deposits. Those visited were in the Parry Sound district, near Verona and Godfrey, Ont., and the Lièvre River district of Quebec.

The Parry Sound deposits consist of veins or lenses of a coarse-grained mixture of plagioclase and orthoclase, with numerous large flakes of biotite and some quartz. These veins are abundant in this region, but as it is impossible to separate the biotite by any economical methods, they are of no value as a source of spar.

The quarries near Verona and Godfrey are worked for both quartz and feldspar, the two occurring in the same vein, but in large masses, so that no difficulty is experienced in separating them. The wall-rock is a grey biotite gneiss.

Much of the spar obtained from this region is shipped to the United States, and on account of its high purity finds a ready market in the pottery trade.

A visit was also made to the kaolin deposits located 7 miles west of Huberdeau, Que., and controlled by the St. James Construction Company of Montreal.

These are all the more interesting because of their occurrence in a glaciated region, but the reason for this soon becomes evident. The kaolin has been formed by the weathering of pegmatite veins, which have been injected along joint planes of the Pre-Cambrian quartzite. The veins seem to be numerous, but the largest seen was 20 feet in thickness, and this, at the time of our visit had not been uncovered for more than 8 feet. A washing plant is also being erected. The development of the deposit will be watched with interest.

## II.

## WHITEWARE MATERIALS IN ONTARIO AND QUEBEC. KAOLIN NEAR HUBERDEAU, QUEBEC.

Deposits of kaolin or white residual clay have always been regarded as rare in the glaciated region of North America, for the reason that even though the decay of feldspathic rocks may have yielded such deposits in pre-glacial times, they have been removed by glacial erosion.

It is conceivable, however, that if such deposits occupied depressions in a hard and comparatively resistant rock they might have been so protected as to remain more or less uninjured.

The upper part of such a deposit occurring in the glaciated area, is likely to be somewhat impure, due to the incorporation of glacial drift in its mass. Such a structural feature should not, however, be confused with an impure iron-stained residual clay. In the former case, we find lumps and patches of glacial material mixed up in irregular fashion with the white kaolin. In the latter the entire clay mass would be more or less discoloured and free from boulders, pebbles, or other material of distinctly glacial origin.

Since kaolin deposits are so rare in the glaciated region, it was with some surprise that I received the announcement of a deposit in Quebec.

The one referred to in this paper lies about 7 miles from Huberdeau, on the road to St. Remi d'Amherst. The former town is a station on the Canadian Northern, about 70 miles northwest of Montreal.

The clay has been encountered in some test pits in a ridge lying on the east side of the wagon road.

This ridge is formed of quartzite, which is covered by a mantle of glacial drift, ranging from 2 to 15 feet in thickness, so far as my observations went. It may be thicker in places, but the figures named represent the thickness observed at the time of my visit in September, 1911.

The quartzite, which belongs to the Grenville series, is cut by two sets of joints, the one striking N. 70° E. and the other set striking N. 40° W.

Several test pits have been put down by different parties, and it is claimed that these encountered kaolin. This fact has led some to assume that the entire ridge was underlaid by a blanket of the white residual clay, a conclusion that is wholly unwarranted on the basis of present evidence.

One cut was excavated from the wagon road eastward into the hill, and encountered a vein of kaolin that was perhaps 15 feet wide, and strikes approximately N. 20° W.

Plate I shows a view of this cut, which was driven about 250 feet before encountering the white clay. It has been uncovered for a distance of perhaps 60 feet, and it was stated that a boring 80 feet deep has been made in it without striking the bottom.

The dip of the vein appears to be very steep.

About 10 feet to the north of the cut referred to, and about 150 feet west of the main road a short vein 4 feet wide was struck.

A second cut was run into the hillside about 300 feet south of the main one. This cut was 8 feet wide and about 100 feet long. At the end, there was exposed in the bottom of the cut a vein of kaolin 4 feet wide, and striking N. 10° W. This, it is claimed, was bored to a depth of 30 feet without striking bottom.

There were also two veinlets 5 inches and 2 inches wide, respectively, which had a strike of N. 40° W., but they pinched out rapidly.

The mode of occurrence is unique, as kaolin deposits in quartzite are comparatively rare. Much careful prospecting will have to be done in order to determine whether there is a large amount of kaolin present in this ridge.

On the west side of the road the rocks are limestone and granite, and show no evidence of kaolin veins.

There is no way of prophesying how deep the kaolin veins are likely to extend, and it would not surprise me to learn that the veins were abundant in this ridge. Their depth will depend on the depth to which the weathering agents have penetrated the pegmatite.

At the time of my visit preparations were under way to erect a washing plant for treating the crude clay.

### PROPERTIES OF THE KAOLIN.

The crude clay is a mixture of fine-grained white clay particles and angular fragments of quartz, mostly under one-fourth or one-eighth of an inch in size. A little tourmaline is occasionally present. In some parts of the vein the material is almost free from quartz, but in most portions of the deposit this mineral forms about 50 per cent of the mass.

When put through a washing test in troughing and settling tanks it yielded about 40 per cent of washed product.

A sample of the latter analysed by G. E. F. Lundell gave:—

| | |
|---|---|
| $SiO_2$ | 46·13 |
| $Al_2O_3$ | 39·45 |
| $Fe_2O_3$ | 0·72 |
| CaO | None |
| MgO | None |
| $K_2O$ | 0·20 |
| $Na_2O$ | 0·09 |
| Loss on ignition | 13·81 |
| | 100·40 |

This analysis shows the material to be of high purity.

The washed material worked up with water to a fairly plastic mass, but one of low tensile strength; the latter being characteristic of kaolins.

The washed clay burns white, and is quite refractory, being unaffected by a temperature of cone 33.

The material is no doubt adapted for use as a paper clay on account of its fineness of grain, and whiteness in the unburned condition.

Whether it will also satisfy the requirements of white ware and porcelain manufacture can only be told by actually making up a mixture of the kaolin with ball clay, flint, and feldspar, and then burning it with a colourless transparent glaze.

### POTTERY MATERIALS IN CANADA.

The interesting occurrence of the Huberdeau kaolin, brings up the consideration of a pottery industry based on domestic materials.

Let us take the case of whiteware for example. This is made up of the following four ingredients: Kaolin to give whiteness and refractoriness; ball clay to give plasticity and bond, but which does not always burn as white as the kaolin, and hence cannot be used in too great quantity; ground quartz (called flint) to reduce the shrinkage and give the body stiffness; feldspar to serve as a flux.

Whiteware is manufactured to some extent in the Dominion, but the kaolin and ball clay come either from England or the United States, or both.

Up to the present time no true ball clay has been discovered in Canada.

It is possible that the clay over the 13 foot seam at Inverness, C.B., or the washed stoneware clay from Shubenacadie, N.S., could be mixed with kaolin for some sanitary ware bodies, but they are not sufficiently white-burning for whiteware.

Quartz can be obtained from veins, or quartzite free from iron, and there would probably be no difficulty in obtaining this from some of the Ontario localities.

Feldspar has been reported from the several localities in Ontario, and is being worked in the region north of Kingston, indeed, some of the spar mined in the vicinity of Verona and Godfrey is of high grade, and is exported in large quantities to the United States where it is purchased by the manufacturers of whiteware.

The deposits around Verona are worked as open-cuts: one of the most important being the Card mine, 2½ miles west of Verona.

The country rock is a grey gneiss, which strikes N. 30° W. and dips 45° S.E. The vein strikes N. 10° E. and then swings to N. 20° E. at the north end of the cut.

The deposit which has been opened up for about 200 feet, has been traced 600 feet farther, but at the south end of the cut it appears to be pinching out.

Both pink and grey spar are found, intermixed with quartz and occasional tourmaline, and the last two have to be separated by hand picking.

While some of the quartz is intergrown with the feldspar, much of it is of later age, so that veins of the former cut across the latter.

The product from this quarry has to be hauled to the railway for shipment.

The largest feldspar mine in Ontario is the Richardson mine, which is located 7 miles east of Godfrey. This is a large opening of considerable depth. The wall rock is a dark grey gneiss, and the boundary between the feldspar and gneiss varies in its degree of sharpness. The spar is mostly orthoclase, with occasional veins of plagioclase, and some veins of later quartz, but the main body of the latter is in a large somewhat flattened mass, which is in the central part of the vein. In this quartz mass there are cavities with crystals of quartz, mica, and pyrite. Occasional blotches of pyrite occur in the feldspar, and at one place on the northwest wall there are dark vein-like streaks of pyrite.

The feldspar vein forks at both ends of the pit. Patches of tourmaline are found here and there in the feldspar, and one large clump of tourmaline crystals is to be seen close to the hanging wall.

The quartz is used for ferrosilicon and the spar is sent chiefly to potteries in the United States.

The two following analyses indicate the high purity of the feldspar:—

| | | |
|---|---|---|
| $SiO_2$ | 66·23 | 65·40 |
| $Al_2O_3$ | 18·77 | 18·80 |
| $Fe_2O$ | trace | trace |
| $K_2O$ | 12·09 | 13·90 |
| $Na_2O$ | 3·11 | 1·95 |
| $CaO$ | 0·31 | None |
| $MgO$ | None | None |
| Ignition | None | 0.60 |
| | 100·51 | 100·65 |

There are a number of other feldspar veins in this district, but many of those exposed or exploited show considerable admixture of quartz, or lie so that economical working is difficult.

An example of some of the difficulties encountered is seen at the McDonald mine, about 1½ miles north of Verona.

Here the vein which strikes N. 40° E., dips northwest under a hanging wall of gneiss. The spar under the hanging is purer, but to follow it far in that direction means the removal of a heavy overburden of gneiss. Towards the foot-wall the feldspar becomes mixed with quartz, blotches of hornblende, and some biotite. The quartz in many cases is later than the spar and forms irregular vein-like masses of it.

Even a hasty examination of the spar deposits in this region emphasizes the fact that although the veins may be abundant, comparatively few are apt to be of commercial value.

Spar must be cleaned before shipment by hand-picking, as concentrating machines such as could be used to separate ore from gangue are not applicable.

A vein of spar may be large, the quality of the material excellent, and the percentage of impurities comparatively small, but if they are uniformly distributed throughout the entire vein, the cleansing of the spar becomes a matter of great difficulty, if not an impossibility.

A case which is somewhat of this character was seen on Ross island in Parry Sound. Strong rumours existed to the effect that feldspar veins of commercial value were said to exist in this vicinity, and consequently a visit was made to this locality.

The shores of Parry Sound consist largely of biotite schist cut by numerous pegmatite veins, some of them 20 feet in diameter. They are coarse-grained, and contain both orthoclase and plagioclase, feldspar, as well as quartz and biotite. The quartz and feldspar are intergrown, although in some cases veins of the latter age cut the pegmatite. The pegmatite veins pinch and swell and branch, but the boundaries are usually sharp.

Inclusions of the country rock were noticed, and there has apparently been folding after the intrusion of the veins.

The vein on Ross island is probably 30 feet wide, and strikes a little south of east. It is very coarse-grained, and contains large pieces of orthoclase, plagioclase, biotite, and scattered quartz. But while the lumps of spar are individually clean and often several inches or more in diameter, they are so surrounded by leaves of biotite as to render the mass unworkable.

If feldspar is to be used for pottery purposes it should be free from iron.

# I.

## NOTES ON TESTS OF CLAY SAMPLES.

*Joseph Keele.*

The following notes give the results of tests on clay samples, which have been sent in at various times for examination.

The samples generally submitted are in too small amounts. Not less than 4 or 5 pounds should be sent by mail. Then, if the clay deserves a more extended examination, a larger sample may afterwards be forwarded either by freight or express.

There are also included in these notes preliminary tests on samples collected from certain scattered deposits, of which special examinations were made by request, or on material outside the area covered by the field work of the season.

### GRAHAM, ONTARIO.

On line of Grand Trunk Pacific railway. Sample submitted by Professor Macoun.

This was a very smooth, non-calcareous clay which, mixed with 30 per cent of water, formed a highly plastic mass that was stiff and hard to work.

The tensile strength of the raw clay was 430 pounds per square inch and the air shrinkage 9 per cent. A good hard red body was produced on burning to cone 010.

Owing to the high shrinkage and difficulty of working, this clay cannot be used alone, but a good common brick may be manufactured by the addition of about one-third sand.

This clay gives a good dry-press brick of red colour, and low absorption when burned to cone 05.

Bricklets made from this clay and burned to cone 03, are deformed and show the effects of overfiring, and are completely fused at cone 1.

### ST. JOSEPH, BEAUCE CO., QUEBEC.

A clay deposit in the Chaudière valley, about 2½ miles south of St. Joseph, has attracted attention at various times, and an examination was made of it by request.

The deposit is a river terrace, composed of stratified Pleistocene clay, about 35 feet in thickness and of considerable extent.

The clay is rather silty in character throughout, but the upper part of the terrace contains more plastic material than the lower portion.

A good common brick can be made by the soft-mud process from this clay, but it does not appear to be suitable for any higher grade wares.

It would be unsafe to attempt the manufacture of vitrified wares here, as the clay shows warping and unduly high fire shrinkage when raised to a temperature a little higher than that at which common brick is generally burned.

This deposit was supposed to contain beds of stoneware and fireclays, but there are no such clays in this terrace.

### MONTMORENCY, QUEBEC.

A sample of weathered shale, collected by Mr. Percy Raymond, from the escarpment at Montmorency falls.

This is a highly calcareous grey shale which, mixed with 22 per cent of water, gives a mass of fair plasticity, but gritty. It has a tensile strength of 66 pounds per square inch, and air shrinkage of 4 per cent.

It makes a good common brick by either the stiff-mud or soft-mud process, and by dry-pressing will make face brick. The fusing point of the clay is low, and it cannot be used for making vitrified wares. Notwithstanding its high calcareous content, the clay is red-burning.

SUSSEX, N.B.

A small sample of smooth, black clay was sent in by Miss Berry from the above locality.

This is a highly carbonaceous clay, and evidently a swamp deposit.

On firing the moulded test pieces, a considerable loss of volume results, owing to the burning out of the carbonaceous material. It burns to a porous red body at cone 03, with the extraordinary high total shrinkage of 29 per cent, so that it is of no possible value in the clay working industry.

MINTO, N.B.

Samples of shales above and below the coal seam at Weltons mine.

These shales were mixed in the proportions of two parts of the upper beds to one of the lower. This mixture was ground and tempered with water to a plastic mass, from which short sections of tile, 3 inches in diameter, were made in a hard press. These tiles were fired in a sewer-pipe kiln at a temperature of 2,200° F. The results showed that the tile burned to a good hard body, with perfect salt glazing. This mixture is recommended for sewer-pipe. These shales will also produce good common and red dry-pressed bricks or fireproofing.

STONEHAVEN, N.B.

Average sample of top of cliff at shoreline, about 25 feet in thickness of red and greenish weathered shales, without overburden.

These shales when ground and tempered with water worked up into a mass of good plasticity, having a tensile strength when dry of 139 pounds per square inch, and air shrinkage of 5 per cent. Short sections of 3 inch tile made from this shale, and burned in a sewer-pipe kiln at a temperature of 2,200° F., showed a vitrified body with good salt glazing. Good common brick and very fine red dry-pressed bricks can be made from these shales.

They would also appear to be suitable for fireproofing and electric conduits.

CLIFTON, N.B.

Two beds of grey shales, about 4 feet each in thickness, interbedded with sandstones, and very thin coal seams.

These are smooth, very plastic shales, somewhat calcareous, and buff burning. They are not fireclays, but are sufficiently refractory to be made into blocks for boiler-settings, and will make good facing brick of buff colour, when dry-pressed, but must be burned to cone 03 or higher for this purpose.

# II

## REPORT ON PROGRESS OF INVESTIGATION OF CLAY RESOURCES.

### OFFICE WORK.

The laboratory work on the samples of clays and shales collected in the western provinces last season (1910) was not finished until June. About 125 samples were submitted to a complete series of physical tests. In addition to the regular tests several special tests were designed and carried out for the purpose of devising a method to cure drying defects in some of the clays. The results of these tests, with very full information on the working qualities, and behaviour under firing, for the different materials, together with a description of the deposits, are included in a report to be published in the near future.

## Field Work.

The field work for the season of 1911 consisted of an examination of scattered deposits of clays and shales in various parts of Canada, and will be only briefly referred to in this report. A very complete series of laboratory tests on the samples collected this season is in progress. The results of these, and a detailed description of the deposits, will be included in the final report.

### WESTERN CANADA.

A classification of the rock formations in which materials of value to the clay worker are likely to be found, and their distribution in western Canada, was given in the Summary Report for 1910, by Dr. Heinrich Ries, so that it will not be necessary to repeat it here.

The work in the west was begun by an examination of the region traversed by the Pembina branch of the Canadian Pacific railway—which includes portions of southern Manitoba and Saskatchewan—between Winnipeg and Estevan.

Bricks are made at four points on this line, Morris, LaRivière, Darlingford, and Estevan.

The material used at Morris is the Red River Valley surface clay, which makes a good, hard, buff-coloured brick, that always finds a ready market in Winnipeg.

The Pierre shale which occurs so abundantly in the Pembina mountains, is used at LaRivière for making dry-pressed bricks. The chief objection to the use of this shale is that it cannot be burned to a dense body at the ordinary temperatures of burning, the brick produced being generally too soft and porous. On the other hand, if the bricks are burned to a dense body, the shrinkage is excessive, and the operation costly.

Turtle mountain, which lies south of the railway line, between Boissevain and Deloraine, is chiefly built of sandstone, and does not appear to contain any shale beds which could be used for brickmaking.

Except in the Red River valley, clays that could be used in brickmaking are not abundant on this line. The greater part of the surface deposits consists of boulder clay, clay loam, or sandy clay: all of which usually carry pebbles and fragments of limestone. Some shallow deposits of clay fairly free from pebbles have been laid down over small areas in flats or hollows. A quantity of common brick made from a deposit of this kind was burned this season at Darlingford station to supply a local demand.

The Estevan Coal and Brick Company at Estevan, Saskatchewan, is making red, dry-pressed, and buff, wire-cut bricks from shales which lie both above and below a thick seam of lignite. The results of tests of these materials are given in the full report on last season's work. A change has recently been made in this plant by the installation of the Boss forced-draft system for burning. By this means the impure, upper portion of the lignite, hitherto regarded as waste, is now used in firing the kilns.

Two new plants for brickmaking, it is reported, are to be shortly erected at Pinto and Douglas, on the Portal branch of the Canadian Pacific railway. The clays and shales at these points are similar to those at Estevan. None of the clays or shales sampled from along this portion of the Souris valley were found to be refractory or even semi-refractory, and it would be unsafe to attempt the manufacture of vitrified wares from them.

A new brick plant has been erected at Weyburn, Sask., consisting of a dry-press brick machine, and two circular down-draft kilns. A red-burning surface clay from the vicinity of the plant is used. This surface clay is found at intervals along the new branch line of the Canadian Pacific railway, which extends westward from Weyburn.

No surface clays suitable for brickmaking were found near Maple creek, on the main line of the Canadian Pacific railway; the material underlying this vicinity is principally boulder clay. No clays or shales were found on the southern escarpment of the Cypress hills, but on the summit and a few miles north of Belanger post-office some very sandy, white clay was seen, which resembled some of the fireclay beds of the Dirt hills.

Extensive deposits of white clay are reported to occur on the Whitemud or Frenchman river, about 35 to 40 miles south of Maple creek. These clays are at present inaccessible, but will be reached later on when the Weyburn-Lethbridge section of the Canadian Pacific railway is completed. A boring for natural gas was made near Maple creek a few years ago: a depth of 2,200 feet was reached but no flow of gas was obtained. No record was kept of the measures passed through in this boring.

The region in the immediate neighbourhood of Regina is underlain by clay to an unknown depth. The trench recently dug for the trunk sewer exposes a section from the surface downward of 4 feet of dark loamy clay, 15 feet of dark, stiff joint clay, and 3 to 6 feet of yellow, silty clay. The latter could be used for brickmaking if found near enough to the surface, but the joint clay would be too hard to work up, and would check in air-drying.

Shales which appear to belong to the Niobrara subdivision of the Cretaceous were found in the cuttings between Valeport and Regina beach, on the newly constructed Craven-Colonsay branch of the Canadian Pacific railway. These shales would probably make a good quality of red dry-pressed brick, but owing to extreme toughness when wetted, it is doubtful if they can be used in any of the wet moulded processes.

A company formed in Regina has recently acquired sec. 24, tp. 12, R. 24, west of the 2nd meridian, for the purpose of mining coal and clay, and operations were begun on a seam of lignite this season. The lignite outcrops on the eastern portion of the section in a coulée at the base of the Dirt hills. It is overlain by grey or white sandy clay, which is a fireclay, and overlying the fireclay is grey, rusty, easily fusible shale. Higher up on the foothills and at the west of the section are small knolls of brown sandy shales, which are practically useless for brickmaking on account of high shrinkage and cracking while drying. It is the intention of this Company to erect a plant for the manufacture of structural clay wares. The succession of clays and shales found here is very similar to that which occurs a few miles west of this locality, and which was examined and reported on during last season's work.

The clay deposit of the Alberta Clay Products Company at Coleridge is being opened up to better advantage this year, and material for making fireproofing and dry-pressed brick is shipped to their works at Medicine Hat. This Company is bringing shale from Calgary for the manufacture of sewer-pipe, as none of the beds at Coleridge were found suitable for this purpose.

The clay and shale exposures in the valley of Bullshead creek were examined for several miles south of Coleridge. Some thick beds of soft, yellowish shale which could be easily worked were sampled. On going farther southward it was found that the shales beds were largely replaced by sands, and soft sandstone.

The wide valley in the vicinity of Walsh, on the main line of the Canadian Pacific railway, contains exposures of shales, clays, and lignite seams. These clays were found to be heavily impregnated with gypsum, and resemble those which occur at Irvine. The clay beds at the latter point were sampled last season; they were found to be of poor quality, and not to be recommended for brickmaking purposes.

The Red Cliff brickworks, situated 6 miles west of Medicine Hat, are producing wire-cut and dry-pressed bricks, from a series of clay and shale beds which occur on the bank of the Saskatchewan river. The dry-pressed bricks are made from a single bed of soft, yellowish shale, which is mined by drifting. These are burned in down-draft kilns, and a good, hard, red face-brick is produced.

The Purmal Brick Company of Medicine Hat is making dry-pressed bricks this season, using a silty surface clay which is exposed in a high bank at the rear of the works. There are five up-draft kilns at this plant, and the burning is done with natural gas. The clay, however, is unsuited to the dry-press process, as the brick made from it is too porous and soft. A Whittikar repress machine, having a capacity of 18,000 a day, is being erected, and it is also the intention of the Company to install a stiff-mud brick machine. The clay, when worked by these processes, will undoubtedly give better results than with the dry-press.

The Wetaskiwin Brick Company has commenced operations this year, making stiff-mud bricks, about 1 mile south of the town. The deposit used is a surface clay, about 14 feet in thickness, overlying boulder clay. The upper 4 feet of the deposit is a rather sandy and loamy clay, the under portion being stiff, stratified clay. The upper portion alone is used in brickmaking, as the underclay is too hard to work, and cannot be dried without cracking. The underclay could be used by the addition of sufficient sand, but there does not appear to be any sand available in the neighbourhood.

Borings for gas and water at Wetaskiwin show about 90 feet of drift, overlying sandstones and shales. Water is obtained at a depth of 200 feet in a series of sandy shale and sandstone beds. Gas is found at a depth of about 950 feet, and a flow having a pressure of 25 pounds is obtained. The natural gas is used to supplement the producer gas used in the power plant of the town.

Thick outcrops of shales and sandstones occur 5 miles east of Wetaskiwin, in the cuttings on the line of the Canadian Pacific railway, the exposures continuing for a distance of 3 miles. Farther east, in the vicinity of Camrose, especially on the Canadian Northern Railway line in Stony Creek valley, an abundance of clay and shale beds occur either exposed in natural sections on the sides of the valley or in railway cuttings. The clay and shale is also found in the town of Camrose when digging pits or trenches. Among the beds thus exposed is a remarkable yellow clay, which turns whitish on exposure to the air. It is exceedingly smooth and soap-like in character, and indeed possesses marked detergent properties. The clay, when dried, will absorb its own weight in water and works up into a paste, with a great increase in volume. The shrinkage and cracking on drying is inordinate, so that it is not suitable for any burned clay products, but a use may be found for it in the raw state.

The tests made on the samples of clays and shales collected in the Camrose district have progressed far enough to show that most of these have low-fusing points, and nearly all of them crack and warp in drying. These defects are unfortunate, as the deposits are well situated for working, and shipping facilities of finished products are excellent, since the three principal railway companies' lines intersect at this point. The lignite seams which occur interbedded with the shales to the south of Camrose have been mined for some years past, and, although thin, would yield enough fuel for manufacturing.

A brick plant for the manufacture of wire-cut brick was in operation at Camrose for a few years, but is now closed, as the surface clay which was used contained too many pebbles.

An examination of the Grand Trunk Pacific line between Edmonton and Saskatoon shows brick clays occurring at intervals in the flat-lying land between Edmonton and Viking. The rolling country between Viking and Wainwright consists of ridges and mounds, which are either sand dunes or silt and gravel ridges with some clay pockets of small extent. For a long distance east of Wainwright there is a monotonous succession of boulder clay ridges, but some of this clay, which is fairly free from pebbles, occurs between Mead and Kinley, and might be used for brickmaking. The flat depression in the neighbourhood of Scott may also contain some brick clays. Shales are exposed at two points on the line, at Tofield and on the west bank of the Battle river.

The shale at Tofield underlies a coal seam and crops out at the surface. It is fairly refractory, and burns to a good, dense body, but cannot be worked for sewer-pipe or brickmaking as it cracks too readily while drying. The shales at Battle river occur interbedded with sandstones and are exposed in the railway cuttings.

An attempt was made during the season of 1910 to make bricks at Wainwright. The deposit worked consisted of silt and sand, with a few pockets of stiff clay. The bricks when burned were too weak and porous to be of any value as their sand content was too great. Messrs. Taylor and Clark have begun making wire-cut brick this season, at a point a short distance west of the old locality. A few were burned in a test kiln, the result being a good quality of hard red brick. The deposits of clay which occur among the sands and gravels are small and scattered, so that a large area of ground will have to be utilized in order to assemble sufficient clay to keep a plant going.

The brickyard at Saskatoon is owned and operated by Messrs. Elliott and Slack. The deposit worked consists mostly of silty clay, containing lenses of sand and stiff clay, the whole overlying boulder drift. There are also streaks and lumps of a hard clay resembling decomposed shale, which is very difficult to work up, and particles of it behave as pebbles in the burned brick. The whole deposit is worked, the silty clay portion being worked alone, and the stiff clay and sand mixed together. The capacity of the plant is 24,000 soft-mud bricks a day, all going to supply the local demand. Considering the unpromising nature of the deposit, a fairly good red brick is produced, the hardest burned having a good ring.

In addition to the above, some unworked deposits of lesser importance were visited before concluding the work in the west. These will be described in the full report, when the laboratory tests are finished.

## EASTERN CANADA.

A special examination was made of a clay deposit near St. Joseph, Beauce county, Quebec, which was supposed to contain beds of fireclay and stoneware clay. The deposit, however, proved to be the ordinary stratified estuarine clay which occurs so widespread in eastern Canada. This clay occurs in great thickness in the Chandière valley, especially so about 2 miles south of St. Joseph. It is smooth and plastic, and will make good common brick or drain-tile. Its fusing point is so low, that vitrified wares cannot be safely made from it. This clay is similar in every respect to the deposit at Ascot, near Sherbrooke, where common red bricks of good quality are made from it, but nothing more.

The investigation of the clay and shale resources of New Brunswick begun two years ago was resumed late in the summer, but owing to lack of time, as the result of performing the large amount of sampling in the west, not much was accomplished in this Province. A further examination was made of the Grand Lake coal district, where there is a considerable area of middle Carboniferous rocks containing shales and a bed of coal. This district is worth the attention of those intending to erect clayworking plants in eastern Canada. At the numerous openings for coal there is an abundance of plastic shales already mined, a good supply of coal is at hand, and plenty of timber and water. The material that can be made here includes common and both red and buff dry-press bricks for boiler settings, sewer-pipe, fireproofing and electrical conduits.

Shales somewhat similar to those of the Grand Lake area outcrop along the south shore of Chaleur bay, between Clifton and Stonehaven. These shales are of great thickness and have little or no overburden at these points. They overlie sandstones which are quarried for grindstones and building stone. Included in the sandstone are two 4 foot beds of grey shales, locally referred to as fireclays. They are not fireclays, but are sufficiently refractory for boiler settings or coke-oven blocks. They are also useful to mix with the upper and more easily fusible shales for the manufacture of vitrified wares. This series of shales and sandstones is of middle Carboniferous age; they include some thin seams of coal which are too small to be of economic value.

There are extensive exposures of felsitic rocks in the vicinity of Campbellton, which resemble the felsite at Coxheath, C.B., recently described as a refractory, but non-plastic material. The felsite at Campbellton is not quite so refractory as that at Coxheath, but included in it are several seams and pockets of decomposed rock which are fairly plastic. If a large enough deposit of the decomposed rock were known to exist, it might be valuable for many varieties of clay wares.

Deposits of surface clay suitable for brickmaking occur in the vicinity of Chatham and Bathurst. These clays are of estuarine stratified type, and are worked at various points in the valleys and lowlands of the Maritime Provinces. The red sand-moulded bricks produced from these clays in Loggie's two brickyards near Chatham are of exceptionally good quality.

# THE ARCHÆAN ROCKS OF RAINY LAKE.

*Andrew C. Lawson.*

In my reports of 1885 and 1887, I showed that the Archæan of the Lake of the Woods and Rainy lake, in western Ontario, consists of two principal parts:—

(1) An upper division of sediments and volcanic rocks which, though often highly metamorphosed, were originally not essentially different from sedimentary and volcanic rocks that have accumulated at the earth's surface in later geological periods. This division I later designated the Ontarian system.[1]

(2) A lower division of granitoid gneisses, commonly called Laurentian, which up to that time had been regarded universally as metamorphic sediments, the oldest rocks in the Archæan, and the basement upon which all other known sedimentary rocks rested. For these rocks, in accordance with current usage, I retained the name Laurentian, but showed that they are not metamorphic sediments but are batholithic intrusions which had invaded the Ontarian rocks from below as igneous magmas, and in doing so had displaced the original basement or floor upon which those rocks were laid down.

In the upper division, or Ontario system, there were recognized two series:—

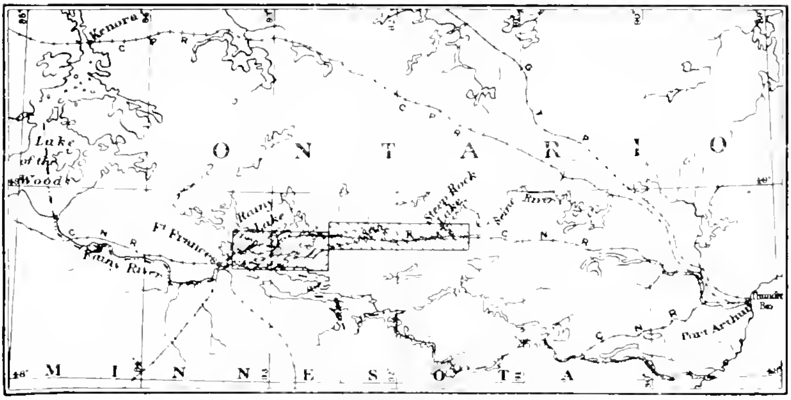
(1) The Coutchiching, a great volume of altered sediments free from volcanic admixture; and overlying these.

(2) The Keewatin, consisting chiefly of volcanic accumulations, but including also sedimentary strata.

This interpretation of the geology of the region established a new point of departure for the study of the Archæan. The studies of the past twenty-five years in Canada and in the United States have confirmed the view first expressed by me that the common Laurentian granitoid gneisses are igneous rocks of later age than the metamorphic rocks which rest upon them, and the whole conception of the Archæan as held by geologists up to the late '80's has thus been changed. The Keewatin series has been widely recognized as a persistent and characteristic constituent of the Archæan complex quite distinct from the Huronian, with which it was formerly confounded.

The Coutchiching series, however, appears to be not so widely distributed and opportunities for its study are, therefore, more limited, so that the Rainy Lake section remains the most convenient one for the study of the relations of this series to other members of the Archæan complex. Officers of the United States Geological Survey, and later an International Committee of Geologists, having visited portions of the field mapped by me in 1887 for the purpose of studying these relations, have stated that I was in error in placing the Coutchiching below the Keewatin. In their view it overlies unconformably the Keewatin with a basal conglomerate and is the correlative of the Huronian. The question raised by these gentlemen is one of peculiar importance in the geology of Canada, where so vast a territory is occupied by Archæan rocks; since the establishment of the sequence of formations in any one section becomes very helpful in the unravelling of the complexities of others. The question at issue is really whether, in general, the Keewatin, composed as it is chiefly of volcanic rocks, is the oldest set of rocks in the Archæan, or whether there is an

[1] Bull. G.S.A., Vol. 1.




DIAG. 8A. Index map of Rainy Lake and Steeprock districts: illustrating Dr. Lawson's Summary Report on "The Archaean rock of Rainy lake."

older set of wholly sedimentary rocks underlying it in some sections, and, therefore, to be expected in any complete series of the Archæan.

When the Director of the Survey invited me in the spring of 1911 to revisit Rainy lake and to review the geology of that field in the light of the work done in various parts of Canada and the United States in the past twenty-five years, I gladly embraced the opportunity to correct the error to which the United States Geological Survey and the International Committee had called attention. To do this I spent over four months in the field, and, assisted by Dr. J. D. Trueman, Dr. R. C. Wallace, and Mr. H. C. Cooke, made a detailed geological survey of a selected portion of Rainy lake, and a reconnaissance of the country to the east of that lake along the Seine river, as far as Steeprock lake and Sabawe lake. The area surveyed is indicated on the accompanying index map. It was selected so as to embrace a field which would reveal as much as possible of the relations of the Keewatin, Coutchiching, and Laurentian. A topographic survey was made on a field scale of 20 chains to the inch, and it is proposed to use this as the basis of a geological map to be published on the scale of 1 mile to 1 inch to accompany my report. The surveys have already been reduced and compiled. In the opportunity which was thus afforded for detailed study of the field, occasion was taken to greatly improve the mapping of the geological boundaries, and the new map is, therefore, more expressive of the structural relations than the old map of 1887.

The general physiographic features of the area mapped were set forth in the report of 1887 and need not be repeated here. In regard to the geological sequence I was gratified as my studies proceeded, to find that these confirmed my conclusions of 1887. I failed to find the evidence which would justify the statement of the United States Geological Survey and the International Committee as to the superposition of the Coutchiching upon the Keewatin. It is with great diffidence that I stand thus opposed to such eminent authorities, but until the latter set forth clearly and specifically the evidence upon which their conclusions are based, a thing that they have not yet done, and how further that that evidence completely nullifies the evidence which I shall assemble in my report, proving that the relations of the Keewatin and Coutchiching are as I stated them in 1887, there is no other course open to me. Some of the arguments sustaining my view of the matter are the same as those advanced a quarter of a century ago, but are more explicitly stated in the report which I am now preparing. Others are new and have to do with the conglomerate of Shoal lake and its equivalents.

The Coutchiching of Rice bay occupies an anticlinal dome completely surrounded by the Keewatin. The Coutchiching of the Bear's passage is similarly anticlinally below the Keewatin, and in its extension to the west-southwest, this belt has in general the structure of an anticline or series of anticlines dipping away from dome-like intrusions of granite-gneiss and flanked on both sides by Keewatin belts which have a synclinal structure. The conglomerate of Shoal lake occupies a well-defined synclinal trough with a belt of Keewatin a mile wide on the south side of it at the east end of Shoal lake. It is the basal formation of a series of rocks which is neither Keewatin nor Coutchiching, but is later than both. To these rocks I have given the provisional name of Seine series, from their abundant and typical exposures along the Seine river. South of the mile-wide belt of Keewatin greenstones, and green schists above referred to, there is another synclinal trough of Seine strata consisting chiefly of pebbly quartzites, quartzites often cross-bedded, and slates, which are notably distinct from the nearby Coutchiching in their obvious clastic structure, feeble metamorphism, bedded structure, and their superposition upon the Keewatin. These Seine strata do not come in contact with the typical Coutchiching mica schists, for to the south of Shoal lake, on the south flank of the syncline, another belt of Keewatin intervenes, and beyond that are the typical Coutchiching mica schists. The conglomerate at Rat Root bay has also been stated to be the basal conglomerate of the Coutchiching resting upon the Keewatin; but, as a matter of fact, this conglomerate also occupies a synclinal trough almost wholly within the Keewatin area, and nowhere comes in contact with the mica schists of the great southern belt of Coutchiching of the Minnesota shore of the lake. It contains large boulders of granite, which are with little doubt derived from an immediately adjacent granite mass intrusive in both Keewatin and Coutchiching; and many of the schist pebbles contained in the conglomerate have no resemblance to the local Keewatin, but were probably derived from the Coutchiching. In the middle of the syncline, which extends from the east end of Dry Weed island to Rat Root bay, are quartzites which bear no resemblance to the Coutchiching mica schists observed in immediate contact with the Keewatin at many localities. These and many other observations will be amplified in my report, all tending to show that the Coutchiching lies below the Keewatin.

The recognition of the Seine series as a new and distinct member of the Archæan complex is an interesting result of the season's work. The contact of the Seine series with the Keewatin has been followed up the Seine river from Shoal lake to Sabawe lake. The contact is characterized on the upper side by lenses of conglomerate occurring at intervals, and on the lower side by abundant evidence of the deep weathering of the Keewatin surface prior to its burial by the Seine sediments. The Keewatin rocks are chiefly greenstones, and the weathering of these has charged them with carbonates and limonite. The carbonates include carbonate of iron. On this same line of contact are bodies of iron ore, the most notable being those now mined just to the east of Sabawe lake. It seems very probable that these workable deposits are the result of the concentration of the iron ores produced by oxidation in the weathered zone of the Keewatin in pre-Seine or early Seine time. It is certain that this contact is a locus of iron-ore concentration, and that the careful mapping of the boundary between the Seine series and the Keewatin in other parts of this region would afford the prospector a valuable aid in his search for iron ore.

Besides these iron ores at the upper surface of the Keewatin where the Seine rocks rest upon it, there are other iron ores within the Keewatin of a quite different origin. These are titaniferous magnetites, probably the result of magmatic differentiation of gabbros which occur in that series. Ores of this kind are known at a number of localities in the Rainy Lake country, and prospecting is in active progress at some of these.

Another interesting and important result of the season's work is simplification of the geology of Steeprock lake and the discovery of fossils in the limestones of the Steeprock series. This series has been an interrogation mark in the Archæan geology of Canada for the past twenty years. I have been able to show that the greater part of the rocks originally included in the series is Keewatin, and that the remnant, or Steeprock series proper, consisting chiefly of a basal conglomerate, several hundred feet of limestone and some volcanic rocks, rests unconformably upon the Keewatin as well as upon the granite gneiss. The series, although post-Keewatin in age, is deeply folded within the Archæan and appears to be unconformably below the Seine series. The fossils which are abundant in the limestone are, so far as I am aware, the oldest well defined organic remains now known to science.

Near Iron Spur, on the line of the Canadian Northern railway, the Seine series is in irruptive contact with the northern edge of an extensive batholith of granite-gneiss which has been mapped as Laurentian on the Seine River sheet. Inasmuch as the Seine conglomerate contains pebbles and boulders of granite-gneiss, it is evident that we have in the class of rocks usually included under the term Laurentian, batholithic intrusions widely spaced in time; and this opens up the question of the significance of the term Laurentian. I shall take occasion in my report to submit some considerations bearing on this important question.

Finally, I may mention that I was fortunate enough to find an outlier of Winnipeg limestone in the immediate vicinity of Fort Frances. A number of people in Fort Frances were aware of the existence of the limestone and were interested in it as a possible supply of lime. The outcrop, which is quite small, emerges from beneath the glacial drift. The rock is fossiliferous, and the fauna which it contains have been determined by Mr. Raymond to be of upper Ordovician (Richmond) age. The discovery of the outlier proves that this limestone once extended from its present easterly boundary in Manitoba as far east as Rainy lake.

# GEOLOGY OF ONAPING SHEET, ONTARIO: PORTION OF MAP-AREA BETWEEN WEST SHININGTREE AND ONAPING LAKES.

(*W. H. Collins.*)

## Introduction.

For purposes of systematic exploration by the Geological Survey, northern Ontario is subdivided into rectangular areas 72 miles long from east to west and 48 miles wide. Maps of these rectangles, published on a scale of 4 miles to 1 inch, are known as sheets and are distinguished by numbers as well as by distinctive names. During the field seasons of 1910 and 1911, the writer and his assistants were making a detailed reconnaissance of a rectangle of this sort which constitutes sheet No. 139. This hitherto imperfectly known area appears to possess economic possibilities worthy of investigation. Keewatin iron formation was known to exist in it. Diabase sills, with associated silver-cobalt veins like those at Gowganda and Cobalt had been traced into it from the adjoining Timiskaming district. Recently, also, gold-bearing quartz veins have been found in the Keewatin schists.

Sheet No. 139, or Onaping map-area as it may be called after its most important geographical feature, Onaping lake, includes 3,456 square miles of country lying between W. long. 80° 20′ and W. long. 82° from N. lat. 46° 55′ to N. lat. 47° 40′. Its centre is 50 miles north of the town of Sudbury.

The adjacent country to the south and east has been mapped already; sheets 130, 131, and 138. Within Onaping district itself, a strip about 2 miles wide, adjacent to the Nipissing-Sudbury boundary, was examined for the Ontario Bureau of Mines by Mr. E. M. Burwash[1] in 1898. In 1905 Mr. W. J. Wilson[2] began the exploration of this district by surveying such portions of Wanapitei, Sturgeon, and Montreal rivers as traverse it. Nine hundred square miles in the northeastern corner of the rectangle were completed by the writer's party in 1910, and, this year, an additional area of 1,000 square miles in the central part near the Canadian Northern Ontario railway and the Nipissing-Sudbury boundary was mapped. From preliminary explorations and previous work by other investigators, the general character of the remainder is already fairly well known.

Much of the work accomplished this year is due to the assistance given by Messrs. J. R. Marshall, N. B. Davis, T. L. Tanton, R. R. Watson, L. C. Prittie, E. P. Hodgins, A. E. Allin, F. J. Mulqueen, and G. M. Taylor.

## Summary.

The area examined in 1911 proves to be a continuation of a Pre-Cambrian geological sub-province, which, so far as it has been traced, covers portions of Sudbury and Nipissing districts in Ontario and continues eastward into Quebec. No field evidence of a westward or southward termination of this province was found, although in the Sudbury district, 50 miles to the south, a different and more complicated succession exists.[3] The whole province, including the present district, is stamped by a profound erosion interval which separates a peneplanated basement

[1] Bureau of Mines Report (Ontario) 1898.
[2] Summary Report, G.S.C., 1905.
[3] Coleman, A. P., Bureau of Mines Report, Ontario, 1905, Pt. III.

consisting of a schist complex intruded by granite batholiths from an overlying cover of gently folded Huronian sediments and associated diabase intrusions.

During August native gold was found in quartz veins in the Keewatin schists of West Shiningtree area, townships of Asquith, Churchill, and McMurchy. Gold also occurs in stratified glacial sand, which forms an extensive plain in the vicinity of Meteor, Shoofly, and Blue lakes, and the Canadian Northern railway, but attempts at placer mining have proved the gold content to be too low for profitable extraction. Silver-cobalt veins of the type found at Cobalt are associated with post-Huronian diabase sills almost as far west as these sills have been traced, but most of the discoveries are of no importance. Those east of Shiningtree lake, in Leonard township, however, show considerable quantities of silver at the surface. An exploration shaft has been sunk 92 feet by Messrs. Caswell and Eplett, and surface exploration has been continued on several other properties. Exploration of the Keewatin iron formation near Shiningtree and Burwash lakes has not revealed ore-bodies of present commercial value.

## General Character of the District.

### TOPOGRAPHY.

The area examined in 1911, like other neighbouring portions of the Pre-Cambrian region, is rocky and hilly, yet plain-like when only its broader topographic features are considered. It lies between 1,200 and 1,500 feet above sea-level. The Canadian Northern Ontario railway, which crosses it for 50 miles, varies in elevation above sea-level between 1,200 and 1,350 feet, and the rivers that traverse it in various directions have correspondingly small gradients.

The amount of relief depends to a notable extent upon the underlying Pre-Cambrian rocks and upon the thickness of the soil-sheet. Huronian quartzite and the intrusive diabase sills give rise to large, often precipitous hills. Some of the quartzite hills in Leask and adjoining townships are 400 feet high. Granite and schist areas possess a much softer and less imposing appearance. The soil-sheet is deeper and more extensive in this area than in adjacent ones hitherto visited, and consequently the harshness of the Pre-Cambrian rock surface is subdued to a greater degree. In the vicinity of Meteor and Shoofly lakes, also in the townships of Ogilvie, Browning, and Unwin there are extensive sand plains.

### DRAINAGE.

The Height of Land divides the area into a northwestern part which feeds several tributaries of Mattagami river, flowing into James bay; and a larger southwestern part drained by Vermilion, Wanapitei, and Montreal rivers, which eventually reach the St. Lawrence; so, near their sources, none of these streams are large. They receive a great number of small creeks that drain an even greater number of lakes. With the exception of Onaping lake, which is 30 miles long, most of the lakes are small. The majority occupy rocky basins, but those in the sand plains fill pit-like depressions in the sand and gravel. These kettle lakes contain remarkably clear water and are frequently without visible outlet.

### FLORA AND FAUNA.

The area is entirely covered with the usual forest of mixed evergreen and deciduous trees common to all northern Ontario. The growth is unusually good, however, owing probably to the deep soil-sheet, and the occasional presence of cherry and hawthorne trees suggests slightly milder climatic conditions than usually obtain in that region. Maples one foot in diameter are common near Gowganda Junction.

Pine and spruce are first in commercial importance. Individual white pines are found throughout the district, and on the deep sandy soil near Onaping lake, Shiningtree lake, and the headwaters of Vermilion river there are splendid forests of white and red pine from 12 to 40 inches in diameter.

The country east of Wanapitei and Opickinimika river lies within the Timagami forest reserve, but west and south of this timber berths are held by various lumber companies. From Creelman township southward large quantities of logs are floated down Vermilion river. Much timber has already been cut near Onaping lake and, though little actual lumbering is being done at present, preparations for future operations are under way.

### TRANSPORTATION.

The Canadian Northern Ontario railway extends from Sudbury 65 miles northward into the district under consideration. During the summer of 1911, an additional section of 15 miles was constructed from the present terminus, Gowganda Junction, to Deschenes lake. A winter road built in 1909 connects Gowganda Junction with Gowganda, 45 miles to the northeast. It is reported that a sleigh road will also be built, this winter, from the present end of steel at Deschenes lake to West Shiningtree lake, a distance of about 18 miles.

## General Geology.

### GENERAL STATEMENT.

The geological succession and structure found in this area are common to at least 6,000 square miles of country in Sudbury and Nipissing districts. A schist complex known as Keewatin is the oldest group of rocks. This was intruded by granite batholiths, to which the name Laurentian in its broader sense is applied. Keewatin and Laurentian rocks were afterwards worn down to a peneplain and covered unconformably during Huronian time by a series of clastic sedimentary formations. This unconformity is a pronounced structural feature, for Huronian beds are but gently folded and seldom schistose, while the underlying Keewatin rocks are highly schistose and dip steeply. Diabase, probably of Keweenawan age, was intruded into all the older formations, taking the form of vertical dykes in the Keewatin and Laurentian, and of approximately horizontal sills in or immediately underneath the Huronian.

At the present time a large part of both sediments and diabase are completely eroded, exposing portions of the underlying schists and granites. Glacial boulder clay and imperfectly stratified sand cover much of the Pre-Cambrian rock surface whose exposed parts show the effects of Pleistocene glaciation.

### TABLE OF FORMATIONS.

| | |
|---|---|
| Recent and Pleistocene | Boulder clay, stratified sands, etc. |
| | Great unconformity. |
| Keweenawan (?) | Olivine diabase dykes, quartz diabase dykes and sills. |
| | Intrusive contact. |
| Huronian | Quartzite, quartz conglomerate, arkose and chert—Lorraine series. |
| | Conglomerate, greywacke and banded slate—Cobalt series. |
| | Unconformity. |
| Laurentian | Biotite and hornblende granites and gneissic equivalents. |
| | Intrusive contact. |
| Keewatin | Various extrusive and intrusive igneous rocks; iron formation, conglomerate. |

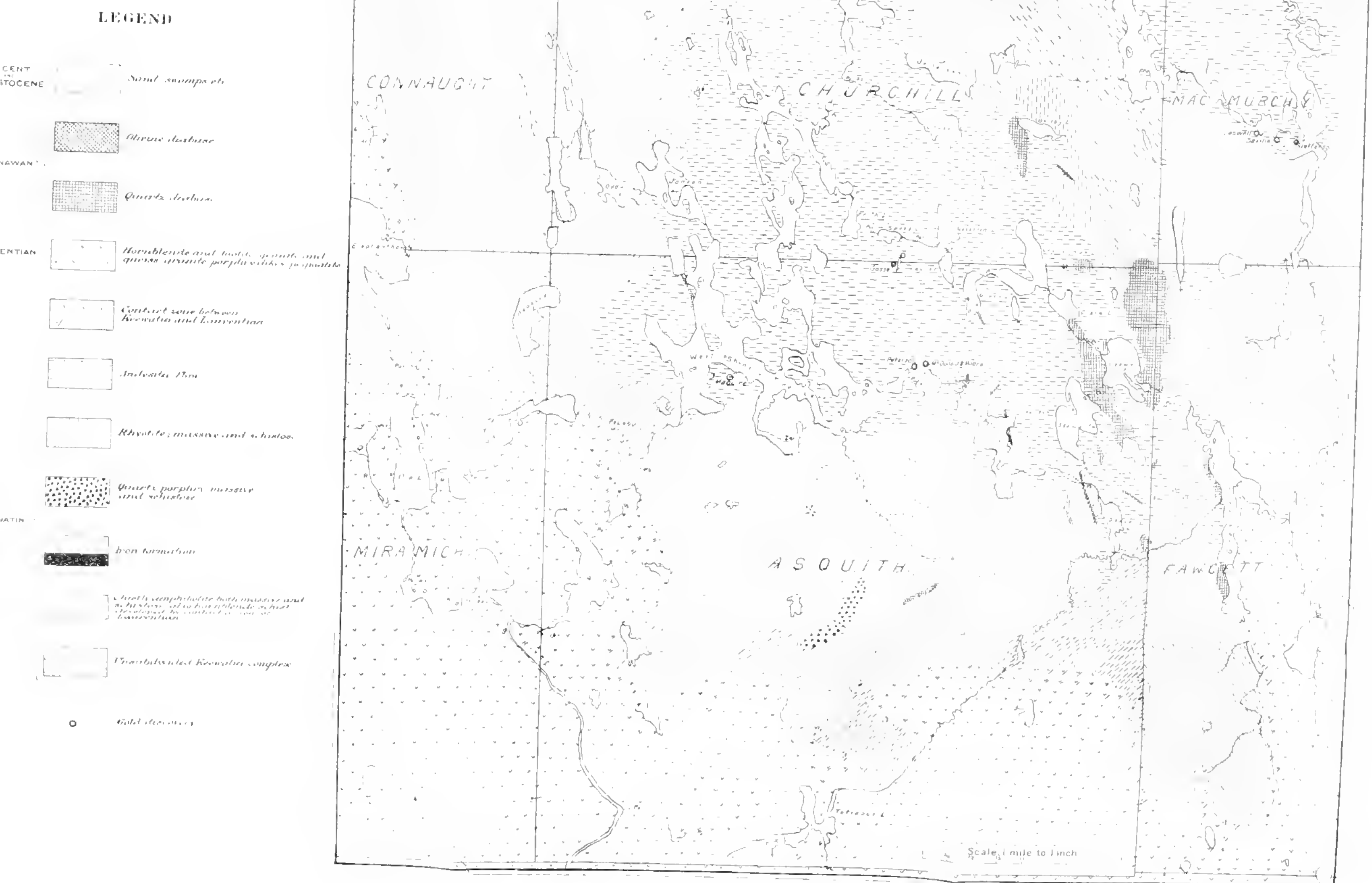



DIAGRAM OF WEST SHININGTREE AREA, SUDBURY DISTRICT, ONTARIO.

Geology by W. H. Collins, 1911.

DESCRIPTION OF FORMATIONS.

### *Keewatin.*

Only a few small patches of Keewatin were found this year. West Shiningtree area, the most important one, is the extreme southwestern lobe of a great Keewatin area that continues 70 miles northward to Porcupine. A narrow outlier of this, separated from it by a few miles of granite, extends southward through Sheard, Amyot, and Hodgetts townships. A smaller patch occurs east of Meteor lake.

The Keewatin group is principally volcanic in origin. Basalt, andesite, rhyolite, quartz porphyry, and ash rocks are all present. Banded iron formation is the chief sedimentary material. Most of these rocks, including the iron formation, are older than the granite batholiths and are greatly metamorphosed, becoming sheared to chlorite and sericite schists or, when near granite contacts, recrystallized into hornblende schists. Some, however, are massive, and less closely folded and may be younger than the granite.

*West Shiningtree Area.*—The Keewatin in West Shiningtree district is gold-bearing, and, therefore, of special interest. Structurally it is separable into an older, closely-folded and highly metamorphosed portion; and a younger, less-folded one of massive rocks which overlies the former. The older part consists largely of basic rocks ranging from diabase to fine-grained decomposed greenstone. Mica andesite, decomposed porphyry containing feldspar crystals, and ash rock are also present but in small amount. The greenstone is also cut by quartz porphyry dykes. A single exposure of iron formation was found in the lake east or Saville lake. A rusty-weathering green carbonate schist, closely resembling similar rocks found at Larder and Opasatika lakes, was seen at the north end of Stewart lake and on the Gosselin claim near the north boundary of Asquith. All these formations appear to have been closely folded for the iron formation stands on edge, striking nearly north-south, and the igneous members have been sheared more or less to chloritic and sericitic schists. Near the granite contact, in Asquith and Connaught townships, a glistening black hornblende gneiss has been developed from basic varieties by contact metamorphic action.

A small amount of sedimentary matter, other than iron formation, is associated with the igneous formations of this older, folded group. Two exposures were found of a conglomerate which, so far as could be seen, dips steeply, forming a narrow north-south band. It consists of subangular and rounded pebbles of grey porphyry and other igneous materials in a grey schistose cement. Contacts with adjacent igneous rocks were hidden by drift. On Michiwakenda lake several isolated exposures were seen of a black slate which is locally banded with magnetite. In one case at least, this slate stands on edge though it is not schistose. It is possible that these sediments occur more extensively in the northern part of Churchill township and may belong to a Huronian series older than the Cobalt series.

These folded rocks are overlain near West Shiningtree and Wasabika lakes by a comparatively undisturbed flow of hornblende andesite, the extrusive nature of which is abundantly indicated by an ellipsoidal structure, amygdaloidal cavities, flow lines, and a notable variability in grain. A pale grey rhyolite associated with the andesite appears to bear a similar relation to the older schists. Both andesite and rhyolite are, for the greater part, massive, and the areal distribution of the former indicates comparatively little folding. Nevertheless they contain local sheared zones, usually less than 100 feet across and from northwest-southeast to east-west in course, in which the original massive andesite or rhyolite has been converted into a highly fissile chlorite or sericitic schist. These zones are of some interest, as they appear to have afforded easy circulation to slate and gold-bearing solutions.

*Laurentian.*

The term Laurentian is applied here in its broad sense to all granites and gneisses which intrude the Keewatin, but are older than the Huronian Cobalt series. Such rocks form a much larger part of the peneplanated basement beneath the Cobalt series than do the Keewatin schists. They underlie the Huronian near the Nipissing-Sudbury boundary, appearing through it in patches, and are exposed continuously over 1,000 square miles between Opickinimika river and the western border of sheet No. 139. Such portions of this area as were examined consist of hornblende, granite and gneiss, aplite and pegmatite, representing variations of one intrusive mass.

*Huronian.*

The sediments that overlie the Keewatin and Laurentian unconformably consist of a lower series (Cobalt series) of conglomerate, greywacke, quartzite, and banded slate of continental deposition and an upper series (Lorraine series) of quartzite, arkose, chert, and quartz conglomerate that were laid down under water. In their present eroded state they vary in total thickness from almost nothing to 1,000 feet. The strata of both series are concordant, and only gently folded except in a few localities, notably along the Canadian Northern railway, where they are greatly disturbed.

Several contacts between the Lorraine quartzite and older greywacke were seen in Lampman township that show but faint evidence of unconformity. The quartzite lies directly upon a somewhat irregular greywacke surface. There is no basal conglomerate in the quartzite, but tongues and contorted pieces of greywacke project a few inches upward into it as if the greywacke had been plastic when the sand now represented by the quartzite was deposited upon it.

*Keweenawan (?).*

The Huronian and older groups are intruded by diabase dykes and sills similar to those in Timiskaming and Montreal River districts, and presumably of Keweenawan age. As in those districts, the dykes are confined largely to the Keewatin and Laurentian; the sills to the Huronian beneath which or along the bedding planes of which they have been injected.

*Pleistocene.*

Boulder clay overlies the Pre-Cambrian rocks over most of the district as a thin sheet, but in places forming ridges. In Ogilvie, Browning, and Unwin townships, also near Meteor, Shoofly, and Oshawong lakes extensive plains of imperfectly stratified sand replace the boulder clay. The surface of these plains is even, but not level enough to imply lacustrine deposition. It is broken by occasional gravel ridges representing eskers, and is also pitted with kettle-holes, many of which now contain lakes. The sand, as revealed along the Canadian Northern Ontario railway, which crosses the second plain mentioned, is strongly cross-bedded and convexly stratified, indicating stream deposition. Some temporary ponding of glacial streams probably occurred during the formation of these sand plains, but the streams themselves appear to have played the most important part in their deposition.

## ECONOMIC GEOLOGY.

### Gold.

*West Shiningtree District.*

Gold was found during June, 1911, in portions of Asquith and adjoining townships, or what is now better known as West Shiningtree district. For over a year past unusually active prospecting has been conducted in this and neighbouring Keewatin areas as a result of the encouraging developments in Porcupine district, which lies 70 miles farther north. A party of prospectors from Sudbury visited West Shiningtree lake late in 1910, and, although no gold was found, the numerous quartz veins seen in the Keewatin schists were thought to be worthy of further examination. It was revisited for this purpose early in the spring of 1911. It is difficult to say when gold was first found, for some of the earlier "discoveries" were premature efforts to arouse public interest. Probably some was obtained in June, but high-grade ore was not found until early in August. This discovery was made near Milepost 3, on the north boundary of Asquith township, by Messrs. Gosselin, Speed, and Frith, and caused a rush of prospectors to West Shiningtree lake, from Sudbury, Gowganda, and other points. On August 19, Mr. L. Jefferson found free gold on Wasabika lake, thus extending attention to McMurchy township. When the writer left this area on August 19, gold had been found in three places, and since then at least three other discoveries have been made. Very little surface exploration had been performed upon any of the properties.

The accompanying map of West Shiningtree district shows that district to be underlain principally by Keewatin rocks with intrusive granites to the south. Also, as stated in the preceding geological description, the older Keewatin formations around West Shiningtree and Wasabika lakes are overlain by a volcanic sheet of hornblende andesite. This andesite contains an unusual number of quartz veins, some of which carry native gold. Indeed, all the gold bearing veins known to the writer lie within this formation.

There are two somewhat different modes of occurrence. In some cases gold occurs in quartz veins that occupy distinct fissures in the andesite. So very little work has been done toward tracing these veins that no true estimate can be made of their extent. However, they are nearly vertical, from a few inches to over 20 feet wide, and traceable for distances up to 200 feet. Some are irregular and short. They consist of white quartz containing occasional small patches of white carbonate, which weathers to a rusty limonite powder. Small aggregates of tourmaline occur in the quartz. Pyrite grains are disseminated through this gangue material in varying amounts and are also present in the wall-rock. Flakes and irregular particles of gold $\frac{1}{8}$ of an inch or less in diameter occur abundantly in places, though other parts of the same veins show no visible gold. At the surface gold particles are occasionally found together with limonitic rust in small cavities produced apparently by the weathering out of pyrite grains. In other cases gold is found in vertical sheared zones in the andesite. These are from a few feet to 100 feet wide and strike between northwest-southeast and east-west. They consist of a highly schistose phase of the andesite through which are distributed a great number of small lenses and veinlets of bluish or white quartz that follow the planes of schistosity. Both schist and quartz are more heavily impregnated with pyrite than are the large veins. Gold in fine particles is obtained by crushing and panning this material, and is said to occur in the schist as well as in the quartz stringers.

*Gosselin Claims.*—This property lies on either side of the Asquith-Churchill boundary, a few chains east of Milepost 3. The small area containing most of the veins is underlain chiefly by andesite, though sheared rhyolite, green carbonate schist, and schistose greenstone are also present. Just east of the little stream which runs from the lakelet on the township line of Speed lake, a large vein traceable through the drift-covering for 100 feet in a southeasterly direction has been stripped in one place for a width of 20 feet without discovering the west wall. Across the stream and 200 feet west of this vein is a second, apparently about 4 feet wide, which can be followed southward for 200 feet. A little south of this second vein there are several smaller ones whose arrangement and dimensions could not be determined owing to the drift-covering. So far as the scanty exposures indicate, the small veins are more richly mineralized with pyrite than the large ones. Good specimens of gold-bearing quartz were obtained from a 2 foot vein which had been exposed for a distance of 8 feet. Gold was not visible in either of the large veins, though its presence was indicated by assays.

*Jefferson Claim.*—This claim covers a high fire-swept knob of andesite on the east shore of Wasabika lake, McMurchy township. The andesite is massive and cut by a number of small quartz veins. In one 18 inch vein that could be traced northwestward for 40 feet particles of gold were found at the surface as well as in many of the fragments of quartz that were broken off and examined.

*Moore and MacDonald Claims.*—Just north of MacDonald lake, Messrs. H. Moore and H. MacDonald have staked claims on a sheared zone in the andesite formation. More work had been performed upon this property than any of the others examined, hence the schistose zone, which varies in width between 10 and 40 feet, could be traced for 550 feet from east to west. The schist is traversed along its strike by an interrupted series of small quartz stringers. Both quartz and schist are impregnated with pyrite. No gold could be seen in any of the samples examined, but by crushing and panning a mixed sample of quartz and schist a considerable "tail" of fine particles was collected. A sample collected by the writer and assayed by Mr. H. Leverin, of the Mines Branch, Department of Mines, yielded a value of 40 cents per ton.

*Peterson Claim.*—This property probably represents a westward continuation of the sheared zone in Moore and MacDonald's claims.

A short distance south of here another shear zone of the same appearance was being opened by Mr. R. Cryderman, but so far as known no gold had been found.

*Maguire Claim.*—The Maguire property, situated on the south side of West Shiningtree lake, was not discovered until the writer had left this district, and consequently was not examined. From descriptions obtained, however, gold appears to occur in an east-west shear-zone similar to that seen in the claims just described.

Considering the drift-covered nature of West Shiningtree area and the limited amount of surface work already done, a surprising number of veins and mineralized zones have been found. It is to be expected, therefore, that other veins will be discovered during the exploration of these now known. It is also likely that some which are already known to be wide or have been traced without perceptible diminution in width for 200 feet or more, will prove persistent in length. But, though trenching and stripping may reveal bodies of sufficient size to encourage underground exploration, yet it will possibly prove them to be poorer in values than expected. Specimens carrying visible amounts of gold that have been taken from rich pockets have circulated more readily than specimens from lean portions of the same veins. Assay returns from a number of samples range from 40 cents up to $15 per ton. These results are little more than qualitative, for, in the present unexplored state of the veins, only approximate average samples are obtainable; nevertheless, they probably indicate within reasonable limits the general richness of mineralization in this area.

*Meteor Lake Area.*

As early as 1897 placer gold was found in the stratified sand around Meteor lake, and the headwaters of Wanapitei river. An unsuccessful attempt to wash the sand and gravel on Meteor lake was made by the Onaping Mining Company. The gold values were found to be too low, the individual colours very fine and difficult to collect, and the country too flat to afford natural washing facilities, consequently the camp buildings and machinery were abandoned. Gold is widely distributed in this area and probably also in the sand plain that covers parts of Ogilvie, Browning, and Unwin townships, but not richly enough to be profitably extracted.

## Silver.

Calcite veins of the same type as the silver-cobalt veins of Gowganda and Cobalt districts are associated with remnants of quartz diabase sills that occur at intervals throughout the district. But, with few exceptions, they are too poorly mineralized to be economically important, and are interesting only in showing how persistently silver-cobalt deposits accompany the diabase. Most of the discoveries were made in 1909, since which time prospecting for silver in this district has steadily declined and has now almost ceased, except near Shiningtree lake.

*Shiningtree Area.*

Shiningtree mineralized area lies east of Shiningtree lake in Leonard township. The known veins are confined to about 4 square miles of a diabase sill that overlies Keewatin and Huronian rocks. A considerable number occupy wide and persistent fissures, frequently in parallel N.-S. series, and a few contain silver. Silver was first discovered in May 1909, since when exploration has continued steadily. At present it is known to occur on four different properties and underground exploration has been commenced upon one of these.

*Neelands Claim.*—This property was described by the writer in the Summary Report of the Geological Survey for 1910. There has been no further development.

*Saville Exploration Company's Claims.*—An account of this property was also given in the Summary Report for 1910.

*Archibald Claim.*—The diabase underlying this property is traversed by a group of three parallel north-south veins, the outermost of which are 80 feet apart. They vary in width from 1 to 3 inches and are stripped for distances varying from 60 to 160 feet in length. Small flakes of silver can be seen at two points along the most easterly one, and a little specularite, chalcopyrite, and cobalt bloom occur in all three.

*Caswell Claims.*—A similar group of parallel, but less regular veins, striking N. 15° E., intersect the diabase of this property. When visited in August a vertical shaft had been sunk 92 feet beside one of the veins, at the surface of which a little native silver had been found. It was proposed, when a depth of 108 feet had been reached, to drift east and west at the 100 foot level in search of the veins. The working plant consists of a small hoist and one steam-drill.

*Rosie Creek Area.*

Rosie Creek area includes adjacent portions of Unwin and Browning townships on either side of Rosie creek, a small tributary of Wanapitei river. It consists of a flat sand plain above which rise occasional hills of Lorraine quartzite or of diabase. The diabase hills represent portions of a sill which rests upon nearly flat-lying quartzite or upon Laurentian granite. This area was prospected actively during 1909 and the early part of 1910, but is now almost deserted. The veins that have been found, though of good size, are crooked and contain a somewhat atypical mineral assemblage. Silver has not been recorded except in traces determined by assays. Smaltite and cobalt bloom occur, but chalcopyrite and galena are more common, and slender prisms of stibnite are present in one vein.

*Other Localities.*

Numerous veins have been found in a diabase sill 250 feet thick which overlies Keewatin and Huronian formations in the township of North Williams. Near the south end of this township a small quantity of silver was found at the surface of a vein on property owned by the Exploration Syndicate Company, but test pitting proved it to be discontinuous.

An 18 inch vein carrying large masses of galena occurs in diabase near the middle of Hodgetts township.

The diabase forming one of the islands in Welcome lake contains a vein of barite.

# GEOLOGY OF LAKE SIMCOE AREA, ONTARIO. BRECHIN[1] AND KIRKFIELD[2] SHEETS.

(*W. A. Johnston.*)

## Introduction

The field work of the past season was a continuation of the topographical and geological mapping of a portion of the Lake Simcoe district, Ontario, on a scale of 1 mile to 1 inch. Topographical relief is shown on the maps by contours at intervals of 20 feet. Intermediate contours, or 10 foot contours, are also used in areas where there is very little relief or for the purpose of showing small features of special significance, *e.g.*, beach ridges, etc.

Field work lasted from May 30 until November 10, in which work R. L. Junkin and C. Freeman assisted and rendered efficient service.

A few days in August were spent by the writer in company with Mr. P. E. Raymond, invertebrate palæontologist of this Survey, in an examination of some of the sections of the lower Ordovician in the Brechin and Kirkfield areas. Collections of fossils were made which have been determined by Mr. Raymond, and the partial results of his work are incorporated in this report.

## Location and Area.

The topographical field work of the past season consisted chiefly of the sketching of the Brechin and Kirkfield map-areas, both of which were completed. The Brechin map-area is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 79° 00′ and 79° 15′, and includes a land area of about 190 square miles. The Kirkfield map-area is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 78° 45′ and 79° 00′, and includes a land area of about 170 square miles.

## General Character of the District.

Within the limits of Brechin and Kirkfield areas the maximum relief is about 400 feet. Flat-lying Ordovician limestones occupy the greater portion of the district and are generally well exposed in the central and northern portions of the area. In the southern part the solid rock is in greater part concealed by drift. A strip along the northern border, having an area of about 40 square miles, is underlain by Pre-Cambrian rocks having comparatively little drift-covering. Near the contact of the limestones and crystalline rocks an escarpment is generally well developed, which varies in height from a few feet to upwards of 100 feet. The limestones have a gentle dip varying from 15 to 30 feet per mile towards the southwest. They are rarely faulted, but the dip is sometimes varied by low undulations or folds.

[1] Formerly Mud Lake sheet.
[2] Formerly Balsam Lake sheet.

## General Geology.

### TABLE OF FORMATIONS.

| | |
|---|---|
| Recent .... .... .......... | Humus, sand dunes, marls, etc. |
| Pleistocene........ | Raised beaches, fluviatile and lacustrine sands, gravels and clays.<br>Glacial clays, boulder clays and sands: fluvio-glacial sands and gravels.<br>Boulder clay. |
| Ordovician........ ........<br>Kirkfield limestone ......<br>(group)........ ........<br>(Trenton)?........ ........ | Upper member (unknown).<br>Prasopora beds.<br>Crinoid beds.<br>Dalmanella beds. |
| Black River .... .. .. ...<br>(group)? .. .. .. ........ | Coboconk limestone, Columnaria beds<br>Upper Lowville (Birdseye) limestone.<br>Lower Lowville limestone, Beatricea beds.<br>Basal series of sandstone, shales, etc. |
| Pre-Cambrian........ ...... | |

### DESCRIPTION OF FORMATIONS.

## Ordovician.

*Black River (group)*—

1. Basal Series of sandstones, shales, etc.—

Resting unconformably on the Pre-Cambrian crystalline rocks in the Simcoe district, Ontario, as a basal series consisting of coarse calcareous sandstone or arkose passing upward into red and green shales with intercalated lenses or thin beds of sandstone, and occasionally thin beds of fine-grained limestone. The thickness of this series varies and the beds are frequently absent on the sides and tops of ridges or domes of the crystalline rocks, where the limestones are seen to rest directly on the old floor. The sandstone and shales are best developed in basins between ridges of the crystalline rocks where they occasionally have a maximum thickness of about 40 feet. They are local in character and derivation, and evidently represent the old soil covering of the Pre-Cambrian rocks somewhat sorted, rearranged, and recemented, and it seems probable that they represent the initial near-shore deposit of the next succeeding formation.

2. Lower Lowville (Beatricea beds).—The red and green shales pass upwards into impure magnesian limestones which on fresh fracture are greenish-grey in colour and weather yellowish-brown. They are characterized by numbers of drusy cavities, occasional quartz grains and crystals of pyrite or limonite, and are generally barren of fossils. They are only a few feet in thickness, and are followed by 6 to 10 feet of fossiliferous blue-grey to dove-coloured limestone characterized by an abundance of a species of Beatricea. These beds somewhat resemble in physical character the typical fine-grained "Birdseye" limestone, but are less compact in texture and weather to a shaly mass. They are overlain by from 7 to 10 feet of unfossiliferous magnesian limestone very similar to the beds which immediately underlie them. A small collection of fossils from the Beatricea beds, as exposed on the west side of Lake Couchiching, Ont., was obtained last year, and the fossils were determined by Mr. E. O. Ulrich, of the United States Geological Survey, as belonging to the lower middle Lowville. One of the best localities in the district where these beds are exposed is about 2 miles south of Dartmoor post-office, on lots 16 and 17, concession I, of Dalton township, and on lot 25, concession VI, of Carden township. A larger collection of fossils was made at this locality the past summer and they have been determined

by Mr. P. E. Raymond of this Survey. Following is the list of fossils, with Mr. Raymond's comments on their occurrence:—

"Near lot 25, concession VI, Carden, Ont., W. A. Johnston and P. E. Raymond, collectors.

*Beatricea* cf. B. *gracilis*, Ulrich.
*Beatricea*, sp. ind.
*Tetradium halysitoides.*
*Cyclocystoides halli*, Billings.
*Rafinesquina minnesotensis*, Winchell.
*Strophomena incurvata* (Shepard), small variety.
*Zygospira recurvirostris*, Hall.
*Ctenodonta nasuta* (Hall).
*Cyrtodonta huronensis*, Billings.
*C. subtruncata*, (Hall).
*Sphenolium*, sp. ind.
*Raphistomina lapicida* (Salter).
*Lophospira bicincta* (Hall).
*L. perangulata* (Hall).
*Orthoceras amplicameratum*, Hall.
*O. multicameratum*, Hall.
*Loxoceras allumettense* (Billings).
*Isotelus gigas*, Dekay.
*Onchometopus simplex*, Raymond and Narroway
*Bumastus indeterminatus* (Walcott).
*Bathyurus johnstoni*, Raymond.
*Pterygometopus callicephalus* (Hall).
*Leperditia fabulites*, Conrad."

"This fauna is peculiar in many ways, and, were its position not definitely fixed by the simple stratigraphy of the region, it would not be easy to place it. The facies is distinctly Lowville, although *Orthoceras multicameratum* is the only typical Lowville fossil present. *Cyclocystoides* and *Bumastus indeterminatus* have not previously been found below the Leray-Black River, while *Onchometopus simplex, Bathyurus johnstoni,* the small form of *Strophomena incurvata,* and several ostracods not enumerated above, occur at exactly this same horizon, just below the typical Lowville, near Clayton, New York, and at Ottawa. The *Tetradium* is not fasciculate like *T. cellulosum,* but grows in a loose form, very much like that of *Halysites*. Some of the larger masses had, on weathered surfaces, much the same appearance as similar broken up colonies of *Tetradium syringoporoides*."

3. Upper Lowville (Birdseye) limestone.—The Beatricea beds are overlain by about 20 feet of fine-grained even-bedded dove-coloured limestone characterized by *Bathyurus extans* and in the upper portion of a great abundance of *Tetradium cellulosum*. At the top are a few feet of coarser-grained dark coloured limestone, and in the section exposed in the quarry at Coboconk, Ont., Mr. Raymond considers that the line between the Lowville formation and the next succeeding formation, which was named the Coboconk formation and correlated with the Leray formation of the New York State geologists in last year's Summary Report, should be drawn about 9 feet above the fine-grained beds, as the *Tetradium cellulosum* still appears in these beds.

4. Coboconk limestone, Columnaria beds, correlated with the Leray limestone of New York State geologists.

Good sections showing the total thickness of the Coboconk limestone are rare in the district. One of the best localities is about 2 miles south of Dalrymple post-office.

The beds consist of dark grey, generally coarse-grained, rubbly limestone in thick beds having a total thickness of about 35 feet. The upper portion is characterized by a great abundance of chert, while the lower half contains comparatively little chert but the fossils are generally silicified throughout the formation where exposed on the surface. The following fossils were collected from the upper cherty beds

"Lot 12, concession III, Carden, Ont. W. A. Johnston, collector.

*Stromatocerium rugosum*, Hall.
*Stromatocerium*, undescribed.
*Beatricea* cf. *B. gracilis*, Ulrich.
*Beatricea*, sp. ind.
*Receptaculites occidentalis*, Salter.
*Columnaria halli*, Nicholson.
*Calapœcia canadensis*, Billings.
*Streptelasma profundum* (Owen).
*Rhynchotrema inæquivalve* (Castelnau).
*Orthis tricenaria*, Conrad.
*Rafinesquina alternata* (Emmons).
*Strophomena incurvata* (Shepard).
*Bellerophon charon*, Billings.
*Holopea nereis*, Billings.
*Maclurites logani*, Salter.
*Hormotoma gracilis* (Hall).
*Hormoceras tenuifilum*, Hall.

"This is a typical Leray-Black River assemblage, but the collection is so small that it probably does not properly represent the fauna. *Columnaria halli*, *Calapœcia canadensis*, and the *Hormoceras* are looked upon as the characteristic fossils, as all the others are found in later beds."

On the north end of Grand island in Balsam lake a few feet of coarse-grained, light grey limestone in thin beds are exposed which are very fossiliferous. On account of the isolated character of the exposure it is difficult to say what the stratigraphical relations of the beds are, but they would appear to underlie the Crinoid beds, as these beds are exposed on the west side of the island dipping slightly towards the southwest. The following collection of fossils was made at this locality.

"North end Grand island, Balsam lake, Ontario. W. A. Johnston, collector.

*Solenopora compacta* (Billings).
*Orthis tricenaria*, Conrad.
*Dalmanella testudinaria* (Dalman).
*Plectambonites sericeus* (Sowerby).
*Rhynchotrema inæquivalve* (Castelnau).
*Rafinesquina alternata* (Emmons).
*Clionychia*, sp. ind.
*Cyrtodonta obtusa* (Hall).
*Ctenodonta nasuta* (Hall).
*Holopea nereis*, Billings.
*H. excelsa*, Ulrich and Scofield.
*H. rotunda*, Ulrich and Scofield.
*H. appressa*, Ulrich and Scofield.
*Bellerophon charon*, Billings.
*Salpingostoma*, sp. ind.
*Eccyliomphalus undulatus* (Hall).
*Subulites elongatus*, Conrad.

*Cyrtospira parvula* (Billings).
*Scenella,* sp. ind.
*Liospira americana* (Billings).
*L. progne* (Billings).
*Lophospira conradana*, Ulrich and Scofield.
*L. bicincta* (Hall).
*Cyclonema,* sp. ind.
*Cycloceras lesueuri* (Clarke).
*Bathyurus spiniger* (Hall).
*Isotelus gigas,* Dekay.
*Bumastus milleri* (Billings).
*Pterygometopus callicephalus* (Hall).
*Ceraurus pleurexanthemus,* Green."

"This fauna is totally unlike any other that has been reported from the district. *Bathyurus spiniger* is usually restricted to the Lowville and Leray-Black river, but the specimens from this locality differ from the typical form in having a much longer and straighter spine on the pygidium, and it may prove to be a new species. The large gastropod element in the fauna also suggests the Leray-Black river, or the lower part of the Trenton, many of the species being common at Paquette rapids on the Ottawa."

*Kirkfield limestone (group). (Trenton.)*—

1. Dalmanella beds.—The thick cherty beds at the top of the Coboconk limestone are followed by about 20 feet of thinly bedded limestones characterized by an abundance of a species of Dalmanella. Some of the beds in the upper portion have a peculiar yellowish or rusty weathering and are overlaid by about 8 feet of thicker-bedded, more compact, light grey limestone, which is followed by about 20 feet of thinly-bedded grey limestones with shaly partings. It is difficult to draw any sharp dividing line between these beds and the crinoid beds which immediately overlie them, and good exposures showing this portion of the section are rare. In the following list of fossils the first three lots are from the lower thinly-bedded limestones, and the latter, which were collected from the dumps along the Trent canal below the Kirkfield lift-lock, are probably from the upper and middle portions of the Dalmanella beds. As stated in last year's Summary Report, these beds are considered by Mr. E. O. Ulrich to be equivalent to the upper part of the Decorah shale of Iowa and Minnesota.

"Lot 22, concession VIII, Carden, Ont. W. A. Johnston, collector.

*Girvanella,* sp. ind.
*Receptaculites occidentalis,* Salter.
*Streptelasma profundum* (Owen).
*Dalmanella testudinaria* (Dalma).
*Rafinesquina alternata* (Emmons).
*Strophomena incurvata* (Shepard).
*Plectambonites sericeus* (Sowerby).
*Sinuites,* sp. ind.
*Hormotoma gracilis* (Hall).
*Bumastus milleri* (Billings).

Lot 23, concession VIII, Carden, Ont.—
*Solenopora compacta* (Billings).
*Streptelasma profundum* (Owen).

*Orthis tricenaria*, Conrad.
*Strophomena*, sp. ind.
*Hormotoma gracilis* (Hall).
*Leperditia fabulites*, Conrad.

Lot 10, concession III, Carden, Ont—
*Receptaculites occidentalis*, Salter.
*Stenaster salteria*, Billings.
*Orthis tricenaria*, Conrad.
*Dalmanella testudinaria* (Dalma).
*Isotelus gigas*, Dekay.

Kirkfield lift-lock. Strata below lock. W. A. Johnston and P. E. Raymond, collectors.

*Receptaculites occidentalis*, Salter.
*Columnaria halli*, Nicholson.
*Carabocrinus vancortlandti*, Billings.
*Stenaster salteri*, Billings.
*Orthis tricenaria*, Conrad.
*Dalmanella testudinaria* (Dalma).
*Platystrophia lynx* (Eichwald), uniplicate variety.
*Rafinesquina alternata* (Emmons).
*Strophomena incurvata* (Shepard).
*Zygospira*, sp. ind.
*Pholidops trentonensis*, Hall.
*Maclurites logani*, Salter.
*Phragmolites*, sp. ind.
*Bathyurus ingalli*, Raymond.
*Thaleops ovata*, Conrad.
*Bumastus milleri* (Billings).
*Pterygonetopus*, sp. ind.
*Encrinurus vigilans*, Hall.
*Leperditia fabulites*, Conrad."

"The first three lists indicate the fossils which are commonly found in the strata immediately above the cherty beds at the top of the Coboconk limestone. The fossils are usually silicified, and a variety of *Dalmanella testudinaria* is exceedingly abundant. The fossils from the Kirkfield lift-lock were collected from the dump at the sides of the canal, and there appears to be a mixture of the faunas of this lowest bed and the next younger strata."

At Fenelon Falls, Ont., a very good section is exposed, showing at the base on the north side of the river below the locks 8 to 10 feet of thickly-bedded, compact, grey limestone followed by about 25 feet of thinly-bedded limestone characterized on weathered surfaces by a great abundance of black silicified Dalmanellas. Along the south shore of Cameron lake, about a mile west of the town, a few feet of similar beds are exposed in contact with the Pre-Cambrian crystalline rocks. The following fossils were collected from these two localities:—

"Fenelon Falls, Ont. Lowest beds in section below locks. W. A. Johnston and P. E. Raymond, collectors.

*Solenopora compacta* (Billings).
*Stromatocerium rugosum*, Hall.
*Receptaculites occidentalis*, Salter.
*Streptelasma profundum*, Owen.

*Orthis tricenaria*, Conrad.
*Dalmanella testudinaria* (Dalman).
*Rhynchotrema inæquivalve* (Castelnau).
*Rafinesquina alternata* (Emmons).
*Ctenodonta nasuta* (Hall).
*C. levata* (Hall).
*Subulites elongatus*, Conrad.
*Hormotoma gracilis* (Hall).
*Lophospira bicincta* (Hall).
*Isotelus gigas*, Dekay.
*Calymmena senaria*, Conrad."

"This fauna indicates that the beds from which they came are those immediately above the top of the Coboconk limestone. The species listed below were collected above the locks, near the contact of the limestone with the granite. They indicate the same horizon, and the inference is that the Coboconk is absent here.

*Receptaculites occidentalis*, Salter.
*Streptelasma profundum*, Owen.
*Rafinesquina alternata* (Emmons).
*Strophomena incurvata* (Shepard)."

2. Crinoid beds.—Along the Trent canal above the Kirkfield lift-lock the Dalmanella beds are overlain by about 30 feet of grey limestones generally somewhat thicker bedded, with black shaly partings containing great numbers of crinoids and cystids. The contact between the Dalmanella beds and the Crinoid beds is not well defined, and as most of the fossils from this locality have been collected from the dumps beside the canal it is difficult to say from what beds they come.

"Trent canal, 2 miles north of Kirkfield. W. A. Johnston and P. E. Raymond, collectors.

*Lingula canadensis*, Billings.
*L. philomela*, Billings.
*Glossina trentonensis*, Hall.
*Trematis ottawaensis*, Billings.
*Camarella volborthi*, Billings.
*Orthis tricenaria*, Conrad.
*Dalmanella testudinaria* (Dalman).
*Dinorthis pectinella* (Emmons).
*Platystrophia lynx* (Eichwald).
*Rhynchotrema inæquivalve* (Castelnau).
*Plectambonites sericeus* (Sowerby).
*Strophomena incurvata* (Shepard).
*Phragmolites compressus*, Conrad.
*Oxydiscus*, sp. ind.
*Subulites elongatus*, Conrad.
*Hormotoma gracilis* (Hall).
*Isotelus gigas*, Dekay.
*Isoteloides homalnotoides* (Walcott).
*Bumastus bellevillensis*, Raymond and Narraway.
*Pterygometopus callicephalus* (Hall)."

"Nearly all the collecting at this locality has been with the object of obtaining echinoderms, and the rest of the fauna is very imperfectly known. The echinoderms have been listed by Mr. Frank Springer in Memoir 15—P, of the Geological Survey.

The fauna is very similar to that found in strata at the same horizon in the Trenton in Hull, Quebec, and in the Curdsville limestone of Kentucky. The presence of *Bathyurus*, *Bumastus*, *Camarella volborthi*, *Orthis tricenaria*, and *Strophomena incurvata* in this fauna indicate a relation to the Black River.

At Fenelon Falls, Ont., in the section exposed on the north side of the river below the locks, the Dalmanella beds are overlain by about 30 feet of limestone closely resembling in physical character the crinoid beds along the Trent canal above the Kirkfield lift-lock. The top beds are exposed on the flat just in front of the Kawaitha House where they are followed by 3 feet of the Prasopera beds. The following fossils were collected from the crinoid beds at this locality:—

"Fenelon Falls, Ont. Just below the locks. P. E. Raymond, collector.

*Cupulocrinus jewetti* (Billings).
Unidentified crinoids.
*Crania*, sp. ind.
*Pholidops trentonensis*, Hall.
*Dalmanella testudinaria* (Dalman).
*Dinorthis needsi*, Winchell and Schuchert.
*Plectambonites sericeus* (Sowerby).
*Zygospira recurvirostris*, Hall.
*Strophomena incurvata* (Shepard).
*Subulites elongatus*, Conrad.
*Hormotoma bellicincta* (Hall).
*Isotelus gigas*, Dekay.
*Bumastus bellevillensis*, Raymond and Narraway.
*Ceraurus pleurexanthemus*, Green."

"This fauna indicates the same horizon as the previous one."

3. Prasopora beds.—At Fenelon Falls, Ont., the crinoid beds are followed by about 18 feet of thin shaly limestones characterized by an abundance of Prasopora. Along the Trent canal above the Kirkfield lift-lock and near the stone-crusher a few feet of similar strata are exposed at the top of the crinoid beds. In a cutting on the Grand Trunk railway, 2½ miles south of Brechin, Ont., about 8 feet of thinly-bedded limestone with clay partings is exposed. This outcrop is an isolated one, but, as calculated from the dips, the beds should be about from 25 to 35 feet above the base of the Prasopora beds. The following fossils were collected from these three localities:—

"Fenelon Falls, Ont. Thin, shaly strata above locks. P. E. Raymond, collector.

*Agelacrinites billingsi*, Chapman.
*Prasopora*, 2 or 3 species.
*Dalmanella testudinaria* (Dalman).
*Hebertella bellarugosa* (Conrad).
*Rhynchotrema inæquivalva* (Castelnau).
*Plectambonites sericeus* (Sowerby).
*Subulites elongatus*, Conrad.
*Ceraurus pleurexanthemus*, Green."

"Trent canal, 2 miles north of Kirkfield, Ont. Thin shaly layers near the stone-crusher. W. A. Johnston and P. E. Raymond, collectors.

*Prasopora*, several species.
*Dalmanella testudinaria* (Dalman).
*Platystrophia lynx* (Eichwald).
*Rhynchotrema inæquivalve* (Castelnau)."

"Cutting on Grand Trunk railway, 2½ miles south of Brechin, Ont. W. A. Johnston and P. E. Raymond, collectors.

*Licrophycus Ottawaensis*, Billings.
*Ischadites*, sp. ind
*Dendrocrinus acutidactylus*, Billings.
*Lichenocrinus crateriformis*, Hall.
*Agelacrinites billingsi*, Chapman.
*Prasopora*, several species.
*Dalmanella testudinaria* (Dalman).
*Plectorthis plicatella*, Hall.
*Dinorthis meedsi*, Winchell and Schuchert.
*Strophomena emaciata*, Winchell and Schuchert.
*Rafinesquina alternata* (Emmons).
*Rhynchoterma inæquivalve* (Castelnau).
*Pholidops trentonensis*, Hall.
*Plectambonites sericeus* (Sowerby).
*Fusispira augusta*, Ulrich and Scofield.
*Hormotoma bellicincta* (Hall).
*H. gracilis* (Hall).
*Lophospira medialis*, Ulrich and Scofield.
*Liospira americana* (Billings).
*Raphistomina*, sp. ind.
*Sinuites cancellatus* (Hall).
*Pterotheca*, sp. ind.
*Isotelus gigas*, Dekay.
*Pterygometopus callicephalus* (Hall).
*Calymmene senaria*, Conrad.
*Ceraurus pleurexanthemus*, Green."

"The fossils enumerated in the first two of these lists came from the very base of the shaly strata characterized by the abundance of *Prasopora*, with the exception of the specimens of *Agelacrinites billingsi* from Fenelon Falls. These specimens came from a layer about 15 feet above the base. The exposure on the railway south of Brechin is an isolated one, but the fauna indicates that the strata belong either to the *Prasopora* zone itself, or else low in the next zone. A very similar fauna is found at Ottawa at the same horizon, a little below the middle of the Trenton."

In the above table of formations the terms Kirkfield limestone group (Trenton) and Black River groups are provisionally adopted, and the dividing line between the two groups are put at the top of the Coboconk limestone on P. E. Raymond's recommendation. Mr. Raymond proposes to take up the question of the nomenclature of these formations in his report on the Ottawa-Cornwall map-area.

# PLEISTOCENE DEPOSITS OF SOUTHWESTERN ONTARIO.

(*F. B. Taylor.*)

## AREAS STUDIED.

Work was begun at St. Catharines on August 26 and closed at Windsor on November 14, 1911.

The work done this season was in four different areas: (1) In the eastern half of the Niagara peninsula; (2) in the region of the escarpment northward from Orangeville to Georgian bay and thence southwest to the vicinity of Clifford and Harriston; (3) between Milton and Toronto, and (4) around Leamington and Kingsville, in Essex county.

## NIAGARA PENINSULA.

The work done in previous years left the mapping of this peninsula incomplete. During the first half of the past season the writer was engaged in detailed work on the Niagara quadrangle in New York, where the topography and general character of the country is substantially the same as on the Canadian side. Certain features found in New York were traced to the bank of the river and their relations afforded strong ground for expecting their continuation westward on the Canadian side. Some of these features had not been observed before, and the three weeks given to this area during the past season were largely devoted to the search for them and to the study and mapping of those found. A little time was also taken for spirit-levelling with a Tesdorpf German pocket-level at four or five localities on the old beaches. At several places gaps in previous observations were filled in and the mapping made more complete.

### MORAINES.

*The Crystal Beach moraine* (the continuation in Canada of the Alden moraine of New York) was found on more detailed study to intersect the shore of Lake Erie at a point about a mile east of Crystal Beach. Thence westward it extends as a very distinct ridge, passing about three-fourths of a mile north of Crystal Beach, and having the main highway on or near its crest through Sherks station and to within about a mile of Gasline. Its front or southward relief is 10 to 15 feet through most of this distance, the back or northward relief being half as much or less. Near Gasline the moraine enters a region of thin drift over limestone and was followed with difficulty, being distinguished chiefly as a belt bearing more crystalline boulders than the average for the surrounding region. The bouldery belt crosses the Welland canal at Humberstone, but appears as a more definite till ridge about 3 miles northwest of Port Colborne, where it rests on the top of the low escarpment of the Onondaga limestone and continues in this relation along the south side of the Wainfleet marsh nearly to Lowbanks. There are no very good sections in Canada showing the composition of this ridge, but there are a number in New York and all show it to be composed of till, not of rock.

*The Fort Erie moraine* (the continuation in Canada of the Buffalo moraine in New York) is a strong, well-defined till ridge for 7 or 8 miles west of Fort Erie, but beyond that it is very faint in its continuation towards Welland. Its composition is well shown in several sections through it. On Niagara river the whole relief of the ridge above the surrounding plain is seen at Fort Erie and Fort Porter to be composed entirely of till. The rock at both of these places is somewhat below the general level of the plain. Sections on the Welland river and the Welland canal, about 2 miles north of Welland, show no rock in the broad, low ridge. Between Buffalo and Depew there are four or five deep railway cuts through the moraine, where its relief is strong and no rock is disclosed.

*The Lundy or Niagara Falls moraine* (the continuation in Canada of the Tonawanda moraine of New York) is strong and well defined for several miles west from Lundys Lane, but weakens toward Fonthill. It is also strong southeast to Chippawa, but is quite faint farther east and across Grand island. A few miles east of Tonawanda it becomes quite strong and continues so to the hills south of Alabama village, New York. The clayey composition of the ridge and the absence of rock is well shown where the Welland canal cuts through it a mile north of Port Robinson, at Chippawa, on both sides of Grand island and where it is breached by several small streams farther east. The best section, however, is at Niagara Falls, extending from Falls View to the bluff south of the Dufferin islands. In this interval the Niagara river has cut into the east side beyond the crest, leaving only a part of the front or western slope standing. This is the case at Falls View and the Loretto convent. The cut here goes nearly to bed-rock, far below the base of the moraine, exposing a section of drift over 100 feet deep.

*The Stamford or Vinemount moraine* (the continuation in Canada of the Lockport moraine of New York) is weak between Queenston Heights and the gravel hills north of Stamford, but from this point southwest and west nearly to De Cou falls it is a well-defined feature. After a gap of about 3 miles at the great break in the escarpment west of De Cou falls, the moraine resumes its strong expression about 2 miles north of Effingham and continues in this character to the vicinity of Hamilton. Until this season the Lockport-Stamford moraine had not been traced west of Lockport in New York nor east of Beamsville in Ontario. Heretofore it was supposed that the Lundy moraine found its westward continuation in the Stamford or Vinemount moraine on the escarpment south of Grimsby, but this is not the case. They are independent throughout, the Stamford following the Lundy as the next later one in the series.

The position and course of the Stamford moraine are quite remarkable. Most of its course is on the escarpment close to its edge, generally less than a mile back. This is the case from Lockport to Queenston and from Camden westward. The heavy beds of the Lockport limestone which form the escarpment dip gently to the south and at many places they rise to a slightly higher level at the escarpment than the general surface of the plain to the south. From this it was thought by some that the ridge standing a little back from the edge was merely a rock ridge veneered with till. But there are several deep cuts through the ridge in New York and also in Ontario that show only glacial till with no bed-rock. The prominent gravel hills north of Stamford lie in the line of this moraine and from this point west of De Cou falls. and then again from Effingham to Camden, the moraine leaves the escarpment and crosses the plain 2 or 3 miles south of it. East of Lockport this moraine leaves the escarpment entirely and runs far to the south of it. There is now no doubt as to its true character: it is a terminal moraine of the Ontario ice lobe, built when the ice barely overtopped the escarpment west of Lockport and rested its front just back of the edge. This, too, is a waterlaid moraine, but has an unusually sharp relief for such a feature.

These four moraines have one rather exceptional characteristic: they are substantially horizontal throughout their extent on this peninsula, and they continue so for some distance eastward into New York. In general, terminal or marginal moraines show a distinct decline in altitude from points on the sides of lobes to their apexes. In this case, however, the basin of Lake Ontario is so deep and so close to the escarpment and to the Erie plain, and it presents such a wide, nearly straight front to the south that the ordinary conditions of an ice lobe did not exist. During the time of these moraines the deep ice mass in the lake basin to the north stood only a little above the level of the escarpment and hence only a relatively thin sheet of ice moved out over the plain. Because the plain is flat and nearly level, the ice found nearly equal facility for forward movement all along the front, and from this circumstance made a series of nearly straight and horizontal moraines.

This fact has an important bearing on the glacial history of the peninsula, for in New York, a short distance east of the Niagara quadrangle, two moraines have been found which are later than the Lockport. The first is the Albion moraine, traced by Mr. Leverett from Rochester to Medina many years ago. This is a strong moraine and extends in good strength to Gasport, but from this place westward the ice front at this time appears to have rested either at the base or against the face of the escarpment. It was traced somewhat doubtfully as far as Lockport, but it has not been identified with certainty in Ontario.

The other was first traced this season and may be called the Carlton moraine. It was followed from Troutberg westward through Carlton, and in this interval and for some distance west of Carlton is a splendid example of the waterlaid form of moraine. But it grows weak toward the west and is represented in the Niagara quadrangle and in Ontario by only a few very faint and fragmentary features. In New York it lies 1 to 2 miles back from the Lake Ontario shore, but in the eastern half of the Niagara peninsula of Ontario the features that probably belong to it are 3 or 4 miles back. This moraine is below the Iroquois beach and is the first one to be found in that relation.

Both of these moraines are horizontal in the parts traced, and considering the horizontal attitude in this area of the four earlier moraines of this series, it is practically certain that these two are also horizontal in the parts where they are too faint for continuous tracing. A moraine is usually formed at the edge of the ice at a time of halting, but it is not to be inferred from this that where a moraine becomes too faint in some intervals to be traced, the ice-front did not halt in those intervals. It is more probable in such cases that other influences caused the moraine to be faint or to become obscured. It is believed, therefore, that a complete inventory of the moraines of the eastern half of the Niagara peninsula should include the four moraines observed and clearly traced, and also the two later moraines whose existence here is inferred mainly from observations in New York rather than from the few faint evidences seen within this district. This makes six moraines in all—six halts of the ice-front during the recession of the Ontario ice-lobe across the eastern half of the peninsula.

In the western part of the peninsula three distinct moraines lying south of the Stamford diverge southeastward from the vicinity of Ancaster and are traceable quite clearly into the eastern part of the township of Glanford. These seem to correspond perfectly with the southern three beaches in the eastern half. The Crystal Beach moraine has not been traced between Lowbanks and Glanford, and the same is true of the Fort Erie and Lundy beaches between Fonthill and Glanford. The topographic contour maps and also observations made at two or three points indicate that all these moraines in this interval lose their relief by broadening and flattening to such an extent that they cease to be visible to the eye as ridges, but are low, nearly flat but continuous clay divides that control the drainage. Some further field work is needed in these intervals. In Haldimand county, in the southwestern part of the peninsula, one or two earlier moraines may possibly be found lying south of the Crystal Beach moraine, but that area has not yet been fully studied.

BEACHES.

Points on the Lundy beach were measured by spirit level near Stamford. Lundys Lane, Fort Erie, Port Colborne, and Lowbanks, and on the Fort Erie beach at the last three places named. Only a little new mapping was done on these beaches. The details of the Iroquois beach were studied between Queenston and Beamsville. A submerged and modified beach found north of Lockport, New York, 32 feet below the Iroquois, has not yet been identified in Ontario.

DRUMLINS.

Two rather small, low, but well-formed drumlins were found about 3 miles south of Chippawa and several other fainter, less perfect ones a little farther south near Black creek. Their axes all run northeast to southwest in harmony with others east of the Niagara river.

THE ESCARPMENT AREA.

Earlier mapping had been carried northward from Lake Erie and along the escarpment to the vicinity of Orangeville, where the work was resumed on September 15. The studies this year were carried northward along the escarpment to the brow of "the mountain" 5 or 6 miles west of Collingwood and thence westward, first in a broader belt to the vicinity of Markdale and Durham and then southwestward in a narrower belt to the vicinity of Harriston and Clifford in northwestern Wellington county.

In this belt parts of three moraines were traced and a small fragment of a fourth was found. The associated lines of glacial drainage, as well as other features, and the general characters and qualities of the drift were also studied. The most remarkable moraines and drainage lines were found in the townships of Mono and Mulmur in Dufferin county, and these townships, so far as examined, were studied in rather more detail than the rest of the belt.

MORAINES ON THE EAST SIDE OF THE HIGHLANDS.

Three strong moraines were traced across Mono and part way into Mulmur township. The earliest or western one lies generally on or a little back (west) of the escarpment; the second lies 2 or 3 miles farther east and down the slope, while the third lies about 2 miles east of the second and along the lower part of the slope. They run like steps along the slope, the second one being 150 to 200 feet below the first and the third the same distance below the second. The first one is the northward continuation of the Paris moraine, traced in the region south from Orangeville in 1899, and the second one is the northward continuation of the Galt moraine. The southward continuation or correlative of the third moraine has not yet been determined with certainty.

At the north end of the highland three strong and well developed moraines turn sharp angles north-northwestward to the southwestward courses on the mountain west and southwest of Collingwood. The Paris moraine was traced continuously from Orangeville to its angle 3 miles west of Singhampton. The Galt moraine was traced continuously to the north side of Mulmur township, but from this point to Rob Roy it was seen only from the hill above. From Rob Roy to its very acute angle east and northeast of Gibraltar it was examined more closely. The third moraine was not traced between the south part of Mulmur township and the mountain west of Collingwood, but its turning point is 1½ miles east of Banks. The turning points of these three moraines were carefully mapped, for they mark the extreme re-entrant of the ice-front at three successive stages of retreat, and show where the great ice mass in the basin of Lake Huron united with the mass in the Lake Simcoe basin. This angle is quite acute, especially in the second and third moraines.

### GLACIAL DRAINAGE ON THE EAST SIDE.

The ice-border drainage channels and gravel terrace deposits associated with the moraines south of the angles, especially with the first and second, are truly remarkable. Their branchings and positions at successively lower levels are quite complex, but they connect perfectly with those previously mapped south of Orangeville. Some of the fluvial gravel terraces are up to or above the general crest of the second moraine, where the ice-front stood when they were being made. Chalmers, Spencer, Hunter, and other early students of this region mistook some of these terraces for old marine or lake shores. In some places their exposed position suggests this origin, but close examination shows no wave-made features. Instead of these, there is a complete set of fluvial forms due to large rivers flowing southward along the front of the ice-mass, and alternating between erosional and depositional phases of action. All the features seen are fully explained by this agency. Some of the fluvial gravel terraces in Mono and Mulmur townships are very strong, bulky features. If it were permissible to attribute them to wave-action it is evident that only prolonged and very powerful waves could have done such a work, and if this were the case strong evidence of wave-action ought to be found on adjacent parts of the escarpment front at or near the same levels. But instead of this, the gravels pass down stream (southward) into large eroded channels in protected positions behind morainic ridges and knolls. These same ridges and knolls of easily eroded boulder clay stand in the same exposed position as the gravel terraces, and yet show no sign whatever of wave-action. The whole set of phenomena are clearly products of large temporary rivers flowing along the edge of the ice-mass and are not shore-line forms.

At one place, about 2 miles west of Elder, there is a "fossil cataract" of no mean size. It is about 70 feet high and the gorge below it is well defined and a fourth of a mile long. It recalls the larger features of the same kind associated with the great river channels on the hills south of Syracuse, New York.

### MORAINES ON THE WEST SIDE OF THE HIGHLANDS.

From their turning points on the mountain the three moraines take courses converging slightly toward the southwest. They keep these courses to the axis of the Beaver River valley at Eugenia and Flesherton. This deep and beautiful valley, opening into the highland from the north, produced a moderate lobation of the ice-front at the time of the first or Paris moraine, a sharper lobe at the time of the second or Galt moraine, and a still more pointed one at the time of the third moraine. Moraine fragments near the valley bottom at Kimberly appear to belong to a fourth moraine and mark the terminus of a narrow ice-tongue. A few miles west of this valley a well-defined secondary re-entrant marks the union of this smaller lobe with the main ice-lobe of the Lake Huron basin. The second and third moraines were not traced beyond this re-entrant this season, but the first or Paris moraine was traced from the angle northeast of Irish lake directly southwest past Bunessan and Holstein to the south fork of the Saugeen river at Glen Eden and thence westward to the vicinity of Clifford. Beyond this it appears to turn southwest and probably, though not yet certainly, finds continuation in a moraine which was previously traced from the south up to Seaforth.

### GLACIAL DRAINAGE ON THE WEST SIDE.

The border-drainage features associated with the ice-front at the time of these three moraines are very pronounced west of the main re-entrant as well as east of it.

The Beaver Valley ice-lobe was, of course, caused by the marked depression of this valley. At the time of the first moraine this valley was filled to its southern extremity by the ice. No lake or depression of any size remained south of the lobe-front. On this account the large river which flowed southwest along the front of the ice from the direction of Singhampton deposited only a moderate amount of gravel in passiug the front of the Beaver Valley lobe south of Ceylon. But at the time of the second and third moraines there was a distinct basin in front of the lobe and it was filled with a remarkable deposit of gravels. These lie chiefly between Flesherton and Eugenia, spreading both to the east and west from the axis of the valley. These gravels are the "Artemesia gravels" of the early investigators of this region. They were deposited during the time of the second and perhaps partly of the third moraines by large, rapidly-flowing rivers which came from the northeast from the vicinities of Rob Roy, Gibraltar, and Banks. Their eroded beds are well defined and easily followed. The small lake was entirely filled and obliterated by the gravels. Near the valley axis the deposit appeared to be quite deep, and it is finer and more sandy on the west side. In the re-entrant west of Flesherton and southwestward from Irish lake the eroded glacial river channels are well developed, but are gradually replaced toward the southwest by gravel deposits, which are quite extensive in front of the broad ice-lobe which had its apex near Glen Eden. Farther west eroded channels again take the place of gravel deposition. There are also great gravel terraces at Durham and east and south of this place.

## The Highland Plain: Drumlins and Eskers.

The Highland plain enclosed on the east, north, and west sides, between Orangeville and Glen Eden, by the first or Paris moraine, was not fully explored, but was found to be a gently-rolling plain, carrying many drumlins, mostly small and more or less imperfect in form. The ground between the drumlins is mostly swampy. Several remarkably long and well-developed eskers or hogback ridges also occur in this region. They run in more or less winding, serpentine courses from northwest to southeast, and the parts observed extend across the plain outside of the Paris moraine. One extends southeast from Glen Eden to Riverstown, but was not traced farther; another extends east from Glen Eden, passing 2 miles north of Mount Forest, and thence southeast to the central part of West Luther township, beyond which it has not yet been traced. This one is very large. Another appears first in broken form at Priceville and 2 miles west of Ceylon, but about 4 miles south of Ceylon becomes a single ridge and was traced southeast to Brice hill in central Proton township. It is said to extend several miles farther. A fragment of another was observed near Shrigley, in the northern part of Melancthon township, with the same course, northwest to southeast.

These ridges are composed of sand and gravel—usually horizontally bedded fine sand in the lower parts, with a thick capping of coarse gravel and pebbles on top. The top is usually narrow and the sides as steep as the material will stand. The ridges are usually more or less broken and discontinuous and sometimes show double or multiple ridges. Irregularities of form are thoroughly characteristic of them. They sometimes expand into a knot or cluster of kames, or they terminate in such a cluster or in a delta fan. Knots most frequently occur where the eskers intersect moraines. The esker that passes a little north of Mount Forest is the longest one so far found in this region.

The eskers mentioned appear to mark the course of rivers flowing from northwest to southeast through a thin and nearly stagnant ice-mass which covered the central highland at that stage of retreat which immediately preceded the uncovering of the central nunatak or island-in-ice described in the writer's summary report for 1908.

The drumlins on the west side of the highland between Markdale and Durham are larger and higher than those of the central plain, and their axes trend from northwest to southeast.

### Area between Milton and Toronto.

A few days near the close of the season were spent in studying the features around Milton and between there and Toronto. These included two waterlaid moraines of moderate strength, with a possible third fainter one. From a point about 3 miles west of Milton a well-defined moraine was traced northward, passing just east of Stewartown and west of Norval. It seems probable that this moraine extends on northeast so as to connect with the Oak Ridges moraine near Bond lake.

Another somewhat fainter moraine was found at Ash, 6 or 7 miles southeast of Milton. It takes a course a little east of north to the valley of Credit river, just south of Meadowvale. Here it turns sharply to the east for about 4 miles and then as sharply to the north again, crossing the Etobicoke west of Elmbank. It is distinct and fairly strong to this point, but was not traced farther.

Another moraine of this series, observed in 1899, runs north just east of Cheltenham and turns gradually to the northeast. These three moraines belong to a system made by ice moving westward and northwestward out of the basin of Lake Ontario.

### Area near Leamington and Kingsville.

The last few days were spent in studying the region around Leamington, especially between Leamington and Kingsville and northwest of Leamington. The only land in Essex county that rises above an altitude of 640 feet above sea-level is a broad low hill lying west and northwest of Leamington. This hill is composed in part of stony till or boulder clay and largely also of gravel. Its summit rises to an altitude of about 740 feet above the sea. At this level it is crowned by a heavy beach ridge or bar of gravel—the Belmore or Whittlesey beach, being here in the area of horizontality and having the same altitude as in adjacent parts in Michigan and Ohio. Below this beach, at successively lower levels, are the Arkona, Forest, or Warren, Grassmere, and Elkton beaches, and all, excepting the last, forming contours around this hill. The Grassmere beach forms a contour at a distance of 2 to 3 miles from the top of the hill, but also sends out bars to the northeast and northwest, in each case extending along the crest of a broad, low drift ridge which is probably a waterlaid moraine. One of these, an irregular, sandy belt, was observed for 2 or 3 miles northeast from Wigle, and the other, a much better formed gravel ridge, runs northwest through Cottam to Essex.

The hill appears to have been morainic, for the till is quite bouldery, which is an unusual quality for this region. The western side of the hill was heavily cut by wave-action and presents a well-defined bluff or sea cliff at the back of the Arkona beach. The top of the hill appears to have been cut away at the Whittlesey stage, and spits were then formed running southeast and northeast from the south and north ends respectively, while a depression along the east side was filled in by a deep deposit of gravel at the higher stages. The original shape of the hill was evidently greatly changed by wave-action, as the lake waters fell through their successive stages.

A bouldery belt with occasional low knolls runs west from this hill past Kingsville and Harrow towards Amherstburg. This is probably a water-laid moraine. A broad, low clay ridge also runs northwest to Windsor and is probably the southeastward continuation of the Detroit interlobate moraine. The original morainic hill, lying mainly north of Ruthven, was probably somewhat of the nature of a water-laid interlobate deposit. But the related moraines are not yet fully made out.

# THE DEVONIAN OF SOUTHWESTERN ONTARIO.

(*Clinton R. Stauffer.*)

## General Statement.

Work on the Devonian of southwestern Ontario, which was definitely undertaken in 1910, has been continued in more detail during the season just past (1911). A considerable portion of the time was spent in collecting palæontological material and in making a careful stratigraphic study of the more important outcrops. Many of the corals contained in the Devonian formations are large and are firmly embedded in the rock; hence it is impossible to form collections of good material from every locality where they occur. To make the identifications more certain, reference books on these organisms were carried into the field and determinations made on the spot. This method was supplemented by making collections of more fragmentary specimens which have been shipped to the Geological Laboratory of the School of Mining, Kingston, and will form the subject of a considerable portion of next summer's investigation.

## Formational Divisions.

### classification.

The classification adopted by Logan,[1] and taken over by him from the New York State reports, is now pretty generally known by the inhabitants of the regions in which these formations outcrop and is firmly rooted in the geological literature of both the Dominion and Provincial surveys. It seems, therefore, that no radical changes should be made in the usage of these terms unless an increase in knowledge of the deposits should demand it. Logan's wisdom in adopting the classification becomes more and more apparent with increased study of the Canadian deposits. It is quite true, however, as pointed out by him, that the Ontario divisions are not the exact equivalents of those bearing the same names in New York state, though the differences are chiefly those incident to distance rather than to the occurrence of marked unconformities. The aid of the drill has brought to light a very considerable amount of knowledge which was not available in 1863. Hence it is not a matter of surprise to find that the once supposed differences are growing constantly smaller, and, therefore, it has become necessary to introduce into the old classification the names of formations not then known to exist in Canada. On the basis of present knowledge the classification of the Devonian, in the region here under discussion, stands as follows:—

| | | |
|---|---|---|
| Devonian | Upper | Portage and Chemung beds.<br>Genesee shale. |
| | Middle | Hamilton beds.<br>Marcellus shale.<br>Onondaga limestone.<br>Oriskany sandstone. |
| | Lower | Wanting (possibly represented, in part, by the upper Monroe). |

[1] Geology of Canada, 1863, p. 20.

## Beds of Doubtful Age.

Owing to the interest which has recently been kindled in the deposits immediately underlying the Onondaga limestone of extreme southwestern Ontario and adjacent territory, it becomes necessary to discuss these, to some extent, at this point. The Onondaga limestone is commonly the lowest recognized Devonian formation in Ontario, although considerable remnants of the Oriskany sandstone are frequent in Welland and Haldimand counties. Throughout the remainder of the Devonian-covered area of Ontario and portions of adjacent states, small quantities of sand are common at the base of the Onondaga limestone. This basal Onondaga shows further signs of the Devonian transgression in that it is frequently a distinct conglomerate. At Buffalo, where the merest trace occurs, this arenaceous material has long since been referred to the Oriskany sandstone. This is probably the true horizon, since, when traced westward, it passes into definite deposits of sandstone carrying the typical Oriskany fauna. Farther to the westward the Buffalo condition seems to be restored and to be maintained throughout the remainder of Ontario and continued into Michigan and Ohio.

Near Fort Erie the Devonian deposits rest on the eroded surface of the Cobleskill limestone. As this contact is followed westward the underlying beds vary in age from slightly younger to slightly older until, finally, the beds of this horizon disappear entirely at a point about midway between Springvale and Boston. At Beachville, near Woodstock, where this contact next appears, a remarkable transformation, in lithology at least, has taken place in the underlying strata. Instead of the argillaceous and dolomitic limestones, a very pure limestone occurs and in it is found a fauna of corals, brachiopods, pelecypods, and gastropods seemingly unlike anything found farther to the east. This is the fauna of the "Anderdon beds"[1] of the Detroit River region, and is common at various places to the northward. This association of species is markedly Devonian in many of the aspects. There are often present numerous corals belonging to the same genera as those which occur in the Onondaga limestone, while the brachiopods and even the Mollusca are remarkably similar to forms belonging in that same Devonian formation. In the quarries near Amherstburg the "Anderdon beds" are especially fossiliferous, while overlying them unconformably, and with traces of the Oriskany (?) band, are the massive layers of limestone typical of the basal Onondaga of the Michigan and Ohio basins. Also, at the Stony Island "Dry Cut" in the Detroit river there is another association of very similar species occurring somewhat more than 100 feet below the highest rocks there exposed and—since the Sylvania sandstone probably overlies all of these—as much as 400 feet below the unconformity at the base of the Onondaga limestone. A study of these lower faunas shows that they are not Onondaga and resemble much less the Oriskany. Indeed they lie below the probable Oriskany horizon, while the top beds of the "Anderdon" show the effects of the erosion which marks the lower Devonian interval over much of Ontario. A comparison of these faunas with the Helderbergian of New York shows that there is little in common between them—less, indeed, than they have in common with the Onondaga. It seems safe, therefore, to conclude that these lower faunas are not Helderbergian, as that series is at present known. But that they contain certain elements ancestral to portions of the Onondaga fauna, is quite certain. Perhaps they represent faunas contemporaneous with the Helderbergian,[2] which lived in an interior sea wholly separate from that to the east. Such a sea might have had an outlet to the northward along the same route by which certain elements of the Onondaga fauna later found entrance to the Ontario and Michigan regions. But it should also be kept in mind that there are certain Devonian characters detectable in the Cobleskill fauna and even in earlier formations. The

[1] Mich. Geol. and Biol. Surv. Pub. 2, Geol. Ser. 1, 1910, pp. 42-47.
[2] See Ulrich, E. O., Bull. Geol. Soc. Am. Vol. xxii, 1910, p. 28.

occurrence of some of the same brachiopods among the corals of the "Anderdon beds" at Amherstburg, Beachville, Kincardine, etc., as those which occur among probable Cobleskill corals in the upper Monroe at Sandusky, Ohio, leads one to suspect that this fauna belongs properly in the Silurian, as at present constituted, and where Grabau and Sherzer have placed it.[1] Such, in the present study of the Devonian of Ontario, is the provisional disposition made of these fossiliferous deposits, lying below the Oriskany (?) horizon.

## Definitions of Devonian Formational Units.

### *Oriskany Sandstone.*

The Oriskany sandstone is the lowest true Devonian formation in Ontario. It consists of heavily bedded, coarse-grained, white to yellowish sandstones lying unconformably on the Silurian. In places absent, in others it varies in thickness from paper-thin to 25 feet and carries the pure Oriskany fauna unmingled with later forms. Evidences of this formation exist from Fort Erie westward nearly to Hagersville, but the arenaceous deposits and scattered bodies of infiltrated sand found beyond that point cannot be definitely assigned to the same formation.

### *Onondaga Limestone.*

This is the "Corniferous" limestone of the older reports. The name "Corniferous" refers to the cherty (flinty) character of the rock and was applied, in New York state, to deposits which later proved to be a portion of the same formation that had previously been called Onondaga limestone. It seems better, therefore, to adopt the correct term in this work, and especially since it is more appropriate to the Canadian deposits. The Onondaga limestone is probably the most variable of all the Devonian deposits of the Province. The basal portion, which rests unconformably on either the Oriskany sandstone or beds of greater age, is often conglomeratic. This conglomerate is made up of pebbles derived from the underlying limestone, and mingled with them are sometimes considerable quantities of sand. This latter may have been derived from the destruction of areas of Oriskany sandstone during the advance of the Onondaga sea. In the vicinity of Springvale this sand becomes so abundant as to locally form a deposit resembling the true Oriskany sandstone, but is much younger in age as evidenced by its Onondaga fauna. In the eastern and extreme northern outcrops the lower 30 feet or more of the Onondaga is a thin, unevenly bedded, cherty, grey limestone carrying a fauna composed largely of brachiopods. Overlying this is 15 feet, more or less, of a relatively pure, thick-bedded, crystalline, grey limestone with partings of greenish shale and full of corals. This, in turn, is overlain by somewhat more than 10 feet of very cherty, dark bluish-black limestone with numerous corals, and passing upward into about 30 feet of very cherty, thinly bedded, grey limestone poor in fossils of any kind. The outcrops of Welland county are not so connected that the entire thickness of the formation can be obtained, but the indications are that it is about 100 feet. To the westward the central purer portion of the formation increases in thickness, at the expense of both the lower and upper cherty parts, and thus passes into the typical Onondaga of Michigan and Ohio. At some of the northern outcrops of this formation, especially in Bruce county, the rock is a most astonishing mass of corals and hydrozoans unlike anything else in the Province.

### *Marcellus Shale.*

In western Norfolk and eastern Elgin counties well records show from 10 to 30 feet of a black bituminous shale immediately overlying the Onondaga limestone.

[1] Mich. Geol. and Biol. Surv. Pub. 2, Geol. Ser. 1, 1910, pp. 217-223.

This shale is covered by from 200 to 280 feet of glacial drift, so that it cannot be definitely determined at the present time. However, its position in the geological scale strongly suggests its Marcellus age. And then in the high banks of drift at Port Stanley are good sized pieces of well-preserved black shale carrying the Marcellus fauna. If these blocks of shale were derived from the bed-rock to the northeast, as is almost certain, there can be no further question as to the age of the deposit of black shale there reached by the drill.

### *Hamilton Beds.*

The Hamilton beds are made up of grey limestones and soft, blue shales. There are commonly three persistent limestones—a lower, middle, and upper—recognized in well sections, and it is the lower limestone that comes in direct contact with the Onondaga as the Marcellus shale pinches out to the westward. This lower limestone, as its fauna shows, is the northward extension of the Delaware limestone of Ohio, and hence may represent, in part, the Marcellus shale lying farther to the east. The total thickness of the Hamilton beds ranges about 300 feet, although greater thicknesses are sometimes encountered.

### *Genesee Shale.*

This formation consists of a bituminous, fissile, black shale similar to that of the same formation to the south and east. As an evidence of the life which existed during the time of its deposition and of the conditions under which deposition took place, this shale contains carbonized plant stems and leaves, an abundance of the spore cases of certain plants, a Lingula, and the occasional bones of large fishes. The Genesee shale lies immediately on top of the upper limestone of the Hamilton beds, and forms a very good outcrop at Kettle point, where the most striking feature is the large spherical concretions projecting from the shale. The thickness of these shales is not definitely known, but some well records indicate as much as 185 feet.

### *Portage and Chemung Beds.*

In a few of the well records, especially in Moore township, 20 to 50 feet of greenish shales and sandstones make their appearance on top of the black shales of the Genesee, and sometimes even interstratified with the upper layers of that formation. These cannot be definitely separated into two formations, nor have they been directly observed, but they probably belong to the horizon of the New York Portage and Chemung beds.

## New Industries Connected with the Devonian Formations.

The economic importance of the Devonian has been indicated in a previous summary report.[1] However, the use of these formations, in a commercial way, is constantly increasing. New quarries, to obtain the limestone for crushing purposes, have been opened at one place and a large new cement mill has been recently installed at another. Moreover, the sandstone belonging to the Oriskany is again receiving attention. A large, well-built mill has been located on the site of the DeCew quarry, where this rock will be crushed for glass and sand-blast sand. This new industry promises to be an important one.

[1] Summary Report of the Geological Survey for the year 1910 (1911), p. 195.

# KEWAGAMA LAKE MAP-AREA, PONTIAC AND ABITIBI, QUEBEC.

(*Morley E. Wilson.*)

## INTRODUCTORY

The past season was spent by the writer in continuation of the geological investigations commenced the previous year in the vicinity of Lake Abitibi, Pontiac county, Quebec. During the summer of 1910 an area to the south of Lake Abitibi and adjacent to the Interprovincial Boundary was examined and mapped. During the summer of 1911 this work was continued to the eastward as far as the Kinojevis and Nawapitechin rivers. The region thus investigated, in conjunction with the area to the south of the Kinojevis river, examined by Dr. J. A. Bancroft for the Quebec Department of Mines, will permit of the publication of a geological map extending from the Interprovincial Boundary to Kewagama lake and from the National Transcontinental railway to the Rainboth-Blouin base-line, or expressed in geographical terms from longitude 79° 30′ 56″ to longitude 78° 15′, and latitude 48° 50′ to latitude 48° 8′ 22″.

During the past season the writer was assisted in the field by Messrs. E. M. Burwash, L. E. Dagenais, J. S. Stewart, and C. P. Sills, all of whom rendered efficient service in carrying on the work.

## PREVIOUS WORK.

During the summer of 1901, Mr. J. F. E. Johnston made a geological reconnaissance along some of the waterways of the region which he described in the Summary Report of the Survey for that year. The district was again visited in 1906 by Mr. W. J. Wilson in the course of a preliminary examination of the country along the National Transcontinental railway. Mr. Wilson's observations were published in brief in the Summary Report for 1906 and again in greater detail in Memoir No. 4, "A Geological Reconnaissance along the line of the National Transcontinental railway in western Quebec."

## GENERAL CHARACTER OF THE DISTRICT.

### TOPOGRAPHY.

Physiographically this region belongs to the great Pre-Cambrian plateau province which occupies nearly the whole of the northern part of the Province of Quebec. It has a general elevation ranging from 900 to 1,100 feet above sea-level, with hills and ridges rising here and there to heights of 500 to 700 feet above the surrounding country. As was pointed out in the Summary Report for 1910, these elevated districts constitute what may be described as a rocky hill country in contrast with the clay flats which surround them. They present all the typical topographic features characteristic of rock surfaces which have suffered continental glaciation. The clay belt on the other hand possesses a uniformly flat surface underlain by stratified clay, and might be described in physiographic terms as a structural plain in the incipient stages of dissection.

Lakes are generally very numerous throughout the Pre-Cambrian region of northern Ontario and Quebec, and this district is no exception. They occur chiefly, however, in the rocky hill country. As a rule the lakes are not very large, although two of them, Lake Makamik and Lake of Islands, have areas of 18 and 14 square miles, respectively. Lake Lois, one of the most picturesque lakes in the region, is 12 miles long but is very narrow, its maximum width being less than 2 miles. There are three other lakes of the long, narrow type which are over 5 miles in length. These are Lakes Kajakanikamak, Kekeko, and Kinojevis.

The drainage of the region is about equally divided between the St. Lawrence and the James Bay basins, so that the height of land passes almost through the centre of the area examined, but with a much more sinuous course than is shown on existing maps. The streams on the south side of the St. Lawrence-Hudson Bay divide find their way into the Kinojevis river and thence to the upper Ottawa. The drainage on the James Bay slope, with the exception of a few headwater streams flowing into the Harricanaw river, is entirely into Lake Abitibi by way of the Whitefish (Amikatik) river and its tributaries.

## MEANS OF ACCESS.

The canoe routes along the upper Ottawa and its tributaries formerly afforded the sole means of access to this region, but the northern part of the district is now more easily accessible by railway from Cochrane, Ont., the junction point of the Timiskaming and Northern Ontario with the National Transcontinental railways. For the southern portion of the region the waterways from Lac des Quinze are yet the best means of communication. There are two roads leading from Lake Timiskaming which may be followed in starting out on these routes, one which leads from Ville Marie to Gillies' farms at the south end of Lac des Quinze, and the other from North Timiskaming to Klock's farm, 15 miles farther north on the same lake. The Kinojevis river may be reached from Lac des Quinze either through Lake Expanse and the upper Ottawa, through Rogers and Crooked lakes or through Barriere, Albee, and Kekeko lakes. The first route requires less portaging, but is more circuitous than the other two.

## GENERAL GEOLOGY.

With the exception of unconsolidated glacial and post-glacial deposits, the rocks of the region are entirely of Pre-Cambrian age, and for the most part belong to the most ancient subdivision of the Pre-Cambrian. In a structural way these Pre-Cambrian rocks divide themselves into two principal classes, to the first of which belongs a basal complex of sedimentary and igneous rocks which has been more or less highly metamorphosed and deformed. The rocks of the second class on the other hand are entirely of sedimentary origin, have been but little deformed, and except for cementation have not been metamorphosed.

In the southern part of the region the prevailing basal rock is a fine-grained mica schist with which is associated some hornblende schist and amphibolite. This group of rocks was formerly[1] called the Pontiac schist, but will now be designated the Pontiac group. In the northern part of the region the rocks of the older complex consist largely of basic and acid volcanics which for purpose of description shall be called the Abitibi group. Both the Pontiac group and the Abitibi group are intruded by batholithic masses of granite and gneiss constituting a third and younger subdivision of the older complex.

The second class of Pre-Cambrian rocks—the Cobalt series—consists of a succession of clastic sediments, conglomerates, greywackes, arkoses, and quartzites with inter-

[1] Summary Report of Geol. Survey 1909, p. 175.
"Geology and Economic Resources of the Larder Lake District, Ont., and adjoining portions of Pontiac county, Que., Memoir 17.

mediate variations which rest in striking structural and erosional unconformity on the denuded and almost baselevelled surface of the older complex. Erosion since Pre-Cambrian times, however, has stripped the greater part of the series from the surface of the ancient peneplane (paleoplane) upon which it was deposited so that it now occurs as small outcrops or as hills and ridges scattered here and there throughout the region.

The rocks thus far described are overlain by a thin mantle of glacial material—gravel, sand, boulders, and boulder clay—deposited from the last Pleistocene ice-sheet. These deposits are in turn overlain by stratified clay laid down from a huge lake which occupied the greater part of this region in post glacial times.

TABLE OF FORMATIONS.

| | |
|---|---|
| Pleistocene and Recent. | |
| Post Glacial | Stratified clay and sand. |
| Glacial | Gravel sand and boulder clay. |
| Nipissing diabase (Keweenawan ?). | |
| Igneous contact. | |
| Cobalt series (Huronian). | |
| Granite and gneiss (Laurentian ?). | |
| Igneous contact. | |
| Pontiac group (Huronian ?). | |
| Abitibi group * (Keewatin ?). | |

* Probably composed of more than one series.

It will be observed that in the above table of formations the various series of rocks have been given local names and that with the exception of the Cobalt series they have not been assigned definitely to any of the major subdivisions of the Pre-Cambrian as defined in the Report of the International Geological Committee for the Lake Superior region. This plan was adopted because there was some doubt as to the place occupied by the different series in the general classification.

The fine grained mica schists of the Pontiac group which are probably metamorphosed quartzose sediments are very similar to rocks which elsewhere in the St. Lawrence basin have been called Huronian, and may represent another Huronian series older than the Cobalt series. But, if the Pontiac group be Huronian then the granite and gneiss which intrudes the Pontiac group are also Huronian in age and can no longer be classed as Laurentian. Furthermore, evidence is accumulating[1] which indicates that a Huronian series older than the Cobalt series is present in the region and that the volcanic rocks now called Keewatin may possibly belong in part to this older series. For these reasons it has been thought advisable to substitute local terminology for the general nomenclature and thus avoid unnecessary assumptions and doubtful correlations.

### *Pontiac Group.*

A series of fine grained mica schists occur at the north end of Lake Opasatika which has been previously described in reports on that district. During the past season these rocks were again encountered in the country farther to the east, and are now known to extend continuously in an east-west belt from 10 to 15 miles wide for a distance of at least 50 miles. They are delimited on the south by intrusive granite and gneiss and on the north pass with an apparent transition into sheared arkose and conglomerate. These rocks are in turn followed by the volcanics of the Abitibi group.

[1] Engineering and Mining Journal, Vol. xcii, pp. 645-649. Geology of a portion of Fabre township, Pontiac county, Dept. of Colonization, Mines, and Fisheries, Quebec

Throughout the belt just outlined the Pontiac group is composed almost entirely of a fine grained biotite schist, but in the region examined during the past summer some hornblende schist and amphibolite are also present. These amphibole rocks are exceedingly variable both in texture and composition which gives rise to a most peculiar irregular appearance on the weathered surface. Both the hornblende and biotite schist have a strike trending approximately in an east-west direction, and in general dip steeply to the north away from the intrusive granite and gneiss.

**Sheared Conglomerate and Arkose.**—If the Pontiac group be studied in transverse section, it may be observed that on passing northward away from the intrusive granite and gneiss the mica schist becomes more massive and that finally outcrops of sheared arkose and conglomerate containing pebbles of granite and rhyolite are reached. This arkose and conglomerate occurs continuously in an east-west belt north of Kinojevis and Kekeko lakes, and was also observed on Kiekkiek lake in the area examined by Bancroft, so that it probably extends along the whole northern border of the Pontiac series. It would, therefore, seem probable that the mica schist, the arkose, and the conglomerate, are in comformable succession, and that the mica schist is simply the metamorphic product resulting from the contact action of the granite and gneiss on the arkose. However, in a region where the rocks have suffered intense metamorphism and are not very well exposed, an unconformity might be present which was not observed, or if observed, was not recognized because obscured by deformation: for this reason alternative possibilities should also be considered.

If it be assumed that the sheared conglomerate and arkose rests unconformably on the Pontiac schist, then these rocks (the conglomerate and arkose) must be either a locally deformed phase of the Cobalt series or a Huronian series older than the Cobalt series infolded with the Pontiac schist. In opposition to the first alternative it may be pointed out that the undisturbed Huronian belonging to the Cobalt series occurs in the Kekeko hills, at a distance of less than 2 miles from this highly sheared and steeply inclined conglomerate and arkose, and that it is improbable that such a change would take place so abruptly. Moreover, if an unconformity exists between the sheared conglomerate and the mica schist, the conglomerate would probably contain fragments of the schist, but no such pebbles or boulders were observed.

It is concluded, therefore, that while the evidence with regard to the stratigraphical position of the sheared conglomerate and arkose is insufficient for a final conclusion, yet such evidence as has been obtained preponderates in favour of their conformable relationship to the Pontiac schist and for this reason they have been placed provisionally in the Pontiac group.

### *Abitibi Group (Keewatin?).*

Throughout the northern part of the region the predominating rocks are volcanic lavas ranging in composition from basalts to rhyolites. The acid and intermediate types are, however, most abundant. Unlike the Keewatin (?) greenstones which occur farther to the south, these rocks are commonly grey or greenish-grey in colour and might be more appropriately described as greystones. There are associated with these volcanics some ferruginous dolomite and dolomitic sericite schist which are also included in the Abitibi group.

In a region where the rocks, on the whole, are not very well exposed, it is not always possible to ascertain the stratigraphical and structural relationship of the lava flows of the Abitibi group, but in places their attitude and trend can be recognized partly from their change in texture from centre to margin and partly from the occurrence of the spheroidal and amygdaloidal structures at their surface. When the spheroidal structure was present the spheroidal masses of lava were observed in place to be flattened on one side, giving rise to what the writer described in the field as a "bun" structure. This flattening was, probably, caused by the flowage of the spheroids of lava under their own weight. The flattening would, therefore, occur on the under side of the spheroid, and affords a criterion for distinguishing the top and bottom of the lava flows. The volcanics of the Abitibi group have been generally folded into vertical or nearly vertical position, the strike varying from northwest and southeast to east and west.

**Relationship to the Pontiac Group.**—Since the Abitibi group and the Pontiac group are areally separate from one another, their relationship can only be inferred from their general distribution or by comparison with other regions. If the Pontiac group be Huronian, older than the Cobalt series, and the Abitibi group be Keewatin—as has been generally assumed—then the Abitibi group would be older than the Pontiac group. On the other hand, the distribution of the Pontiac group in a narrow belt intervening for a distance of 50 miles between the Abitibi group and the batholithic granite and gneiss suggests that the occurrence of the schist in this relationship is not a mere coincidence, but that the Pontiac group is stratigraphically below the Abitibi volcanics and has been tilted up into its present attitude by the intrusion of the granite batholiths. This evidence, however, is insufficient to warrant a positive conclusion, so that the relationship of the Pontiac group to the Abitibi group must for the present remain an unsettled problem.

*Granite and Gneiss.*

Both the schists of the Pontiac group and the volcanics of the Abitibi group are intruded by batholithic masses of granite and gneiss, ranging in size from small isolated intrusions 3 to 10 miles or less in diameter to a huge massive of which only a marginal portion intruding the Pontiac group on the south occurs within the confines of the region examined. The smaller batholithic masses occur in the northern part of the region and are in igneous contact with the Abitibi volcanics. Since there are probably granites of varying age present in the region it cannot be assumed that these masses are connected with the larger southern batholith, although such may be the case. Both hornblende and biotite granites and gneisses are represented in these intrusives, but the hornblende varieties are most common in the northern batholiths, whereas biotite granite and gneiss predominate in the southern massive.

The intrusion of the rocks of the Pontiac group and the volcanics of the Abitibi group by these batholiths was accompanied by the usual contact phenomena which characterize such magmatic invasions. The junction of the southern batholith and the Pontiac group is marked by a contact zone, several miles wide, on which dykes and irregular masses of granite, aplite, and pegmatite intrude the schist, increasing in size and numbers towards the south until finally only isolated blocks of schist are observed. The blocks, however, with few exceptions, maintain the same attitude and strike as the schist farther north, showing that they have not been tilted from their original positions. The smaller batholiths are filled along their margin with angular, subangular, and rounded blocks of the Abitibi volcanics with which are associated hornblende rocks and "schlieren" of hornblende granite, so that there appears to be a complete gradation from blocks which are undoubtedly greenstone or greystone of the Abitibi group to "schlieren" of hornblende granite. It is, therefore, more probable that the hornblende variations in the granite have been formed by the assimilation of the Abitibi volcanics rather than by differentiation from the granite magma.

*Cobalt Series.*

Huronian strata belonging to the Cobalt series was observed in this region in only two or possibly three localities. As these rocks commonly occur, however, as small remnants lying here and there on the truncated surface of the Abitibi volcanics, it is probable that there are other small occurrences in the region which were not observed. The Cobalt series has its greatest development in Boischatel township, where conglomerate and arkose occur in the Kekeko hills, having a vertical thickness of 700 feet. Conglomerate similar to that of the Cobalt series was also observed in Dexter township, about 3 miles north of Lake Kajakanikamak. On some of the islands in Lake Kajakanikamak a rock occurs associated with rhyolite and andesite of the Abitibi group, which appears to pass gradationally into the volcanics and cannot be distinguished from them except for the presence of grains of quartz. This, when examined microscopically, was found to be an arkose, but it is doubtful whether this arkose belongs to the Cobalt series, for unlike the typical arkose of that series its feldspar grains have been highly corroded and sericitized.

**Origin of the Cobalt Series.**—The origin of the conglomerates, greywackes, and arkoses of the Cobalt series was discussed at length in a recent report on the Larder Lake district, Ont., and adjoining portion of Pontiac county, Que., in which it was concluded that the greater part of the conglomerate of the series was of glacial origin, and that the stratified greywacke, arkose, and quartzite represented interglacial or post-glacial deposits of fluviatile or lacustrine origin. The strongest evidence in support of these conclusions was obtained during the past summer at the east end of the Kekeko hills, where scratched and faceted pebbles were obtained from the conglomerate.

### *Nipissing Diabase.*

The Nipissing diabase is not extensively developed in this region since it was observed in only a few localities. It occurs as narrow dykes—usually less than 200 feet in width, intruding the rocks of the older basement complex. Its correlation with the Post Huronian Nipissing diabase is, therefore, based solely on its lithological similarity not only in mineralogical composition but in its fresh unaltered character to the diabase which in this district intrudes the Huronian.

### *Pleistocene and Recent.*

The rock surfaces in this region where exposed to view present the usual smoothly eroded and striated appearence which results from glacial denudation. The greater part of the surface of Pre-Cambrian rocks of the region are, however, hidden beneath a thick mantle of glacial and post glacial deposits.

The lowermost Pleistocene deposits consist of sand, gravel, and boulders, which are partly glacial and partly fluvioglacial in origin. The fluvioglacial deposits are roughly stratified and usually take the form of kames. In a few localities elongated, narrow ridges of a similar character occur which are probably eskers.

Throughout the larger part of the region the older Pleistocene deposits are overlain by stratified clay and sand, sediments, which are evidently of lacustrine origin. The stratified clay is uniformly bedded in layers averaging about one-half inch in thickness, the beds being separated as a rule by a thin layer of calcium carbonate. Locally the stratified clay becomes arenaceous, and in these places a bed may contain two or three subsidiary layers due to an increase in sand content. The stratified sands never exceed a few feet in thickness and always overlie the stratified clay. They appear to be confined to the vicinity of glacial and fluvioglacial deposits in which sand is abundant.

It is believed that these uniformly stratified Pleistocene deposits were laid down from a huge lake which occupied this region in post-glacial times. This lake was evidently connected with the Timiskaming basin during a considerable part of its history, for the stratified clay was observed on the height of land in Launay and Trécesson townships, at an elevation of 1,074 feet above sea-level, and from that point has been traced continuously along the Nawapitechin and Kinojevis rivers and southward to the stratified clay north of Lake Timiskaming.

If it be assumed that each bed in the stratified clay represents the deposition of a single season, then by counting the number of beds an estimate of the length of time the lake occupied the district can be obtained. Since the maximum number of beds observed in the cuts along the National Transcontinental railway was only 250, the post-glacial lake—if each bed is an annual deposit—was of very temporary duration in this region.

The surface of some of the Pleistocene sand areas in Trécesson township has been subject to wind action and presents a typical sand dune appearance. Some of these dunes have been very recently formed, for in one locality where a forest fire had removed the vegetation, several birch and banksian pine have been partly buried in sand.

## Economic Geology.

### *Gold.*

Quartz veins are common everywhere in the region, but are most extensively developed in the rocks of the Abitibi group.

On the north side of the Kinojevis river, near the Cascade rapids (Manneville township), an east-west belt of dolomitic sericite schist occurs which is intersected by numerous veinlets and veins of quartz. Some of the veins are from 4 to 10 feet in width and in one place a huge lens of quartz about 30 feet wide has been formed. The occurrence of these veins and irregular masses of quartz in dolomitic sericite schist is strikingly similar to the veins and quartz lenses of the Porcupine district, but assays of samples taken from all of the larger developments of quartz were made by Mr. Leverin of the Mines Branch of this department, and in every case returned no gold whatever.

Some very irregular veins of quartz occur in a shear zone in greenstone on an island at the north end of Lake Agotawekami from which it was reported assays of $20 per ton had been obtained. An average sample of this quartz taken by the writer, and assayed by Mr. Leverin of the Mines Branch, however, was found to contain no gold.

A large number of quartz veins cutting sericite schist, greenstone, and ferruginous dolomite have been staked in the vicinity of the National Transcontinental railway, but the assays of samples from these veins have never exceeded $1 or $2 per ton.

While it is evident from the above results that an auriferous quartz deposit of commercial value has not, as yet, been discovered in this region, it must also be remembered that the country has not been prospected except in a very superficial way. Geologically the region is very similar to the Porcupine district, and with the transportation facilities now afforded by the National Transcontinental railway, is probably one of the most promising fields for the prospector in northern Ontario and Quebec.

### *Copper.*

A large number of the quartz veins of the region contain chalcopyrite, but no deposit of this mineral was observed which was of sufficient dimensions for commercial mining operations.

### *Molybdenite.*

The pegmatite and aplite occurring in the contact zone between the Pontiac group and the granite and gneiss contains molybdenite in a number of localities in this region. These occurrences, however, are all small, and are not at all comparable in extent to the deposits of this mineral occurring in the vicinity of Kewagama lake.

# CERTAIN MICA, GRAPHITE, AND APATITE DEPOSITS OF THE OTTAWA VALLEY, AND AN OCCURRENCE OF EOZOON CANADENSE.

(*John Stansfield.*)

## INTRODUCTORY.

During the season of 1911, work was carried on in the region immediately north of the Ottawa river, in the townships of Hull and Buckingham, and the Seignory of La Petite Nation. An examination of certain typical mines of the region was undertaken, the Gemmill mine at Cantley being taken as an illustrative mica deposit, the Walker mine and Dominion Graphite Company's mine near Buckingham as illustrative of the occurrence of graphite, and the Emerald mine at Glenalmond of apatite. A small area at Côte St. Pierre illustrates the occurrence of Eozoon Canadense.

Topographical and geological work was carried on simultaneously, no contouring being done. Detailed large scale maps were made in each area. The method employed was transit and stadia traversing, in some cases details being filled in by compass and tape traverses. At Cantley one area 330 × 400 yards, and another 400 × 400 yards were mapped for publication on the scale of 200 feet = 1 inch, and the road running from Kirk Ferry through Cantley and back to Kirk Ferry, was surveyed for publication on a scale of 2,000 feet = 1 inch. At the Walker mine an area of about 1½ square miles was mapped for publication on a scale of 400 feet = 1 inch. At the Dominion Graphite Company's mine an area of 800 × 800 yards, at the Emerald mine one of 970 × 1,100 yards, were mapped for publication on the scale of 200 feet = 1 inch, and at Côte St. Pierre another area 490 × 800 yards was mapped for publication on a scale of 400 feet = 1 inch. In addition telemeter traverses were run connecting the Walker and Emerald mines with the post-office at Buckingham, and connecting the Côte St. Pierre locality with the Ottawa river at Papineauville.

Assistance was rendered by Messrs. C. C. Galloway in topography, and Mr. G. H. Gilchrist in topography and geology, the place of the latter being taken by Mr. W. S. McCann, from the beginning of August to the end of the season. Great kindness was shown to the party by the Dominion Graphite Company.

## HISTORY AND PREVIOUS EXPLORATION.

In 1873, Mr. H. G. Vennor visited and reported on the graphite and apatite deposits of the Lièvre River valley, including the Emerald mine. In 1876, he surveyed an area including the graphite and apatite deposits of Buckingham township.

In 1877, Dr. J. B. Harrington visited several apatite and mica occurrences and reported on the minerals found in association with these deposits.

In 1883, Mr. J. F. Torrance visited and reported on the apatite deposits of Quebec, including those of the Lièvre River valley.

In 1897, Mr. A. A. Cole surveyed the Walker mine and other graphite deposits in the township of Buckingham.

In 1899, Dr. R. W. Ells reported on those parts of Ontario and Quebec included in the Grenville sheet, and in the same year Mr. A. Osann studied the geology of the areas surveyed this summer, with the exception of the Dominion Graphite Company's mine.

That part of the Lièvre River valley in which occur the graphite and apatite deposits examined, was reported on in 1905 by Prof. E. Haycock.

## General Geology.

### TABLE OF FORMATIONS.

The rock formations developed in the region have been subdivided in accordance with the following table:—

II. Quaternary.—Marine-glacial clay (Leda clay) and sands.

I. Pre-Cambrian—

3. Igneous intrusives—
   - 3*c*. Trap dykes.
   - 3*b*. Gabbros and pegmatites of the mineral deposits.
   - 3*a*. Older pegmatite veins.
2. Grenville series.
1. Ottawa gneiss.

*The Ottawa gneiss* is seen at Cantley, at several points along the north road of the main traverse, and on the east hill of the Gemmill mine. It is a reddish gneiss of the composition of a granite, or in some cases of a syenite. Gneissic structure may be well developed or only broadly suggested. Syenitic gneiss is abundantly developed in the Walker Mine area; a dark-coloured biotite-gneiss occurs in the same area, and also on the road between the Walker mine and Buckingham.

*The Grenville series* is more abundantly developed than the Ottawa gneiss in the area examined, constituting the major portions of the outcrops. It includes impure crystalline limestones, quartzites, garnet-gneisses, sillimanite-gneisses, and black-weathering gneisses rich in pyrites whose exact nature is not yet determined. The graphite deposits examined are found closely associated with members of the Grenville series, most often with limestones.

*Older Pegmatites.*—The Ottawa gneiss and Grenville series in all areas visited are cut by very many pegmatite dykes, their development being not so marked in the limestones as in rocks of other types. These pegmatites often carry tourmaline, as is especially the case in the Cantley district. They are classified as of one general age, older than the gabbros and associated pegmatites, because members of the gabbro group cut these pegmatites at Cantley, and because of the general absence of pegmatites of this type cutting the gabbros and associated rock types.

*Gabbros and Pegmatites of the Mineral Deposits.*—The gabbros have been described by Osann as being all hypersthene-gabbros, enstatite-gabbros, scapolite-gabbros, or normal gabbros with the exception of the gabbro at the Dominion Graphite Company's mine. These rocks lack gneissic structures and form relatively small bodies. The pegmatites of this group are later than gabbros, since included blocks of the latter in the former are frequently met with at the Emerald mine. At the Dominion Graphite Company's mine the "blue quartz veins" are the representatives of this group.

In some rare cases these pegmatites are younger than the ore-deposits.

*Trap Dykes.*—Two diabase dykes between 30 and 40 feet wide occur near the Buckingham-Glenalmond road. One is found on the Emerald Mine hill, striking 86° E. of N. The other is about halfway between Buckingham and Glenalmond, and strikes 71° E. of N. They dip vertically and belong to a family of dykes developed in the region of the Lièvre and Gatineau rivers and which can often be traced across country for many miles. Others of these dykes occur in and round the town of Buckingham, *e.g.*, opposite the vicarage and just north of the Alexandra Hotel, and also just to the west of the bridge over the Lièvre.

QUATERNARY: MARINE-GLACIAL CLAYS AND SANDS.

The clays fill in the lower depressions between the hills of Pre-Cambrian rocks. The clay at a few points shows stratification, individual bands being, as a rule, ¼ inch in thickness. At one or two points marine fossils are met with in the clay. They are:—

*Saxicava rugosa.*
*Astarte cf. Laurentiana.*

Both forms are met with on the left bank of the Gatineau river, 400 yards below the falls at Kirk Ferry. The Astarte is found at Gow's farm at the Gemmill mine, and also on the road from Buckingham to the Walker mine, near the cheese-factory.

The sands occur, covering a considerable area, as a thin capping above the clay, and are unfossiliferous. They are found at points all along the north bank of the Ottawa river, and in the valleys of its tributaries.

## Economic Geology.

### MICA.

#### *The Gemmill Mine.*

The deposits at the Gemmill mine, situated on lot 10, range XII, of the township of Hull, and also known as Gow's, the Vavasour or Nellis's mine, occur on two hills, known as the East and the West hills, which are separated by a clay-filled hollow. The mica occurs in veins which cut gabbro, gneiss, and pegmatite alike. The vein-walls are clear-cut in the pegmatite and gneiss, but wavy in the gabbro, constancy of thickness being associated with the former types of country rock and "bulging" with the latter. The veins constitute a system with a general parallel development. The whole of East hill is cut by veins, usually about 15 feet apart, whilst on West hill they are developed chiefly on the southern face, with a few at the northeast corner. The veins of East hill have a gentle curve, the strike varying from N. 68° E. at the northeast corner to N. 23° E. at the southwest corner. The dips vary between 37° and 87° to the southeast, and are for the most part high (between 60° and 75°). On West hill the strikes vary from N. 45° E. on the western face to N. 78° E. at the southwest corner, the majority being close to N. 65° E., whilst the dips are high, ranging from 68° to the southeast to vertical. On the northeast corner of the hill a few veins occur, which have not been opened, the strikes varying from N. 29° E. to N. 49° E.; the dip, obtained in only one case, was 75° to the southeast. The thickness of the veins varies from almost nothing up to 15 feet, a common width being about 6 feet. Veins very often pinch out to 1 foot or less at the surface, widening out a few feet below the surface.

The chief minerals of the veins are, in the order of deposition, pyroxene, phlogopite, apatite, and calcite. Parallel banding is well developed, the pyroxene occurring in a dark green comb on each wall, with bands of phlogopite, and in the centre a mixture of apatite and calcite in varying proportions. The calcite is best developed on East hill, being sparingly present or absent in the veins of West hill. The apatite is most commonly green, the red variety being occasionally seen on East hill, whilst it is more typical of West hill than the green variety. Other minerals found include fluorite, quartz, and actinolite, but these are uncommon, at any rate so far as present exposures are concerned.

The phlogopite bands vary in width from 1 inch to 1 foot, or even more. As a rule the mica is arranged with the cleavage planes parallel to the walls of the vein.

The mica has a rough hexagonal shape in the case of the larger masses, the shape being more perfect in the case of the smaller forms, especially in those found completely embedded in calcite. The mica reaches 2½ and even 3 feet across in the rough state, such masses yielding large cuts. For the most part the mica yields cuts comparable in size with the original crystal, but occasionally it is found to be flawed and much cracked, having been subjected to movement or differential pressure subsequent to its formation. In such a case the mica is worthless for cuts of any size.

In a few cases the veins occur on fault planes along which movement of a few feet took place before the formation of the veins.

Actual mining is not being carried on at present, but prospecting is being kept up. Several new veins have recently been found on West hill and openings are usually made on them to a depth of a few feet only, but often yield large masses of mica for a small expenditure of labour. The mica can be dug out near the surface or loosened by small charges of dynamite. Only that mica close to the surface is useless, owing to the action of the weather. For a considerable time no sales have been made, working for stock being the present policy of the owner of the mine. As a result the warehouse is filled with prepared mica, and picked phosphate is lying on the dumps. The mine was first worked in 1878, and was formerly worked for phosphate. Mining was more actively carried on, several shafts being sunk on East hill. The shafts were sunk on the veins, the deepest one reaching a depth of 160 feet, a drift along the vein from it reaching a length of 190 feet. The shafts are now practically abandoned. When first operated the mica was dumped as waste, fortunately in one place, and free from other material, and is now being utilized for scrap mica.

## GRAPHITE

In both the areas mapped and in several other occurrences of graphite visited the graphite deposits were found to be closely connected with bodies of intrusive igneous rocks. In some cases the ore is found as a band at the junction of the igneous intrusive with the intruded rock, in other cases as an impregnation of the intruded rock close to the igneous contact, and in others as an impregnation of the igneous rock itself. This association of graphite ore and igneous rocks was found in all but a few small exposures, which owing to lack of time were not so thoroughly studied as the more important bodies constituting the ore-shoots, and in all probability closer study of these few cases would disclose igneous rocks in close association. The country rock is either a pyritic-micaceous gneiss, which previous observers have determined to be sillimanite-gneiss, or limestone. The types of igneous rock with which the ore-bodies are associated are two in number, a gabbro (hypersthene-gabbro of Osann), and a pegmatitic representative of the gabbro.

### *Walker Mine.*

Lots 20 and 22, range VIII, township of Buckingham.

At the Main pit the ore is an impregnation of gabbro, limestone, and gneiss, situated on the underside of an almost flat sheet of igneous rock. The working is now filled with water and close examination of the ore-body is impossible. The mine was worked by underhand stoping from time to time between 1890 and 1896, when the mill was permanently closed down. The graphite was separated from the crushed ore by a wet process.

The openings of the Nelly's Pit group and the openings between this point and the Main pit are much overgrown and do not appear to have been carried beyond the shallow pits of the prospecting stage. These openings are on clean veins of columnar graphite, which vary in width from ¼ inch to 4 inches. Examples occur of veins cutting pegmatite, cutting gabbro, and limestone, and following a gabbro-pegmatite contact. Large sphenes about the size of a walnut are associated with the ore in these pits.

In addition, pegmatites are occasionally met with in other parts of the district which carry graphite throughout their mass.

### *Dominion Graphite Company's Mine.*

Lot 20, range V, township of Buckingham.

*Pit 1.*—Here the ore-body has the form of a shoot whose dimensions at the surface are 60 feet × 30 feet. The central mass of this ore-shoot is a mixture of graphite and calcite, the edges consisting of impregnated gabbro. The ore-body splits to the south into four tongues or veins of impregnated gabbro. On the east the mass is cut by a highly quartzose vein, of the type locally called "blue quartz vein." This type of vein is probably an acid representative of the later stages of the gabbro intrusion. It is found to be composed of quartz with a very subordinate amount of hornblende. The northern extension of the shoot was not exposed at the time the mine was examined. The ore-body is worked by underhand stoping. The graphite is usually amorphous, occasionally the columnar variety being met with in small amount. Apatite in nests up to the size of a hen's egg was found in the graphite ore. Pyrite veins cutting the ore are often met with, sometimes massive, sometimes with a honeycomb structure, with the development of crystal forms.

*Pit 2.*—The ore-body is a very richly impregnated band from 3 inches to 1 foot in thickness, on the upper side of a "blue quartz vein." The immediately adjacent country rock is limestone above and gneiss below. This body appears to be small and was nearly worked out at the time of examination, though the same type of deposit is indicated in small openings along the upper surface of the same dyke to the south. A small vein of gypsum was found associated with the ore-body.

*Pit 3 (Swamp Pit).*—Here rocks of the gabbro and pegmatite types occur. At the time of examination ore-bodies only a few inches thick on the west side of a gabbro dyke and on the west side of a pegmatite dyke were exposed. Development work has since been carried on at this pit and an ore-body has been exposed which promises to be an important supply.

*Pit 4*—Contains a small exposure of graphitic gneiss a few inches thick, overlain by a dark-coloured limestone bearing a striking resemblance to a spherulitic rock. No important work had been carried on at this pit when visited.

Work has been carried on at this mine during the past summer. The mill was erected in the winter of 1910-1. The mill, which is built on the slope of a hill to make use of gravity in the handling of the ore in the various stages of the extraction, is one of the most up-to-date in the country, and is designed to treat 200 tons of ore per day. The ore is roasted in kilns, passed through crushers, the graphite flattened into flakes and separated in the dry way by means of revolving bolts.

Employment is fonnd for 80 to 100 men, some difficulty being experienced in obtaining sufficient labour.

## APATITE.

### *Emerald Mine.*

Lots 18 and 19, ranges XI and XII, township of Buckingham. The occurrence of apatite at the Emerald mine is very similar to that at the Gemmill mine, the two most striking differences being that at the Emerald mine mica is only met with in veins round the rim of the hill, and sulphides are present in the ore. Pyrite is much the more common sulphide, pyrrhotite being a good deal rarer. Of other minerals found mention may be made of actinolite and tourmaline; the latter not being found in situ its relation to the apatite is not clear. Pyroxenes embedded in calcite are met with, sometimes with a rim of uralite round the pyroxene.

In the centre of the hill the apatite occurs in large masses rather than veins. They are in reality widened veins and send off smaller veins into the country rock, which is here a gabbro. The main mass of the filling, now removed, was apatite; but from small patches left on the walls of the openings the green apatite and pink calcite are seen to occur in exactly the same way as at Cantley. The maximum width of the largest of these pockets is 50 feet. Instances of this pockety occurrence of the ore are known as Murray's, Watt's, and Boilleau pits.

Veins cut gabbro, pegmatite, and gneiss indifferently, there being again a tendency to departure from rectilinear bounding surfaces when gabbro is the country rock. Outside the gabbro area the veins are narrower and show good parallel banding, often with excellent comb structure. A large number of openings have been made in the area included in the sheet and a number of shafts and winzes sunk, and several drifts have been run into the hill for the purpose of striking ore-bodies, or for draining the workings. In all cases the shafts appear to have been sunk to a shallow depth only, before being abandoned, 50 feet being about the maximum. The mine was most actively operated in the early eighties, when it was one of the three largest producers of apatite in Quebec.

## AN OCCURRENCE OF EOZOON CANADENSE AT COTE ST. PIERRE.

Subsequent to the discovery of Eozoon in specimens from Burgess, Ont., and the finding in 1858 of other specimens at Grand Calumet, Que., by Mr. McMullen of the Geological Survey, Eozoon was reported from a number of Canadian localities. Mr. J. Lowe found it at Côte St. Pierre and made collections from this localities, between 1863 and 1866. In 1875 Mr. T. C. Weston made collections for Sir J. W. Dawson under the auspices of the Geological Survey. This locality has yielded some of the best specimens of Eozoon.

The area mapped is situated about 10 miles north of Papineauville. The southern edge of a mass of gabbro is exposed, its margin being overlain by glacial clay and sand. A small area of limestone is included in the exposure, and a few minor outcrops of quartzitic gneiss also occur.

The limestone is altered along its contact with the gabbro for a width of 150 to 200 feet. The chief minerals produced are diopside and tremolite. The former is predominant close to the contact and is developed to a far greater extent than the tremolite, which is found at a greater distance from the intrusion. Beyond the zone where tremolite occus is the Eozoon band, consisting of serpentine and calcite with the well-known pseudo-organic structure. The Eozoon was exposed at only one point and only a very small area was seen. It is at this point that small veins of asbestos cut the rock, which caused an opening to be made some thirty years ago in an attempt to work the asbestos.

Exposures in the contact-metamorphic zone are not good, so that an attempt to map the extent and zones of the metamorphism met with small success.

# GEOLOGY OF ORFORD MAP-AREA, QUEBEC, SOUTHERN PART OF "SERPENTINE BELT," BOLTON TOWNSHIP.

(*Robert Harvie.*)

## INTRODUCTORY.

In accordance with the instructions of the Director, the writer was occupied during the past field season in the mapping and geological examination of the serpentine belt of southern Quebec, in continuation of the work which has been progressing for three seasons under Mr. J. A. Dresser.

As this was the writer's first work with the unusual types of rocks here found, progress has naturally been slow, and this slight acquaintance has further limited his comparison of this district with other portions of the belt. For the same reason the generalized account of the geology given below is largely based on the work of Mr. Dresser.

Before beginning the regular work and in order to become somewhat familiar with working conditions, two days were spent in studying the chrome iron and asbestos mines at Thetford and Black Lake. Work in the field was commenced at Eastman on June 8, and closed at Knowlton Landing on October 10. In order to establish a proper connexion with Mr. Dresser's work of the previous year, Mr. J. J. O'Neill, his assistant on that occasion, was attached to the party for the first week. Mr. Alex. MacLean and Mr. A. Mailhiot acted as assistants until September 9, and I am indebted to them for thoroughly efficient and enthusiastic services. Mr. MacLean's intimate knowledge of other parts of the belt, gained with Mr. Dresser, was especially helpful to the writer. I also wish to thank Mr. N. S. Parker, of Eastman, for placing at our disposal his accurate and detailed information concerning the prospects, mineral locations, and other features of the district.

## LOCATION.

The serpentine belt lies in that part of the Province of Quebec southeast of the River St. Lawrence, and runs in a northeasterly direction approximately parallel to that river from within Vermont to Gaspé. The portion examined in last season's work includes parts of Bolton and Brome townships of Brome county. This district lies south of the Canadian Pacific Railway line from Montreal to Sherbrooke, north of the boundary of Vermont, and immediately west of Lake Memphremagog.

## PREVIOUS WORK.

The first accounts of the general geology of the district were by Sir Wm. Logan in the early reports of the Geological Survey, and these he later compiled and included in his Geology of Canada in 1863. Logan believed in the sedimentary origin of the serpentines, and his work and intended map on the scale of 4 miles to 1 inch were prepared with that in mind. The publication of the map was, however, delayed (for one reason or another), and in the meantime Dr. Selwyn, who had succeeded Logan as Director of the Survey, questioned this origin. Finally in 1882 it was proved by microscopic examination that the serpentines were of undoubted igneous origin, and it was definitely decided to revise Logan's work before publication. The revision was entrusted to Dr. R. W. Ells, whose reports and maps on the various districts traversed by the serpentine belt were issued in the Annual Volumes of the Geological Survey for the years 1886, 1887, and 1894. In order to meet economic needs, a special report on the copper-bearing rocks, by Mr. Dresser, was issued by the Geological Survey in 1907 as Publication No. 974.

## Object and Progress of the Present Investigation.

Since the first shipment, about 1876, the production of asbestos in Quebec has steadily increased until now it has an annual value of over two and a half million dollars, placing the Eastern Townships near the top in order of importance of the mineral districts of Canada. In view of this economic importance of the serpentine belt, with which asbestos, copper, chrome iron, talc, and other valuable minerals are associated, the present investigation was commenced in order to obtain more complete information concerning its real distribution, geological structure, and economic resources. The field work was begun by Mr. Dresser in 1907 and continued in 1909 and 1910, his reports of progress being included in the Summary Reports of the Geological Survey for those years. His report for 1909 gives briefly a very satisfactory account of the principal geological features of the belt. A preliminary report on the district between the Chaudière and St. Francis rivers is now ready for the press.

## Summary and Conclusions.

The serpentine belt which Mr. Dresser has been tracing and examining in a general southwesterly direction from East Broughton, is found to continue through the district examined this year to the boundary line of Vermont. Although called the serpentine belt, the area occupied by serpentine is a relatively small proportion, but the predominant economic importance of these areas is sufficient reason for the application of this name to the belt as a whole. In Bolton and Potton townships the serpentine continues to be of minor areal importance, but on the other hand, as contrasted with districts to the northeast, its economic importance is reversed since the copper deposits associated with the other related types of rocks—diabase and porphyrite, have already given a large production in the past, while the asbestos deposits of the serpentine have not got beyond the early stages of prospecting.

Trial shipments have been made of chrome iron, talc, and iron ores, but with unsatisfactory results.

## General Character of the District.

The district lies just within the border of the Appalachian mountain system, and the topography as a whole partakes of the features usually found to characterize that region. In general the country is traversed in a northeasterly direction by numerous parallel ridges and valleys. Locally the western border of the district is formed by the mountains of the Sutton Mountain anticline, many of the peaks probably averaging 1,800 feet above sea-level. Adjoining this range to the east is the strongly marked valley of the Missisquoi river, ranging in altitude from 675 to 800 feet. The next ridge to the east is from 3 to 4 miles wide with an average elevation of 1,100 feet. The serpentine belt intrusions are found chiefly along this ridge and compose the highest mountains of the immediate vicinity, three of them rising to over 2,000 feet. The next important depression is occupied by Lake Memphremagog with an elevation of 690 feet. The influence of the topography is well shown by the location of the railways, a good example being the Canadian Pacific Railway's line from Montreal to Newport, the excessive detours shown thereon being simply an expression of the difficulty of finding a suitable grade in a direction across the trend of the hills and valleys.

## General Geology.

The outstanding feature of the geological structure of the Eastern Townships is the existence of three main anticlines composed of ancient sediments and volcanics, between which are synclinal troughs underlain by younger sediments. In a broad way the anticlines are expressed as ridges and the synclines as valleys, the reason for this probably being found in the kind of underlying rock. The anticlines, to a large extent at least, are composed of volcanics considered to be of Pre-Cambrian age. Flanking the volcanics are arranged various sedimentary formations in ascending geological order towards the axes of the synclines. In the succession are represented the Cambrian, Ordovician, Silurian, and Devonian. The serpentine belt includes a series of intrusives occurring chiefly along the eastern slope of the Sutton Mountain or westernmost anticline.

### TABLE OF FORMATIONS.

| | |
|---|---|
| Quaternary | Sand, gravel, and clay. |
| Devonian ? | Shaly limestone, serpentine, peridotite, pyroxenite, gabbro, diabase, granite, aplite, alkaline rocks of the Monteregian type. |
| Silurian | Shale and limestones. |
| Ordovician Farnham Series | Graphitic argillite and limestone conglomerate. |
| Cambrian | Greywacke, purple and green slates; red marble, schistose grey quartzites. |
| Pre Cambrian—Sutton Mountain series | Porphyries and greenstones. |

### DESCRIPTION OF FORMATIONS.

#### *Pre-Cambrian.*

*Sutton Mountain Series.*—The rocks of the porphyry-greenstone series are probably the only ones older than Cambrian. In the early geological work in the district the volcanics were mistaken for sediments owing to their being much squeezed and folded and thus having had the features commonly associated with igneous rocks almost entirely removed. The porphyries are well shown on the railway line between Eastman and South Stukely, while the greenstones are well exposed near Foster.

#### *Cambrian.*

The rocks belonging to this system comprise an extensive development of a grey usually schistose quartzite with smaller amounts of greywacke, green and purple slates, and a few bands of a red marble. These are found chiefly in the valley of the Missisquoi, the best exposed section being found just south of Eastman.

The correlation of the so-called Cambrian and Pre-Cambrian has never been definitely established. Apparently these terms were first of all given on the basis of broad generalizations, and have been accepted since simply for lack of more exact information.

#### *Ordovician.*

*Farnham Series.*—The black slates which are the principal rocks of this series have been correlated with the lower Trenton. In most places the entire formation has been metamorphosed to such an extent as to completely remove all signs of its original bedding, and at the same time cause the production of secondary minerals. The correlation is made on the determination of fossils collected at Castle Brook west of Magog, from which locality the formation has been traced laterally for many miles.

## *Silurian.*

The Silurian system is of relatively small extent in the district, but it furnishes important evidence as to the age of the serpentine series. The northern half of Lake Memphremagog lies in a synclinal trough of Silurian measures whose age as previously determined has been chiefly based on a few species of not very characteristic corals. However, the discovery of a new fossil locality at Knowlton Landing containing a much wider range of species has given an opportunity for a much more decisive determination. Mr. P. E. Raymond has kindly made the following preliminary report on a collection of some 300 pounds of fossiliferous material.

"The following species were determined:—

*Dalmanites lunatus*, Lambert; abundant.
*Dalmanites*, sp. ind.; probably new; common.
*Calymene*, sp. ind.; rare.
*Bronteus pompilius*, Billings; rare.
*Ceratocephala*, cf. *C. goniata*, Warder; rare.
*Chonetes*, sp. ind.; rare.
*Coelidium*, sp. ind.; rare.
Operculum of gastropod, like that referred to *Oriostoma* by Kindle.
*Orthoceratites*, indeterminable; common.

"Trilobites form the most important part of this collection. The specimens of cephala and pygidia are numerous, and though distorted, fairly well preserved. The most common one is very similar to *Dalmanites pleuroptyx*, Green, but differs from that species in having fewer rings on the axial lobe of the pygidium and fewer ribs on the pleural lobes. It is, therefore, referred to Lambert's species, described from the Silurian at Littleton, New Hampshire (Bull. Geol. Soc. America, Vol. XV, p. 480, 1904.) The other species of *Dalmanites*, represented only by pygidia, is characterized by its rounded outline, the absence of a caudal spine, and the few (about 10-13) rings and ribs (8-9) on the pygidium. The presence in this fauna of a *Calymene* and a *Ceratocephala* of the type of *C. goniata* indicate the middle Silurian age of the strata at this locality.

"The fossils from a second locality, a little higher in the section, are mostly indeterminable. The pygidium of a species of *Encrinurus* was recognized, and some of the *Orthoceratites* are identical with those in the lower beds."

"The strata at a third locality on the other limb of the syncline are full of badly squeezed brachiopods, none of which could be recognized with certainty. The most common shell is a rhynchonelloid, possibly a *Wilsonia*. Two or three specimens appeared to be *Atrypa nodostriata*, Hall, and another looked like *Leptaena rhomboidalis*. With these was a large and well-preserved specimen of *Favosites gothlandicus*, Lamarck."

## *Devonian.*

Two outliers of rocks which have been referred to the Devonian are found at Knowlton Landing and Owls Head on the west side of Lake Memphremagog, and as far as is known rest conformably on the middle Silurian. The diabase which accompanied the intrusion of the serpentine alters the middle Silurian strata in the vicinity of Knowlton Landing, and since the outlier of Devonian rests conformably on the middle Silurian at that point, it is thus considered probable that the intrusion of the serpentine rocks in this vicinity took place after the deposition of this representative of the Devonian. The highly altered and squeezed character of the serpentine and, also to a limited extent, of the Monteregian rocks, observed chiefly in Shefford and Brome mountains to the west, indicates that they were intruded before the cessation of folding to which this, in common with other portions of the Appalachian system district, has been subjected. This movement is considered to have been complete in Carboniferous times, and thus gives a younger limit to the age of these sediments. It would seem very probable that they are late Devonian in age since this was a period of great igneous activity in the Appalachian uplift, especially in the Hudson valley north of New York.

*The Serpentine Belt.*

The rocks of the serpentine belt are—serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite. The previous work of Mr. Dresser has indicated that these different rock types are, in the main, parts of one consanguineous intrusion, having separated from one another during the process of cooling. In the case of intruded sheets examples are commonly found showing peridotite in the lower portion and on ascending, a zone of pyroxenite, then gabbro, and finally diabase. Where the intrusions form stocks or plugs, the types are found to be arranged in the same order from the centre outwards, as is found in the sheets from the base upwards. The granite and aplite, which represent the most extreme acid phases of the process of differentiation, have generally been intruded a little later than the other rocks. The serpentine is an alteration phase of the peridotite and all gradations are found between a pure serpentine and only slightly altered peridotite. The district examined this year was noteworthy on account of the predominance of the diabase end of the series.

*Alkaline Rocks.*

On the St. Lawrence plain to the west of this district there are a number of residual hills of intrusive igneous rocks which have received the name of Monteregian hills from the best known representative, Mount Royal, at Montreal. Dykes of rocks belonging to these intrusions are found in many places quite distant from any of the large masses. They are readily recognized on account of being composed of minerals of an unusual alkaline composition.

An exposure of these rocks is found in a cutting on the Canadian Pacific railway near Orford pond, about 2 miles from Eastman. The rocks represented are camptonite, nordmarkite, and monzonite. At the Huntingdon mine a camptonite dyke cuts both the serpentine and the ore-bearing schistose diabase. In a cut on the railway, ¾ of a mile south of Bolton Centre, a deeply weathered dyke of tinguaite cuts the Cambrian schists. Numerous other dykes of this class have been found at Lake Memphremagog and have been described in minute detail by Marsters.[1]

*Quaternary.*

The superficial deposits, more especially in the valley of the Missisquoi, consist chiefly of sands and gravels deposited on the retreat of the ice-sheet and almost unmodified since. On a small scale splendid examples may be found of outwash sand-plains, kames, and terminal and lateral moraines. Bolton pass, which cuts across the Sutton Mountain anticline, shows very evident glacial action, and what was probably a good-sized englacial stream discharged easterly through this pass into the Missisquoi, building the sand-plain in the vicinity of South Bolton village.

[1] V. F. Marsters, Amer. Geologist, July, 1895.

## Economic Geology.

### COPPER.

#### *Huntingdon and Ives Mines.*

The copper mining industry in this district was in its most flourishing condition about 1870 while copper was selling at about 20 cents per pound, at which time both the Ives and Huntingdon mines near Eastman were vigorously worked, seemingly at good profit. The extreme decline in the price of copper soon after this date caused the gradual abandonment of these mines as soon as the known bodies of ore had been worked out. The ore of the Huntingdon mine is said to have contained from 7 to 10 per cent of copper and that of the Ives mine from 10 to 14. While no specific information can be found as to the output of these mines, it is known that for the three years 1869 to 1871 the total production of Quebec from five mines was 27,082 tons of ore valued at $333,817. It is not improbable that half of this was from the Huntingdon and Ives mines. About 1890 the Nicols Chemical Company reopened the Huntingdon mine, but apparently their prospecting was unrewarded, since after having done a lot of expensive work they closed down again. During the past summer Mr. N. S. Parker, while prospecting on the surface at the Ives mine, uncovered a promising looking outcrop of ore, but the lateral extent has not been proved and it may be that in depth the ore was stoped out by the former workings. It may be mentioned here that there are large dumps containing low grade ore at both these mines, which under present improved conditions it might be profitable to concentrate, especially in view of their favourable situation.

#### *Lake Memphremagog Mine.*

This is situated on the northwest slope of Hogsback mountain, not far from Knowlton Landing. According to the estimate of Dr. A. W. G. Wilson,[1] of the Mines Branch, the amount of ore as shown by the present workings will not be more than 20,000 tons, with a copper content probably less than 2 per cent. A quantity of ore reported to be as much as 500 tons, shipped in 1907, is the total production to date.

On lot 1, range IX, of Bolton, at Eastman village, a shaft about 15 feet deep, on one wall shows a small vein with a lens of ore about 1 foot thick containing chalcopyrite, sphalerite, and pyrite. Owing to a fault the vein is not continuous across the pit.

Prospect pits on lots 24 and 25, of range VII, of Bolton, sunk recently, do not show any valuable ore-bodies.

### CHROME IRON ORE.

Chrome iron ore has been found and prospected on lots 9 and 13, of range VII, and 26 of VI, of Bolton. All these showings are small, and the only production has been one shipment of 27 tons in 1896 from lot 9, of range VII.

### IRON ORE.

On lot 9, of range X, of Bolton, there is a series of lenses of hematite and quartz, occurring in a fine-grained basic igneous rock near its contact with quartzite. The largest body is about 40 feet long and 7 feet wide at the surface, but at the bottom of a pit 70 feet deep it is said to be 18 feet wide. The lenses outcrop for about 100 yards and are then covered by soil. In places the hematite is quite pure and of the specular variety, in other places it is intimately mixed with the quartz, and in some places.

[1] Summary Report of the Mines Branch, Dept. of Mines, 1909, p. 71.

chlorite. Copper stains are commonly found in fissures in the ore. The mining rights belong to John McDougall & Co., of Drummondville (now included in the Canada Iron Corporation, Ltd.), who mined a trial shipment of 200 tons in 1903.

### ASBESTOS.

Although a large number of pits and other openings have been made in search of asbestos, nowhere has this been found of good enough grade to warrant serious mining operations. The most promising prospect is on lot 9, of range VII, of Bolton, but even there the fibre is harsh and not over half an inch in length, while the deposit is of unknown and possibly limited extent. The openings already made are in a poor location since they are close to the upper contact of the serpentine body, which position has been shown by Mr. Dresser's previous work to be usually an unfavourable place for the development of asbestos. The owners or promoters of this property had evidently once thought well enough of it to start building a mill, but did not get farther than laying the foundations.

### TALC.

Deposits of talc are found on lots 26, range II, 24, range VI, and 24, range VII, of Bolton, and on 28, range V, of Potton. Excepting the first mentioned, all of these are very impure and dark-coloured, containing numerous crystals of magnesium carbonate. From lot 24, range VI, of Bolton, 300 tons, valued at $1,800, were shipped in 1871.

The deposit on lot 26, range II, of Bolton, which was only recently discovered by the owner, Geo. R. Pibus, is the most promising of these prospects. A pit 15 feet deep shows schistose talc 7 feet wide, and the band is found along the strike in pits 75 and 375 feet distant. The talc, although not perfectly pure, appears to have a sufficiently good colour, and the body is probably large enough to be mined economically. The deposit is 5 miles from South Bolton station, and connected therewith by a good road with favourable grade

# BELŒIL AND ROUGEMONT MOUNTAINS, QUEBEC

(*J. J. O'Neill.*)

## Introduction.

The first two weeks of the season were spent with Mr. R. Harvie in continuing Mr. Dresser's work on the serpentine belt. The remaining three and a half months were devoted to the study of the two mountains, Belœil and Rougemont, with the purp se of completing the work on the Monteregian province.

After the fie'd work had been completed, a number of duplicate sets of the principal rock types from Belœil, Rougemont, and Mount Johnson were collected; to procure which it was found necessary to engage blasters to secure fresh specimens.

The contour map of this district, lately issued by the Department of Militia, enlarged to a scale of 4 inches to 1 mile, was used as a basis for geology.

The field-work was carried on alone, except for temporary assistance in surveying contacts.

## Location and Size.

The Monteregian province is made up of eight volcanic intrusions of alkalic magma in the form of laccoliths or volcanic necks, situated in the southwestern part of the Province of Quebec, and extending from Mount Royal at Montreal, to Shefford mountain, nearly 50 miles due east.

Mount Royal, St. Bruno, Belœil, Rougemont, Yamaska, and Shefford mountains are spaced at from 5 to 15 miles apart along the west-east line; Mount Johnson is 6 miles south of Rougemont, Brome mountain is 2 miles south of Shefford.

The areas of these mountains range from 0·422 square miles in the case of Mount Johnson, to 30 square miles, in the case of Brome, which is more than three times as large as Shefford, the next largest.

## Topography.

The Monteregian hills stand up in striking contrast to the low-lying plain of Palæozoic strata, known as the St. Lawrence lowlands, which extends from the Laurentian highlands on the northwest to the Appalachian province on the southeast, with a width of about 80 miles at Montreal.

The plain is deeply mantled with glacial drift, and the subdued character of the hills, with their crag and tail profiles, points also to the profound glaciation which has affected the whole of eastern Canada.

Terraces surrounding many of the hills are the result of the sea invasion following the retreat of the ice, and sand and gravel deposits on Mount Royal show that the water rose relatively to 493 feet at least, and, not improbably, to 560 feet.[1]

Most of the Monteregian hills enclose one or more lakes in basins gouged out by the ice, and these form the natural reservoirs for the water-supply of the surrounding villages.

The drainage of the Belœil-Rougemont region is effected by the rivers Richelieu and Yamaska, which flow northward through the drift and are tributary to the St. Lawrence.

[1] Goldthwait, J. W., Raised Beaches of Southern Quebec: Summary Report for 1910, Geological Survey, 1911, p. 226.

## Belœil Mountain.

Belœil mountain rises to a height of 1,375 feet above sea-level, or 1,275 feet above the plain. Near the south end of the mountain there is a lake about a fourth of a mile square, with a maximum depth of about 40 feet, at an elevation of 535 feet. This lake occupies the bottom of a wide basin gouged out of the mountain by the ice.

Belœil is the product of two intrusions, an earlier one of essexite which forms the western half of the mountain, followed by nephelite-porphyry which contains fragments of the essexite and occupies the eastern half of the mountain. There are also many dykes of complementary nature representing at least two stages of intrusion.

The dykes seem to radiate from the essexite magma and to cut through it in many places. None were observed cutting the porphyry nor seeming to come from it directly. Two sheets of tinguaite, 4 feet to 6 feet in thickness, come off from the eastern side of the mountain, presumably from the porphyry.

The intrusions seem to have taken place without any disturbance in position of the sedimentary beds, and the relation of the igneous rocks, together with the relatively thick zone of rocks strongly altered by contact metamorphism, and the fact that the magma is coarse-grained right to the contact, point to the intrusion as having been progressive through the same channel; in other words a volcanic neck.

## Rougemont Mountain.

Rougemont mountain rises to 1,275 feet above sea-level, or about 1,150 feet above the plain. It is heavily timbered, and the extensive covering of drift permits of few exposures of the underlyiug rock. The exposures are mostly decomposed to a depth varying from a few inches to several feet.

There are two small lakes contained in this mountain, one at the north end at an elevation of 800 feet, and the other at an elevation of 500 feet, near the south end.

An essexite varying in texture, and perhaps in composition, within short distances, seems to be the only intrusion forming the mountain. The rock is very high in ferro-magnesian minerals and in many places weathering produces a regular gossan. There are also a few dykes which indicate the latter phases of activity.

The igneous rock at the borders of the intrusion is more or less filled with masses of hornstone fragments for a width up to 200 feet in places. No disturbance of the surrounding sedimentary beds seems to have taken place, and the same contact phenomena occur as at Belœil. It would seem then that Rougemont is also of the nature of a volcanic neck.

## Economic Geology.

Enclosed within Belœil mountain are three areas of limestone and marble. The two areas exposed on the hills to the east and north of the lake are coarsely crystalline and streaky marble, covering an area of about 4 acres. The surface material crumbles easily due to the action of weathering, but that lower down is probably more compact.

At the third exposure, at the northeast end of the mountain, two old lime-kilns are situated which have been long out of use. The rock here seems to be on the margin of the intrusion with bedding nearly vertical. It is exposed on both sides of a swampy depression, between the hornstone collar to the north and the porphyry hill to the south. It is about 500 feet in length and probably 150 feet in breadth. The portion exposed nearest the porphyry is a fine-grained, compact, whitish marble containing dark streaks of impurities, but on the opposite side of the depression the exposure seems to be a calcareous conglomerate in which the pebbles are rarely larger than peas, and there are thin shaly layers showing the bedding planes.

Close examination was made for fossils, but without success. Dr. F. D. Adams has shown the author a memorandum from Dr. Ells that fossils of the Devonian age have been found in this occurrence.

It would seem that the marble present in the mountain is well worth proving and testing for its value for decorative purposes.

# RECORDS OF POST-GLACIAL CHANGES OF LEVEL IN QUEBEC AND NEW BRUNSWICK.

*(J. W. Goldthwait.)*

## INTRODUCTORY.

About six weeks were spent in July and August, 1911, by the writer and two assistants, in southeastern Quebec and eastern New Brunswick. The investigation of raised beaches and other marine deposits of the post-glacial epoch, as reported a year ago, was continued, from Matane on the lower St. Lawrence, eastward around the Gaspé peninsula to Chaleur bay, and thence southward down the coast of New Brunswick to Amherst, Nova Scotia. Measurements of altitude of these elevated beaches were made at a number of localities. A special effort was made to trace the Micmac terrace and sea-cliff[1] outward from the lower St. Lawrence to the gulf, with a view to the correlation of the relatively recent uplift it records, with recent changes of level along the gulf coast. Special attention was placed, also, upon supposed evidences of modern subsidence on the New Brunswick coast. In this connexion observations were made on the distribution of plants of fresh-water and salt-water types, in districts where progressive subsidence or elevation has been suspected; and borings were made at many places to determine the depth of peat bogs and to gather other facts which might aid in settling the disputed question of modern stability of the coast.

## CO-OPERATION WITH THE SHALER MEMORIAL INVESTIGATION.

A few weeks before entering the field, and with the approval of the Director, the writer conferred with Professor Douglas Wilson Johnson, of Harvard University, and arranged the details of a plan for co-operation between the Geological Survey and the Shaler Memorial party, which was already engaged in a comprehensive study of the evidences of modern subsidence along the Atlantic coast, both in this country and in Scandinavia. The advantages of this co-operation to the Survey are both direct and indirect. Professor Johnson will prepare for a forthcoming memoir a chapter on the modern stability or instability of the coast of Quebec, New Brunswick, and Prince Edward Island, in which his own observations and those of the present writer will be set forth and discussed, in the light of the newly collected evidence from the whole field. Indirectly, the Survey has gained, through the more critical and intelligent search for evidences of modern subsidence which the writer has been enabled to make as a result of Professor Johnson's suggestions. The question of present rising or sinking of the coast has a peculiar interest, since it must take account of changes witnessed by those who have dwelt long near the shore. In some localities the rights of property owners on the seaboard have rested upon the correct answer to the question, whether the coast, in the last few centuries, has been rising or sinking, or perfectly stable. In view of these human aspects of the question, Professor Johnson's contribution to the subject will very distinctly add to the value of the forthcoming report.

[1] This name was given last year to a remarkably strong and continuous terrace and sea-cliff which stands about 20 feet above mean sea-level, in the region between Quebec and Matane. See "The twenty-foot terrace and sea-cliff of the lower St. Lawrence," American Journal of Science, Vol. xxxiii, 1911, pp. 291-317.

A second conference with Professor Johnson was held in Quebec, on November 18 and 19, in order to discuss on the ground several questions raised by the strong development, uniform height, and fresh appearance of the Micmac shoreline, which forms a connecting link between the evidences of the early post-glacial uplifts of the coast and those of modern elevation or subsidence. The conference led also to a more definite conception of the origin of certain non-marine terraces which lie between the city of Quebec and Ste. Anne-de-Beaupre.

## Records of the Champlain Submergence.

In 1910, the upper limit of marine submergence was found to decline very steadily from about 630 feet at Quebec to less than 200 feet at Matane. Observations during the present season in the same district, including old localities which were revisited and an examination of new ones, strengthen that correlation. In one instance only, has a correction of last season's data seemed necessary—namely, at Matane. There, although the highest distinct beach stands at 174 feet, as reported last year, the washed sands extend farther, to the foot of a rather persistent bluff, at 218 feet, which harmonizes better with determinations of the upper marine limit at localities both to the east and to the west, than did the 174 foot measurement. As a supplement and amendment to the data given in last year's summary, therefore, the upper marine limit at the following places is here recorded:—

St. Joachim.—Rolled gravels up to 560-570 feet (aneroid).
L'Islet.—Highest of a series of strong beaches, 520 feet ± (aneroid).
Priceville.—Delta of Grand Métis river, 270 feet ±.
Matane.—Upper limit of sands at foot of bluff, 218 feet.

The observations of raised beaches from Matane eastward to Ste. Anne-des-Monts, including not only barometric measurements but the results of more precise levelling at several places, extend this water-plane 50 miles farther east. It appears to continue the same uniform descent east of Matane which it holds to all the way from the city of Quebec, reaching an altitude of approximately 150 feet at Sainte Anne-des-Monts. The new data from this district are as follows:—

Ste. Félicité.—Wide, gravelly terrace, 204 feet.
Grand-Mechin.—Top of extensive delta, 175 feet.
Cape Chat.—Short spit of shingle back of the mountain, 156 feet.
Ste. Anne-des-Monts.—Two miles west of village, pocket beach, highest of a group, 150 feet.
Ste. Anne-des-Monts.—Two miles east of village. Gravelly beach, highest discovered on favourable slope, 137 feet.

The figures given above, unlike the other measurements, refer to the last high-tide mark on the beach, instead of mean tide-level. They are, therefore, subject to a correction of a few feet. All are measurements made with German pocket-level and rod.

An unlooked for feature which complicates the task of correlating the beaches of this more easterly district with those west of Matane, is the presence along this north Gaspé shore of marine terraces and delta deposits at altitudes much higher than the water-plane referred to in the preceding paragraphs. The topographic strength of these higher shorelines is extraordinary, and thus quite unlike the beaches farther up the lower St. Lawrence, excepting, of course, the Micmac shoreline, which is always conspicuous. At one particularly exposed headland near Capucins, the most typical cobblestone beach which I have seen anywhere east of

Covey hill was found, at an altitude of 273 feet above high tide, or fully 100 feet above the water-plane which has been traced down the estuary from Quebec.

The reason for these higher marine terraces and beaches can at present only be conjectured. While a local bulge in the upwarped water-plane is not impossible, no other facts have been found which might support that view; moreover, as already stated, the highest shoreline from Quebec to Matane seems to be traceable all the way out to Ste. Anne, in terraces and deltas which harmonize with that plane. A more satisfactory theory is that the Gaspé peninsula bears a record of earlier and deeper submergence than the lower St. Lawrence coast possesses, because of an earlier disappearance of the ice-cap from it than from the latter shore. As Chalmers has said,[1] glacial drift covers the upland, near the shore, as far east as Ste. Anne-des-Monts, although not far beyond there the presence of residual soils and certain details of topography indicate that the coast did not suffer glaciation. Further than this, little is known about the glaciation, and more especially the de-glaciation of the Gaspé coast. In view of the probability that the whole lower St. Lawrence region was glaciated from the south, rather than from the Laurentides, it seems not unlikely that this great peninsula had a glacial history somewhat independent of the region to the west. Whatever that history may be, it is still well concealed by a forested wilderness of mountains. With the few facts now available, the theory of a relatively early de-glaciation of the north Gaspé coast can only be regarded as a working hypothesis.

As reported a year ago,[2] the elevated beaches between Quebec and Matane seem to be about alike in weakness of topographic expression, at all levels except the Micmac shoreline, 20 feet above the sea, which is a very conspicuous terrace and sea-cliff. The conclusion that was drawn last year, that "the coast seems to have emerged steadily from the very first," developing beaches among which none particularly excel in strength, seems to be contradicted by facts from the Gaspé coast, east of Matane: for there is at least one very strongly marked terrace and sea-cliff, intermediate in height between the Micmac shoreline and the one which lies on the plane of the "highest" beach of the Quebec district. This shelf and cliff, while naturally less sharp and fresh than the later Micmac shore, closely rivals it as a record of long continued wave-work on a stationary or subsiding coast. An observer in this field would scarcely hesitate to conclude that the post-glacial emergence of the north Gaspé coast was not steady, but subject to one or two interruptions.

It was my expectation, after reading the literature of the district, and following the raised beaches down the lower St. Lawrence, that the coast of Chaleur bay would furnish equally good records of wave-work and marine sedimentation, and at altitudes not far different from those of the neighbouring portion of the St. Lawrence, that is, from 150 to 200 feet. It was, therefore, both a surprise and a disappointment to find at all places visited between Campbellton and Gaspé basin no acceptable evidence whatever of wave-work above the altitude of 75 feet; and even below that, only faint records of it. At Gaspé basin, Port Daniel, and other places, there are gravel deposits with horizontal surfaces, which, while not records of wave-work, appear to signify at least conditions of submergence of the coast by the sea, to the depth of 50 to 75 feet, during which deltas formed at the mouths of the largest rivers, and some smoothing of the shallower portions of the shore took place. At Port Daniel the remnants of a delta deposit and faint beaches agree in fixing the upper marine limit at about 70 feet. On the equally favourable slopes above this altitude, only a sheet of the red boulder clay, containing striated stones, covers the ledges. At Grand river, the limit of submergence, similarly marked, is close to 50 feet. Dr. John M. Clarke, Director of the Geological Survey of New York state, has

[1] R. M. Chalmers. Surface geology of eastern Quebec; in Summary Report of the Director, Geological Survey, Canada, 1904, pp. 250-263.

[2] Geological Survey, Canada, Summary Report of the Director, 1910, p. 228.

kindly furnished me with detailed information concerning fossil-bearing beach deposits near New Richmond, which indicate former marine conditions at levels well below the 70 foot mark.

It is as difficult to account for the slight amount of post-glacial submergence of the east and south coasts of Gaspé as it is to explain the extraordinarily deep submergence of the north coast. On the south side, as on the north, there is nothing, apparently, to support the theory of local departure from that regularity in upwarping which is clearly registered by the beaches between Quebec and Matane. On the other hand, the faint and uncertain records of the Chaleur Bay coast agree fairly well in fixing the upper limit at about 70 feet. It seems likely that the Chaleur Bay district was covered by ice longer than the lower St. Lawrence, so that by the time the ice-cap disappeared from it the coast had risen all but about 70 feet of the net amount. This hypothesis is supported by the occurrence of many kames, especially near the mouths of the large rivers, as noted in detail by Chalmers.[1] These kames rise ordinarily to a height of 150 to 200 feet, and possess steep ice-contact slopes, as if they had accumulated in recesses against tongues of ice which were tributary to a large glacier in Chaleur bay, for some time after the ice-cover had gone from off the lowland coast of the St. Lawrence. The exposure of these kames is such that their steep ice-contact slopes would have been greatly flattened by the waves if the ice had not remained around them while the coast emerged from the sea. The satisfactory settlement of this question, like that raised in the discussion of the phenomena of the north Gaspé coast, must await a very thorough exploration and investigation of the glacial geology of the rugged wilderness from which the Restigouche, Cascapedia, and other glaciers seem to have issued.

Near Bathurst a well-defined upper limit to beach deposits was found at the altitude noted by Chalmers—viz., 195 feet. At Caraquet, likewise, the figures given for the upper marine limit, 138 feet, seem correct. Near Newcastle, search revealed no very strong mark of wave-work at the upper edge of the submerged zone; but the best one found, a gravelly spit at the mouth of the Bartibog river, was found to be 152 feet above high tide, instead of 125 to 150 feet, as Chalmers has put it.[2]

South of Newcastle, no satisfactory evidences of submergence at altitudes comparable to those already noted could be found, although localities described by Chalmers were visited, and an effort was made to determine the upper marine limit. Near Berry Mills station, and a few miles east of it, at the base of Indian mountain, morainic hillocks and kames were seen, which seem to possess nothing unusual, either in form or in structure, to mark them as of marine origin. The extensive sand-covered plain just west of Moncton, up to 100 feet or more, is probably a wave-swept feature; but no good place at which to measure the upper limit of this was found. At Shediac, and at Amherst, Nova Scotia, the evidence of submergence, likewise, was rather clear on the lower ground, where sands are extensive and deep; but distinct shoreline topography seems to be absent. Observations at St. John and Pennfield, New Brunswick, support Chalmers' statements concerning an upper marine limit there of about 225 feet.

## THE MICMAC SHORELINE.

The conspicuous terrace and sea-cliff, reported a year ago as extending with little interruption from the city of Quebec at least as far as Ste. Anne-de-Beaupré on the north side, and from Lévis at least as far as Matane on the south side of the

[1] R. M. Chalmers. Surface geology of northern New Brunswick and southeastern Quebec (Geological Survey, Canada, Annual Report, 1886, Part M, pp. 22-27.

[2] R. M. Chalmers. Surface geology of eastern New Brunswick, northwestern Nova Scotia, and a portion of Prince Edward Island, Geological Survey, Canada, Annual Report, Vol. VII, 1895, p. 23, Part M.

St. Lawrence, was again studied, and was traced with ease from Matane to Ste. Anne-des-Monts. This carries the Micmac shoreline fully 275 miles down the estuary. The same wonderful strength, and the same uniformity of altitude which characterize the terrace and cliff west of Matane, characterize it here, on the north Gaspé coast. Along the 25 mile stretch of bold, almost mountainous coast between Grand-Mechin and Ste. Anne, where great headlands like Cape Chat alternate with gently concave re-entrants behind which the upland rises less precipitously, the Micmac shelf extends with remarkable persistency. At the capes, it becomes narrow, but seldom disappears. When one considers the steep declivity of this coast, and the vigorous wave work which is going on there, it is surprising that a narrow shelf like this has not been completely cut away since its elevation from the sea. One is almost compelled to regard the emergence of the Micmac shelf as of very recent date. While the outer portion of the shelf, which is still under water, is much narrower along this bold coast than off the gentler upland west of Matane, it is sufficient menace to navigation to discourage, if not to prevent small freight steamers from making landings at the docks. Freight and passengers are transferred to small sail boats, a hundred yards or so off-shore. The largest rivers, like the smallest, enter the sea across ledges and reefs of rocks, having entrenched themselves but imperfectly beneath the surface of the Micmac terrace since its uplift. Still more striking as an indication of the recency of the post-Micmac uplift is the fact that the small streams, where they pass out through the Micmac sea-cliff to the terrace, come with abrupt descent, over cascades or falls. The larger rivers, like the Rimouski, Matane, and Ste. Anne rivers, have worn back their over-steepened channels very considerably, yet they, too, retain enough of the heritage of this recent rejuvenation to yield water-power for the great lumber mills around which the larger towns have grown up.

After discovering that this shoreline extended without change of strength or altitude from Quebec to Ste. Anne-des-Monts, 275 miles, I expected that it would be found at Gaspé basin, only a little more than 100 miles farther east. Owing to lack of time for a continuous journey by carriage along this difficult stretch of coast, and to the fact that the next steamer for Gaspé basin was not to leave until a week later, we returned to Matane and proceeded by rail to Campbellton, N.B., and thence to Dalhousie, where we began a search for elevated beaches along the north side of Chaleur bay, with Gaspé basin as the final goal. No trace of the Micmac shelf and cliff was found at Campbellton, Dalhousie, Carleton, nor, in fact, at any point on Chaleur bay. High cliffs of fresh rock are everywhere being cut back by the sea, and the platform below slopes off rapidly under water, allowing boats to come close in shore. This condition becomes more impressive eastward, as one passes out from Chaleur bay and around the east end of the Gaspé peninsula. A continuous wall of red and grey rocks, rising vertically from the water's edge, affords no hope of discovering any trace of a Micmac shelf and cliff. Even in the protected re-entrants, the cliffs are freshly cut and naked. The picturesque rock at Percé and the high capes beyond bear testimony only to the incessant attack of the sea on a coast which has certainly not been rising in recent times. While this coast may have been perfectly stationary during the period when the Micmac terrace was rising from out of the lower St. Lawrence, one is constantly tempted to adopt the view that subsidence, rather than stability has been the condition here for a long time—the cliff recession is so impressive, where crags stand 500 feet above the water, and at the same time, because the depth of water on the submerged shelf beyond is considerable.

To determine where the Micmac shelf disappears, in its course down the lower St. Lawrence, plans for the last week of the field season were changed, so as to allow the writer to take the trip from Gaspé basin, on the steamer "*Gaspesien*" around the cape, and along the north Gaspé shore, past Fox river, Grande-Vallée, and Ste. Anne-des-Monts. Fortunately, the trip was by daylight from Gaspé basin as far as Mont Louis; and fine weather allowed the boat to keep very close in-shore. The details of cliff and beach could thus be seen almost as well as from a moving carriage, though with the obvious disadvantage that no opportunity was given to set foot on the land—especially since the landings are accomplished by transfer to sail-boats, as already mentioned. From Cape Gaspé as far as Pointe Séche not a sign of a dry shelf at the foot of the precipitous cliffs was seen. Here, however, the cliff was observed to be turf-covered, and on the beach at the base were seen many fish houses, reached by long flights of steps from the houses which stand perched on the edge of the bluff. At Cloridorme, again, a line of fish houses was observed, strung along the foot of turf-covered cliffs, apparently out of reach of the storm-waves. In this re-entrant there seems to be no active recession of the cliffs, although the shelf, as well as I could judge, stands but little above the level of the sea. Similar suggestions of a low, narrow shelf appear at a number of points between here and Cape Magdalen. From the lighthouse at that point a very distinct terrace extends westward along the shore for fully a mile—to all appearances like the Micmac terrace along the coast west of Ste. Anne-des-Monts. From this series of observations, I am inclined to believe that the Micmac shoreline descends to sea-level somewhere in the vicinity of Pointe Séche, and that everywhere east and south from there it is submerged and destroyed. That the old shoreline should disappear, as it seems to do, within a distance of 75 miles from Ste. Anne, after continuing without change of altitude for 275 miles, is certainly surprising; but possibly the change in direction of the coast beyond Ste. Anne swings the line of observation into an oblique position with respect to isobases to which it has up to that point been parallel. If so, the isobases for the Micmac shoreline run almost at right angles to the isobases for the "highest" beach of the lower St. Lawrence.

## Modern Instability of the Coast.

In the last two or three years, the question of present upward or downward movement of the coast has received renewed attention, chiefly as a result of studies of salt-marsh structure by plant physiologists.[1] The discovery last year of the Micmac terrace, but slightly, and apparently recently elevated from the sea, suggested the desirability of a closer study of the modern shoreline of the Maritime Provinces, in order to sift the so-called evidences of modern subsidence, both botanical and physiographic. As indicated in the opening paragraphs of this report, a considerable share of our time was devoted to this work, the results of which will be presented in detail in a later paper, and will be discussed by Professor D. W. Johnson, in their relation to his own researches, both in North America and Europe.

As regards the lower St. Lawrence, the physiographic and botanical evidence suggest that the Micmac terrace is still slowly rising from the sea. The marshy shore, hardly scarred by the waves, the slight amount of intrenchment of stream and river channels where they cross the terrace, and the shortness of the gorges which they have cut back from the face of the Micmac cliffs—all these convey the impression that the elevation of the coast is still in progress. Had it ceased even a few centuries ago, one would expect to find the waves trimming back the shore more distinctly, and the streams better adjusted to the new base-level. If subsidence had set in since the elevation of the Micmac terrace, and were now in progress, the wave-cutting should be even more distinct, and the streams should possess channels deep enough at their mouths to admit small boats to enter without danger. The mixed salt and fresh water vegetation of the high-tide zone of the Micmac terrace supports

[1] C. A. Davis. Salt marsh formation near Boston, and its geological significance. Economic Geology, Vol. V, 1910.
W. F. Ganong. The vegetation of the Bay of Fundy salt and dyked marshes; an ecological study. Botanical Gazette, Vol. XXXVI, 1903, pp. 161-186, 280-302, 349-367, 429-455.

the view that emergence is still going on. Convincing proof of it, however, is yet to be found.

A variety of evidence has been adduced from New Brunswick to prove that the coast of that Province is now sinking beneath the sea. So far as I was able to find and test this evidence, it is questionable if not indeed fictitious. While, locally, there are signs of an increase in the height of the high-tide surface, killing trees which stand near the border of salt marshes, such cases are rare, and in some instances of uncertain value. The general absence of a dead fringe of forest trees around the edges of the salt marshes, in northeastern New Brunswick, is, indeed, rather an indication that no rapid subsidence is now in progress. Freshwater peat bogs reported to reach depths considerably below high-tide level, appear from soundings made this season to go down no farther than mean low tide. If the close approach to that limit is as general as the measurements in certain typical bogs suggest that it is, we have in these peat deposits reason for a belief in present stability rather than in present subsidence; for sphagnum and other peat-building plants might accumulate in basins whose floors extended to mean-tide level, and whose waters, consequently, were fresh, while they might not, under ordinary conditions, accumulate in deeper basins because of brackish or salty conditions. Modern subsidence, if continued for several centuries, should have lowered such bog floors to greater depths than that to which our borings indicate they extend. An instrumental survey of the beaches of Grande Plaine, on Miscou island, which are known from the presence of walrus bones to be a few centuries old, supports the opinion expressed some time ago by Chalmers, that these beaches record stable conditions of land and sea at the present time.

# PLACER GOLD ON MEULE CREEK, SEIGNIORY OF RIGAUD-VAUDREUIL, QUEBEC.

(*Joseph Keele.*)

## INTRODUCTION.

Placer gold mining was carried on in the Chaudière River valley during many years, the most active period of mining operations being included between the years 1863 to 1878. The Chaudière river is a northwesterly-flowing tributary of the St. Lawrence, heading near the Quebec-Maine boundary and joining the St. Lawrence not far above Quebec city. The gold-bearing territory, known as the Beauce gold district, borders the middle third of the river valley. Some of the ground was very rich, the Gilbert river, one of the principal tributaries of the Chaudière, for example, yielded nearly $2,000,000 in coarse gold in a distance of 2 miles, the gold being taken out principally by open-cut work. Much of the ground in the district though it carried good pay could not be profitably worked by individual miners, on account of the great thickness of over-burden lying on bed-rock—where mostly all the gold was found—the presence of underground water, and the large size of the boulders frequently encountered in the workings. Mining operations, however, were carried on until 1896, but were mostly unprofitable during this later period.

Recently a Montreal syndicate operating under the name of the Champs d'Or cie Rigaud-Vaudreuil, have acquired the mining rights on the territory known as the seigniory of Rigaud-Vaudreuil, comprising an area of 70,000 acres, and covering a great portion of the Chaudière valley and its tributaries, including Gilbert river. Prospecting was begun early in 1910 on Gilbert river, River des Plantes, Bras river, and Meule creek, using Keystone and Empire drills for piercing the gravels. As the prospects and water supply were favourable on Meule creek, the work of installing an hydraulic plant was begun there during the winter of 1910-11.

Only a few days were spent by the writer in this field, so that the following descriptions are incomplete.

A summary of the former mining operations carried on in this region was published by the Geological Survey in 1898.[1]

## GEOGRAPHICAL AND GEOLOGICAL SKETCH.

The region that includes the gold fields is a dissected plateau lying northeast of the more hilly portion of southern Quebec, and has a general elevation of 1,200 to 1,500 feet above sea-level.

The Chaudière river traverses the region in a northwesterly direction; it occupies a valley of considerable dimensions, and carries the drainage of the gold district into the St. Lawrence river, its mouth being about 8 miles above the city of Quebec.

The valley is underlain principally by grey and reddish Ordovician slates. These slates are penetrated by narrow bands of basic igneous rocks, which recur at intervals of one-half to 1 mile.

The wider parts of the valley occur where the comparatively soft slates have been eroded by the river, and the contractions are formed where the harder igneous bands project as spurs from each side of the valley walls. The valley is apparently an ancient one, as the river for the greater portion of its course flows without change

[1] Chalmers, R. Surface geology and auriferous deposits of southeastern Quebec.

in grade over hard and soft rocks alike. A mantle of unconsolidated material principally of glacial origin, is nearly everywhere present.

The valley of the Chaudière is rather thickly settled, and all the bottom lands and much of the side slopes are cultivated. Fairly extensive tracts of mixed timber still exist in the small tributary valleys, and on the upland, a quantity of pulp wood being produced annually from them.

The Quebec Central railway crosses the valley of the Chaudière at Valley junction, situated 43 miles southeast of Lévis, the railway's terminal point on the St. Lawrence. A branch line of this railway extends up the valley of the Chaudière from Valley junction for a distance of 56 miles.

The only mining now being done is on Meule creek, a tributary of Mill river, which enters the Chaudière opposite the village of Beauceville, 12 miles south of Valley junction.

The prevailing bed-rock seen in the creeks is composed of dark grey or red slates of Ordovician age. The cleavage of the slates is the most pronounced structure of these rocks, and is parallel to the bedding planes. The beds are also traversed, irregularly, by numerous joint planes at various angles to the cleavage. On weathering, the rock breaks down into thin slabs, wedge-shaped fragments, and splinters.

The slates have been disturbed from their original attitude, and the beds are now in a vertical position.

The slate bed-rock is penetrated at intervals by dyke-like sheets of diabase of 100 feet in width or more. These intrusive sheets may have originally been injected as sills between certain beds of the sediments while the latter were in their original horizontal position, the whole being subsequently dislocated until the formation stood on edge, and the intrusive sheets asumed the appearance of dykes. Enclosed within the diabase sheets are bands of quartz porphyry or porphyrite, of irregular width. Whether the porphyrite originated from the same magma as the diabase, or has subsequently eaten its way up through it, could not be determined without more extended observations. Both the diabase and porphyrite have schistose phases, and show considerable alteration in places.

Veins, stringers, and kidneys of quartz are often locally abundant in the intrusive bodies, but are by no means a persistent feature in them. In certain parts of the district, quartz veins are found traversing the slates and other sediments.

A mantle of unconsolidated material, principally of glacial origin, is spread nearly continuously over the region. The thickest deposits of boulder clay appear to occur in the narrow valleys of the tributary streams, while terraces of alluvial sand, gravel, and clay border the main river.

Pre-glacial deposits of sand, gravel, and clay overlying the bed-rock are still preserved on some of the side streams. These pre-glacial beds are of no great thickness, they are overlain by thick deposits of glacial drift, and their presence is only revealed during mining operations.

## Mining.

Meule creek is a small stream flowing in a narrow valley of rather steep grade, with heavily timbered side slopes. The gold is mostly all found on bed-rock, so that mining operations involve the removal of the overlying materials, and the hydraulic method is here used for moving these alluviums.

The workings in August, 1911, consisted of an open pit, made on the right limit of the creek, about half a mile above its junction with Mill river. At the time of the writer's visit, the operations preliminary to a clean up were being made after a month of hydraulicking. The plant in use is the first of its kind to be installed in this gold field, so that the results obtained from it are awaited with great interest.

Water for the monitors is obtained from Lake Fortin, a sheet of water which measures 1½ miles, by three-fourths of a mile in its extreme dimensions. A ditch nearly 7 miles long, of which distance about 4,500 feet is flumed, brings the water to a penstock, from which starts a rivetted steel pipe 18 inches in diameter tapering to 15 inches. At a distance of 1,400 feet from the penstock this pipe branches into two 10 inch lines, each 500 feet long, terminating in monitors or giants. One of these giants is used for cutting down the bank of gravel, and the other for driving the gravel through the sluice to the elevator pit, the fall from the penstock to the monitors being 260 feet.

The sluice leading from the hydraulic pit is about 100 feet long, and about 3 feet wide, and is floored with steel rails laid longitudinally.

At the end of the sluice a bucket elevator, equipped with a stacker, has been installed to handle the tailings and to save whatever gold was not caught in the sluice.

The tailings are raised 40 feet by the chain of buckets, each of which has a capacity of 1½ cubic feet. The buckets deliver the tailings into an elevated sluice, and the material is driven through it and stacked by a powerful stream of water supplied by a centrifugal pump electrically driven, having a capacity of 6,000 gallons a minute. Power is supplied from a steam-power house built near the railway station at Beauceville; it is transmitted to the field of operations by a copper transmission line, 8,000 feet long, at a voltage of 2,200, which is reduced by a transformer to 440 volts.

Many large boulders, too heavy to be moved by the giant, become concentrated in the bottom of the pit as hydraulicking proceeds. These are moved to one side and piled with a derrick, the power for this purpose being supplied by a Pelton wheel driven by a water jet.

The timbering of a shaft and drift are revealed at the bottom of the bank at the up-stream end of the hydraulic pit. These are the remains of the old workings of Coupal, who operated here on a small scale in 1896.

The overburden is heavy on the south side of the pit as the bank rises on this side and forms the lower part of the valley slope. The section revealed in this bank consists of 1 to 4 feet of yellow gravel and clay lying on bed-rock; above this and showing a fairly distinct unconformity with it, is 25 feet of blue boulder clay. Above the boulder clay is 10 feet or so of slide material, which is an unsorted mass of loamy clay, gravel, and rock fragments which has crept down the valley slopes.

The yellow gravel lying on bed-rock is composed chiefly of fragments of slate and diabase mostly angular, but with some well-rounded pebbles; this material is all in small pieces, none being over 6 to 8 inches in diameter, and all derived from the drainage basin of the creek. These gravels are mixed with a highly plastic, smooth, yellow clay, which is very different in colour and texture to any other clay found in the vicinity, either in the boulder clay or the later stratified clay of the river terraces.

These yellow gravels are probably remnants of pre-glacial or Tertiary accumulations, which, owing to their protected position in the bottom of narrow stream channels, escaped total destruction by the advancing ice-sheet during glacial times.

The boulder clay, which is the direct glacial contribution to the drift, is a mixture of pebbles, chiefly well worn and smooth, of diabase, porphyry, slate, granite, gneiss, and occasional fragments of serpentine. Boulders and blocks up to 3 and 4 feet in diameter are encountered in this deposit, the whole being bonded by a very compact gritty clay. Portions of this deposit do not break down very readily under the stream from the giant and have to be blasted.

The bed-rock surface exposed in the bottom of the pit shows the greater part to be dark grey slates of rather fresh appearance, having their cleavage running in the same direction as the flow of the stream. The slate is well-jointed in a direction across the flow of the stream, but the principal crevices are found in the cleavage planes. The gold is found wedged into these crevices to a depth of a foot or two.

There is a portion of a band of diabase and porphyrite, partly decomposed and crumbling, exposed along the north side of the pit; it forms a tighter bed-rock than the slate, and does not allow the gold to penetrate so far.

The bed-rock surface where cleared up is very uneven, ridges of the harder parts standing up a foot or so above the more weathered portions. The yellow clay was found to have been forced into the larger crevices and had to be removed by hand-picking, as owing to its smooth and sticky qualities the stream from the giant was unable to tear it out.

The hydraulic pit measured about 200 feet long by 100 feet wide, and the area of bed-rock cleaned up after one month's hydraulicking, was about 17,000 square feet. Of this area about one-third was said to have been worked out by Coupal, leaving an area of virgin ground amounting to 11,300 square feet.

The amount of gold recovered from this area is reported to be $7,500, or an equivalent of about 70 cents to the square foot of bed-rock. The amount of dirt moved amounted to 16,600 cubic yards, which would give 45 cents to the cubic yard.

The yellow gravels are said to contain some gold, but there is no doubt that the greater portion is on bed-rock, so that it is obvious that the less overburden to be removed, the more profitable the mining operations.

The black sand resulting from the final washing of the gold consists mostly of grains of magnetite. The quantity of fine gold carried over into these concentrates is so large that it might be worth while to install a small magnetic separator for its recovery.

## Origin of the Gold.

The gold so far found on Meule creek is all coarse, and varies in size from nuggets worth $150 to grains about the size of the head of a pin, but a considerable portion is about the size of flaxseed.

The gold is very smooth, many of the particles are flattened, and show signs of wear by prolonged attrition. There are a few rough pieces of gold, some with quartz still adhering to them, but these can be explained on the assumption that they had not been long enough released from a quartz fragment to become worn smooth.

The well worn appearance of the gold is generally supposed to indicate that it had travelled from some far distant source, and had suffered much abrasion from being transported by water in company with the usual alluvial material, but this, however, is not always the case with placer gold, as it may have a local source and still present this worn appearance.

The origin of the gold is obscure, as it seems to have no connexion with the bed-rock on which it lies. Locally the slates contain small cubes of iron pyrite, but no mineralization was observed in the intrusive portions. A large number of assays made from the quartz veins and intrusive rocks of this district, in former years, gave only small quantities of gold or none at all.

Various speculations have been made regarding the origin of the gold of the auriferous gravels. Logan and Hunt, the earliest investigators in the field, believed the original source of the gold to have been the so-called Pre-Cambrian crystalline schists of the district, and that from there the gold was set free during processes of degradation and laid down with the Cambrian and Ordovician sediments to be afterwards concentrated and eventually deposited with the gold-bearing gravels. Other investigators have endeavoured to connect the origin of the gold with that of the dyke-like igneous bodies found traversing the sedimentary strata of the region. Dresser has suggested that the gold of the placer deposits may have been directly derived from the basic igneous rocks (the Pre-Cambrian of Logan and Hunt) with which are associated the numerous copper deposits of the region which carry small values in gold.

An alternative hypothesis is that the gold originally existed in rich bunches of quartz stringers or kidneys in the intrusive rocks, but at a much higher level than where it is now found. These rich quartz kidneys were eroded down, but their gold content was left behind and concentrated in the drainage channels.

Owing to its gravity, coarse gold soon drops out of the current, and remains behind, while every particle of the rocks which originally contained it is eventually carried away.

The horizontal movement of gold lying in such a bed-rock as the creviced slates of Meule creek is very small, the vertical downward movement as erosion proceeds is the principal one.

The gold while passing downward during the various stages of erosion, becomes pinched and flattened in bed-rock cracks, is subjected to all manner of abrasion from the wash gravels, and is probably found now at not more than a few thousand feet in a horizontal direction from its source. But during this time it may also have travelled 1,000 feet or more in a vertical direction, which would be the principal factor in giving the gold the well-worn appearance which it now presents.

## Prospecting.

In future operations in this field a considerable portion of the mining costs are to be charged up against prospecting, as the old reports on the district indicate that the ground is "spotted," or in other words that the "leads" or paystreaks are not continuous.

If the gold originated in veins in the intrusive rocks, and if the rich veins were bunched in certain parts of the intrusive, while the greater part of it was barren, then the breaking down of such rocks would give rise to spotted ground. If the gold originated in these intrusive rocks, then the most probable places to repay prospecting would be on the downstream side of these rocks.

The bottoms of the narrow valleys of the tributary streams generally contain the richest concentrations of gold on account of the restricted area in which the gold accumulates.

There is a prevalent opinion that the valley bottom of the Chaudière must contain considerable gold, but this has not been proven, as the few shafts sunk there did not reach bed-rock on account of too much underground water.

The side streams do not contribute very much to the gold values in the main rivers, and in many cases the paystreaks on the tributaries do not reach down to the main valley at all.

All the gold that is liable to be in the main river valley may be restricted to whatever that stream itself has broken down from quartz veins which it traversed in its course.

The amount of gold-bearing veins broken down would probably be much more than those of the side streams, but the area of bed-rock over which the gold would be distributed in the main valley would be large.

Very little gold, only amounting to a few fine colours to the pan, is found in the boulder clay. The paystreak in any stream in the district, if it existed, was always found on bed-rock below a variable thickness of yellow gravel and clay, which are pre-glacial.

The extent and distribution of the yellow gravels throughout the region is unknown. Since they are always covered with a varying thickness of loose overburden, of a widely different character, their presence is only revealed in mining operations or by borings. So far, they have always been found resting on bed-rock, and in some cases they are actually composed of fragments of weathered and rotted bed-rock in situ.

They are generally regarded as being of pre-glacial age for the following reasons: (1) They contain no material having a source outside the drainage basin in which they occur; (2) no foreign material has been found underlying them; (3) they are overlain and sharply divided from deposits of glacial drift, or later stream gravels largely derived from the drift.

During some of the earlier prospecting in this field, the glacial drift was found resting on bed-rock, and, when this occurred, the gold was either absent or did not occur in paying quantities.

Whenever prospecting is carried on by means of the Keystone drill, the yellow gravels may be used as a guide. If hard rock is encountered, without having pierced the yellow gravels, it may probably prove to be a large boulder, and it would then be advisable to move the drill a short distance away.

No benches or rims of bed-rock at a higher elevation than the present streams, and carrying gold-bearing gravels have ever been located. Mr. Wm. P. Lockwood, who spent thirty years in prospecting over a great portion of this district, is of the opinion that no high-level, gold-bearing gravels exist here.

It may be noted in this connexion that remnants of old channels or terraces at high levels on the valley slopes would suffer greatly from erosion during glacial times, and that the gold in the boulder clay may be derived from that source.

Dredging in the wide flats at the mouths of tributary streams is proposed for this district. Before commencing operations of this kind, the ground should be thoroughly prospected with an Empire or other similar make of drill. The principal obstacles to the success of dredging here, will be the presence of large boulders, and the difficulty of recovering a great deal of the gold, if present, from the deeply-creviced bed-rock.

# GEOLOGY OF THE MONCTON MAP-AREA, WESTMORLAND AND ALBERT COUNTIES, NEW BRUNSWICK.

(*G. A. Young.*)

## INTRODUCTORY.

Because of the development taking place in the Stony Creek gas and oil field, situated about 8 miles south of Moncton, N. B., the writer was instructed to commence geological field work on an area embracing the petroleum field, and also the city of Moncton on the north, and, on the south, the gypsum quarries of Hillsborough and the oil-shale area of Albert Mines. In order that the origin of the important gypsum deposits of Hillsborough might be more fully treated from a chemical standpoint, Mr. H. E. Kramm was associated with the writer and devoted considerable time to the study of the deposits in the field. During the progress of this special investigation, it became apparent that for the proper solution of various problems raised, it would be desirable that Mr. Kramm visit some of the other gypsum deposits of the Maritime Provinces and, accordingly, with the sanction of the Director, he did. A summary report dealing with the results obtained by Mr. Kramm in his study of the gypsum deposits is appended. The writer, under instructions from the Director, also extended his field of operations beyond the district primarily being studied, and visited a greater part of the area over which the Albert oil-shales are known to outcrop. During the progress of field work, the writer was ably assisted by Mr. M. F. Bancroft.

While in the field, the party received favours from many persons. The writer wishes to acknowledge his particular indebtedness to Mr. M. Lodge, of Moncton, and to Mr. O. P. Boggs and other officials of the Maritime Oilfields Company, and, on behalf of Mr. Kramm, to Mr. C. J. Osman, managing director of the Albert Manufacturing Company.

## LOCATION AND AREA.

The Moncton map-area lies in southern New Brunswick; it is about 18 miles long in a north and south direction, about 12 miles broad in an east and west direction, and embraces a rectangular area of about 230 square miles. The northern boundary of the district lies just north of Moncton, while the southern passes about 5 miles south of Hillsborough; the eastern boundary lies about 2 miles east of Hillsborough, while the western passes just west of the upper waters of the west branch of Turtle creek.

The map-area is traversed from north to south by the Petitcodiac river which empties into Shepody bay, one of the two northeasterly-extending prolongations of the Bay of Fundy. Moncton and Hillsborough, the two chief centres of population of the district, are situated on the Petitcodiac; Hillsborough lying to the south almost in sight of the mouth of the river, while Moncton is situated to the north where the Petitcodiac, after flowing from its source in a general easterly direction, bends sharply and flows southward to the Bay of Fundy.

## PREVIOUS WORK.

The Moncton map-area includes part of two geological map-sheets—No. 1, N.E., Grand Lake Sheet, and No. 4, N.W., Cumberland Coal-field Sheet—both on a scale of 4 miles to 1 inch. The geology of the area represented by the Grand Lake Sheet is described in a report by Messrs. Bailey, Matthew, and Ells in the Report of Progress of the Geological Survey for 1878-79; the geology of the Cumberland coal-field map-area is described in a report by R. W. Ells, forming part E of the Annual Report, Vol. 1 (new series), of the Geological Survey. Various phases of the geology of the Moncton map-area are treated in Summary Reports of the Geological Survey, in Dawson's Acadian Geology, and elsewhere. Two reports have been issued dealing with the oil-shales of the Moncton map-area and adjoining districts. The first of these, by L. W. Bailey and R. W. Ells, appeared as part of the Report of Progress of the Geological Survey for 1876-77; the second, by the late R. W. Ells, was, in 1910, issued jointly by the Mines Branch and Geological Survey.

## Physical Features.

As regards its physical features, the Moncton map-area presents a considerable diversity since within it are portions of two contrasting physiographical provinces. One of these, the Carboniferous Lowland, forms the greater part of the southeastern half of the Province of New Brunswick and extends into Nova Scotia. Over this lowland area, the country seldom rises higher than from 200 to 300 feet above the sea, and for the most part is only gently rolling. The second physiographical province is that which may be called the Caledonia Upland, an elevated tract of country fronting on the Bay of Fundy and stretching northeasterly from near St. John city almost to the mouth of Petitcodiac river. Over considerable portions of this upland, the surface is comparatively level with general elevations of over 1,000 feet above sea-level. These two physiographical provinces were regarded by R. A. Daly as representing, in part, two peneplains: that of Caledonia mountain was supposed to be of Cretaceous age, while the Carboniferous lowland was thought to be of Tertiary age.[1]

In the Moncton map-area, the Carboniferous lowland is best exemplified in the neighbourhood of Moncton where the country is low and broken by gently-rolling slopes whose summits rise from 100 to 300 feet above sea-level. On the other hand, in the extreme south of the map-area, the northern edge of the eastern end of the Caledonia upland is represented by an elevated tract of country whose summit levels rise between 1,000 and 1,300 feet above sea-level. This border portion of the upland is broken and trenched by water courses, and its northern boundary, at many points, is marked by a series of relatively deep, east and west trending valleys.

Viewed from a commanding situation either in the lowland or upland area, the two physiographical provinces seem to be sharply divided from one another. When the country is traversed, however, or when a topographical map of the area is examined, it is found that, in reality, the two types of country merge one into the other. For instance, proceeding southwesterly from the Carboniferous lowland about Moncton, the summit levels of the country rise gradually higher and higher in the form of broad, relatively flat-topped hills penetrated and separated from one another by the valleys of minor streams, until, finally, about 15 miles south of Moncton the rolling top of Caledonia mountain is reached where the general level is about 1,000 feet higher than that of the neighbourhood of Moncton.

## General Geology.

### general statement.

The greater part of the Moncton map-area is floored by Carboniferous sediments ranging in age from Millstone Grit or mid-Carboniferous, to very early Carbonifer-

[1]Daly, R. A. The Physiography of Acadia; Harv. Coll., Mus. Comp. Zool., Bull., Vol. XXX, pp. 73-103, 1901.

ous as represented by the Albert series. Some writers have preferred to place the Albert series in the Devonian, but the palæontological evidence[1] favours the assumption that the series is of very early Carboniferous age rather than very late Devonian age. Of these Carboniferous measures, the younger strata, as represented by the Millstone Grit and immediately underlying measures, occur in approximately horizontal, unfaulted attitudes, while the older beds in many places, are faulted and tilted at various angles. The Carboniferous strata comprise a wide range of sedimentary types—conglomerates, sandstones, shales, limestones, and gypsum of varying compositions, colours, etc.—but all are relatively unaltered and in no instance were they observed to be penetrated by igneous bodies.

In the southwestern part of the map-area, over the included part of Caledonia mountain, an entirely different set of rocks outcrop. These appear to be largely of igneous origin, and at many localities have a schistose structure and present other characteristics indicating that they have been greatly modified in attitude and appearance. The original rock types appear to have been mainly volcanic varieties, both massive and fragmental, and both acid and basic, but dyke-like bodies of granite and diabase are also common. The plutonic rocks, as developed in the district, form relatively small bodies, but, to the west of the map-area, within the limits of the Caledonia upland, plutonic rocks—granite, diorite, etc.—have been described as forming large bodies, and true sediments—slates, crystalline limestones, etc.—have been noted at various places.

For the present it is proposed to apply to the rock complex forming Caledonia mountain, the term, Caledonia group. The rock assemblage is undoubtedly older than Carboniferous, and the rocks were deformed before the deposition of the Carboniferous measures, since representatives of the various rock types may be recognized as making up the conglomerates and other coarse detrital rocks of the bordering, in part, overlapping Carboniferous strata. The Caledonia group, in various preceding reports has been classed as belonging to the Pre-Cambrian, but in the present report, it is proposed to return to an older usage and to refer to it as being pre-Carboniferous since it seems not improbable that early Palæozoic sedimentary and igneous rocks may form an integral part of the rock complex.

TABLE OF FORMATIONS.

| | |
|---|---|
| Carboniferous | Millstone Grit group |
| | (unconformity) |
| | Intermediate group |
| | (unconformity) |
| | Albert series |
| | (unconformity) |
| Pre-Carboniferous | Caledonia group. |

(The group names in the above table are provisional only.)

SUMMARY DESCRIPTION OF FORMATIONS.

For various reasons, it seems inadvisable in the case of this report, to enter into a detailed description of the geology of the district except so far as is necessary to give some idea of the conditions under which petroleum and natural gas have been found.

*Caledonia Group.*

The modes of occurrence and distribution of the various members of the pre-Carboniferous, Caledonia group, do not seem to have had any bearing on the occur-

[1] Lambe, L. M. Palæoniscid Fishes from the Albert Shales of New Brunswick; Canada, Dept. of Mines, Geol. Surv., Memoir No. 3, 1910

rence of crude oil and natural gas in the Carboniferous strata except, that since the rock complex forming Caledonia mountain may have acted as a unit block during periods of folding and faulting, it may thus, in part, have guided the actions of these deforming forces and so, indirectly, influenced the formation or accumulation of the hydro-carbons. The pre-Carboniferous complex of Caledonia mountain appears to represent a part of the rim of the ancient basin in which were deposited the Carboniferous measures of New Brunswick.

### *Albert Series.*

The oldest member of the Carboniferous system in the district is the Albert series, a group of thinly bedded, usually dark coloured slates, calcareous slates, limestones, and sandstones. Enclosed in the above strata, whether or not at more than one general horizon has not yet been determined, are slate beds relatively rich in hydro-carbons and of a distinctive appearance. These, so-called, oil-shales when retorted yield varying amounts of crude oil and nitrogen—about 27 to 56 imperial gallons of crude oil, and about 30 to 112 pounds of ammonium sulphate per ton.[1] In these oil-shales and associated beds, in places, are numerous remains of fishes of the genus palaoniscus.[2] The hydro-carbons of the shales or slates are present, at least partly, in a solid state, forming a substance that in appearance resembles albertite, but, whatever the present state of the hydro-carbons may be, there are grounds for believing that they are essential, original constituents of the shales, that the oil-shales do not represent beds that have been saturated with oil originating outside of the shales and absorbed by them.

Former estimates of the total thickness of the Albert series have given amounts in the neighbourhood of 850 feet or, if certain conglomerates are included in the series, of 1,050 feet. This estimate seems to be too low, for wells lately drilled in this series, in the Stony Creek district, have penetrated a thickness of this strata of 1,800 feet without passing through the Albert measures which it is assumed are there approximately horizontal.

The Albert measures are exposed in a few, relatively small, isolated areas in the southern portion of the Moncton map-area. They outcrop along the flanks of Caledonia mountain in the southwestern corner of the district in the main and tributary valleys of the east and west branches of Turtle creek. The strata are exposed farther east over a small area about Albert Mines in the southeastern part of the map-area; they may also be seen farther north, just south of Stony Creek, for a limited distance along the western bank of the Petitcodiac river; and again, to the southeast of that locality, on the east side of Petitcodiac river in the valley of Downing creek.

The above-mentioned areas of the Albert series belong to a succession of similar areas occurring at intervals over a narrow zone of country, rarely more than 4 miles broad, that passes through the Moncton map-area and extends in an east and west direction for at least 30 miles—from beyond Elgin on the west to past Taylorville on the east. To the west of Elgin, strata occurring in rather widely separated areas have also been recorded as belonging to the Albert series.

The Albert series as exposed in the southwestern area about the head-waters of Turtle creek, has a general northerly dip at angles varying from 5° to 30°. In the Albert Mines area, the strata form a rather tightly compressed anticlinal fold, and in places, are vertical. As exposed along the shore of the Petitcodiac south of Stony Creek, the measures appear to be exposed along a section transverse to a flat anticline. Over the area to the southeast, in Downing Creek valley, the structure is not

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia; Part I, p. 17; Canada, Dept. Mines, 1910.

[2] Lambe, L. M. Paleoniscid Fishes from the Albert Shales of New Brunswick; Canada, Dept. Mines, Geol. Surv., Memoir No. 3, 1910.

so apparent: the outcrops there seem to belong to a series of neighbouring, in part separate, areas found to the south and also to the east in the valley of Memramcook river, in which, though in some places the measures form flat anticlines, in others they are faulted and tilted in various directions at comparatively steep angles. West of the Moncton map-area, the Albert series, as exposed at intervals as far west as Elgin, in some places has a gentle dip in a uniform direction while in others, the effects of powerful disturbing forces are apparent.

In connexion with the description of the Albert strata, mention may be made of the occurrence of the substance or mineral, albertite, as found in and adjacent to the limited area of the Albert series exposed at Albert Mines. Albertite, by many authorities classed with the asphalts and supposed to be a solidified form of petroleum, is a black substance, having a conchoidal fracture and a hardness of about 2 on the ordinary scale of hardness. It is easily fusible and readily ignites in an ordinary flame. It is essentially composed of hydrogen and carbon with about 3 per cent of nitrogen, 2 per cent of oxygen, and a trace of sulphur. The mineral occurs filling fissures, usually narrow, not only in the Albert series but in strata of the Millstone Grit and Intermediate groups. Most of the reported occurrences of such veins have been within a radius of a few miles from Albert Mines, but one occurrence, many miles to the westward, has been recorded. The only large vein of albertite ever discovered was found cutting the Albert strata at Albert Mines and has been worked out long since. This vein, it is said, was mined over a distance of about half a mile and to a depth of 1,100 feet or more, beyond which it became too narrow to be profitably worked. The vein was nearly vertical and followed an almost straight course along the general direction of an anticlinal axis in the country rock, but varied in width up to 15 feet and sent apophyses into the adjoining strata.

## *Intermediate Group.*

In certain cases, at least, the areas of Albert series are bounded by faults. In other cases, the strata of this series disappear beneath members of the younger Carboniferous divisions that for convenience in this report are referred to as forming the Intermediate group. This group may be defined as including all the Carboniferous measures between the Albert series and the base of the Millstone Grit group. A final decision concerning the succession and contents of the various divisions forming the Intermediate group has not, as yet, been made. The following statements, therefore, are intended to be only provisional.

The strata of the Intermediate group together with those of the Albert series, floor the narrow zone of country already referred to as stretching for about 30 miles from Taylorville on the east to beyond Elgin on the west, these two points being situated, respectively, east and west of the limits of the Moncton map-area. This zone is bounded on the north and east by the overlapping Millstone Grit group. The southern boundary of the zone, over the greater part of its course, is formed by the pre-Carboniferous complex of Caledonia mountain, but in the east, the area of the Intermediate group is prolonged beyond the limits of the district, first southward and then westward, around the end of Caledonia mountain.

What appears to be the lowest division of the Intermediate group holds as a characteristic member, a considerable thickness of red strata that in composition vary from an argillite to a limestone, are generally of bright brick-red colour but in many places are splotched or banded green, and in many localities lack distinct signs of bedding. With these rocks are associated reddish sandstones and conglomerates and, perhaps, grey and dark grey limestones and siliceous beds. Strata, such as the above, are exposed on Weldon creek and its tributary, Peck creek.

A second division of the Intermediate group, younger than the above, consists of coarse, heavily-bedded conglomerates and sandstones overlain by dark grey, thinly-bedded limestones which in places, as near Hillsborough, are capped by a considerable volume of anhydrite and gypsum.

A third, still younger member of the Intermediate group, is made up essentially of red conglomerates and sandstones succeeded by red and green argillites and argillaceous limestones.

The total thickness of these three divisions must surpass several thousand feet, but at present it seems inadvisable to attempt to give a definite statement regarding their thickness, especially as there is good ground for believing that the various series are only partially represented in the Moncton map-area.

The strata of the Intermediate group, like those of the older Albert series, in places lie with high angles of dip; in other localities they are nearly horizontal, and in such cases different divisions may appear to succeed one another conformably, as if without a break, although there is indirect evidence to indicate that prior to the deposition of each succeeding division, the strata of the immediately underlying division had been eroded in no inconsiderable degree.

### *Millstone Grit Group.*

Younger than the Intermediate group, is an assemblage of strata usually classed as forming the Millstone Grit formation, but which in this report is provisionally considered as forming a group. These measures have already been described as forming the northern and eastern boundary of the zone of the Intermediate group and the Albert series that laps around the pre-Carboniferous rock complex of Caledonia mountain. The Millstone Grit rocks floor the greater part of the Moncton map-area and extend continuously over a large part of New Brunswick.

Unlike either the Intermediate group or the Albert series, the Millstone Grit group seems to represent a period of continuous deposition and, in a striking fashion, the strata seem to have escaped the action of any pronounced earth movements and still lie almost horizontally, the beds forming wide arches whose limbs seldom dip at higher angles than 5° or 10°. The only observed exception to this general horizontal attitude of the measures, was at Dorchester, east of the Moncton map-area, where, over a considerable area, the Millstone Grit beds have an angle of dip of from 15° to 25°.

Although there is every reason for believing that prior to the deposition of the Millstone Grit strata, the older Carboniferous beds were severely eroded, and had passed through periods of at least locally pronounced earth movements, yet at a number of localities there is little or no direct evidence of such having been the case, and at different points the Millstone Grit strata seem to regularly and conformably succeed different divisions of the Intermediate group and even of the Albert series.

The strata of the Millstone Grit group are, in general, of the nature of quartzose sandstones and conglomerates; shales occur, but not nearly so abundantly as the other varieties. Over wide areas, the rocks are uniformly light-coloured, usually light yellow, but in some areas, beds with a more or less pronounced red colour are abundant.

To the writer, it appears that the strata of the Millstone Grit group are naturally divisible into at least two divisions. The higher of these two divisions consists of a quartz conglomerate overlain by a quartz sandstone. Both types of rocks are light-coloured, weathering yellow. The conglomerate is usually crowded with smooth, rounded pebbles of white and variously tinted quartz lying in a sandy, in part, calcareous base. This conglomerate with its distinctive characters, and the overlying sandstones, were noted at various points within the Moncton map-area. The same conglomerate, or a very similar one, has been described as being present at many places over the wide extent of the Carboniferous area of the Maritime Provinces.

Whether in all cases the strata belong to the same horizon is not apparent, but, in the Moncton map-area and adjoining districts, it is believed that the conglomerate always marks the same horizon.

At some places, as at Hopewell cape, the above conglomerate may be seen resting directly on a division of the Intermediate group, but in other cases of which, perhaps, the best examples are found outside the limits of the Moncton map-area, there is interposed between the base of the Millstone Grit quartz conglomerate and the top of the underlying strata of the Intermediate group or the Albert series, as the case may be, an assemblage of sandstones and argillaceous beds that seem to form the lower division of what, in this report, has been termed the Millstone Grit group. This lower division, as developed more particularly in the districts immediately east of the Moncton map-area, seems to occur filling depressions—old valleys formed by the active erosion preceding the Millstone Grit period. The strata of the lower division may be described as having levelled the ancient, pre-Millstone Grit surface preparatory to the laying down in a practically continuous sheet, of the quartz conglomerate of the upper division of the Millstone Grit group.

The lower division of the Millstone Grit group, as above defined, shows a considerable variation in lithological characters. In some places the beds are largely of pale grey, rather fine-grained sandstones with only occasional red beds. In other places, as exposed on Stony creek, the strata comprise quartz conglomerates, coarse and fine, light-coloured sandstones, and red and green argillaceous and calcareous shales.

In the northern half of the Moncton map-area, rock exposures are very scarce and no definite conclusion has yet been reached as to what formations are there represented. A very few outcrops of the characteristic quartz conglomerate of the upper division of the Millstone Grit were seen, but elsewhere were found various reddish sandstones, red shales, and red argillaceous limestones that probably belong either to the lower division (as defined above) of the Millstone Grit group or to a third and higher division overlying the grey quartzose conglomerate, but possibly in part or in whole, may belong to divisions of the Intermediate group.

The thickness of the Millstone Grit group varies. The greatest thickness of the strata of the upper division as found in the territory examined was not above a few hundred feet. The lower division from its mode of occurrence—filling up depressions in the pre-Millstone Grit surface—is wanting in places, in others is very thin, and in other instances may have a thickness of several hundred feet. On the whole, it is not believed that the strata of the Millstone Grit group as developed in the territory under review, anywhere attains a thickness comparable with that found in various districts of Nova Scotia, and that, in general, the Millstone Grit beds form a comparatively thin mantle resting on and covering the variously disturbed and eroded members of the older divisions of the Carboniferous system.

## Economic Geology.

Information relative to the important gypsum deposits of Hillsborough is given in the appended report of H. E. Kramm. Accounts of other economic deposits, such as the bog manganese of Dawson Settlement, are deferred to the final report. The possibilities in connexion with the establishment of an oil-shale industry in the region have been dealt with by the late R. W. Ells in a recent report,[1] and need not be more than incidentally referred to in this report. It is proposed, however, to briefly outline some of the main points in connexion with the history and results obtained by various companies that have engaged in the production or search for crude oil and natural gas within the Moncton map-area and adjoining districts.

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia; Canada, Dept. of Mines, 1910.

PETROLEUM AND NATURAL GAS.

*History of Development.*

Some time between 1854 and 1856, Abraham Gesner, at one time provincial geologist of New Brunswick, noticed the oil-shales of the Albert series as exposed in the eastern part of the belt over which they occur and, by retorting them and re-distilling the product, he obtained a burning oil. Following this discovery, a company was organized to work the oil-shales of Taylorville and a refining plant was erected at St. John. Prior to this, however, in 1894, the substance albertite was found filling a large vein in the area of the Albert series at the locality now known as Albert Mines. After the conclusion of a series of law suits, during which the material was adjudged to be a coal, the deposit was actively exploited; and since albertite yielded from 130 to 135 gallons of oil per ton, while the oil-shales of Taylorville only gave about 35 gallons per ton, the enterprise of mining these oil-shales was abandoned. Subsequently, however, shipments of the oil-shales of Taylorville were made, and about 1862, a plant was erected on the upper portion of the east branch of Turtle creek, about 12 miles west of Taylorville, to treat the oil-shales there developed. With the opening up of the great oil-fields of Pennsylvania and elsewhere, practically all attempts at the mining of the oil-shales ceased. Of late years attention has again been attracted to the oil-shales of the Albert series; the previously unknown or unappreciated fact that under suitable treatment the oil-shales are capable of yielding not only crude oil but also sulphate of ammonia, making their economic development a possibility. The mining of albertite, unlike the mining of the oil-shales, proved to be a profitable industry and continued until about 1876, when the deposit, a true fissure-filling deposit and not a coal, was worked out and mining ceased.

The character of the oil-shales and the presence of albertite, together with other phenomena, naturally suggested to such as were acquainted with the region, that crude oil also might be present in the Albert strata. This idea was further strengthened by the fact that over the district lying south of Dover and between the Petitcodiac and Memramcook rivers, the early settlers were frequently annoyed by finding on their farms beds of maltha, in some cases covering acres to a depth of from 1 to 18 inches. These various phenomena being known, some time between 1850 and 1860, certain oil men from Pennsylvania became interested in the district and three shallow wells, the deepest not over 190 feet, were sunk in the Albert series. In each of the three wells small quantities of oil and considerable volumes of gas were found, but owing to lack of money the enterprise was abandoned.

In 1876 or 1877, interest was again aroused in the possibilities of the Dover-Memramcook field, and during the next two or three succeeding seasons, seven wells were drilled at various localities in the district. Six of these wells either started in the Albert rocks or else entered them after passing through a thin cover of younger strata. The seventh well, which proved to be a complete failure, was drilled entirely in strata younger than the Albert series. The wells were drilled to depths of from 1,000 to 1,900 feet, and in all, except the one above mentioned, considerable volumes of gas were found, and in the case of two wells, oil in considerable quantities was obtained, one well yielding at the rate of 20 barrels per day for some three or four days. For financial reasons this enterprise also was abandoned.

In 1901, the New Brunswick Petroleum Company began operations in the Dover-Memramcook district, and in the course of about five years drilled about eighty wells, most of which were located directly on outcrops of the Albert series or penetrated these rocks after passing through a thin cover of overlying strata. Most of the wells drilled were shallow wells sunk only to depths of between 300 and 600 feet, but, in all, the Company pumped from them between 9,000 and 10,000 barrels of oil.

In 1909, the Maritime Oilfields Company, the Company at present operating in the region, entered the field, first drilling a few wells east of the Petitcodiac, but afterwards confining their efforts to a district on the west side of the river just south of Stony Creek. Their first well in the Stony Creek field was drilled to a depth of 1,728 feet, mainly in the Albert series, and yielded oil at the rate of about two barrels per day and gas at the rate of about 300,000 cubic feet per day.

In all the Company has drilled twenty-two wells into the Albert series in the Stony Creek field, three of which were not completed, but all of the remaining nineteen yielded oil or gas. In 1910 the amount of oil pumped from the wells then completed was 1,485 barrels, but no effort has been made to develop the full capacity of the wells as oil producers since the great volumes of gas encountered warrants the treating of the field as a gas field. In the autumn of 1911 the Company had partly completed a pipe-line to Moncton, 8 miles distant, and hoped before the close of the year to be in a position to supply the town with gas fuel.

Figures are not at hand for a reliable estimate of the total amount of gas already available. From seven of the wells the total calculated yield, as derived from measurements made with a Pitot tube, was nearly 4,000,000 cubic feet per day, the closed pressures of the individual wells varying from 20 to 200 pounds per square inch. From the remaining twelve completed wells, varying results were obtained. One well had a closed pressure of 525 pounds, rising in three days' time to 610 pounds, and an estimated flow of 3,695,000 cubic feet per day; a second had a closed pressure of 475 pounds and an estimated flow of 8,893,000 cubic feet per day; and a third had a closed pressure of 560 pounds with an estimated capacity of 6,417,000 cubic feet per day. In these three cases, the volume was estimated from observing the rate of rise of pressure at minute intervals. As regards oil, in the case of one well, 60 barrels accumulated in 20 hours; from another after an interval of 7 days, 87 barrels were pumped; while a third gave an estimated yield of 40 barrels in 25 hours. The above figures have been taken from records furnished by the Company.

## Stony Creek Field.

The present developments of the Stony Creek field are confined to an area about 2 miles long by 1¼ miles broad, fronting on the west bank of Petitcodiac river and lying between Stony Creek on the north and Weldon Creek and its tributary, Hiram creek, on the south. Between the two creeks the land rises rather rapidly from the level of the tidal river, to a height of about 460 feet above mean tide, then gradually drops in a westerly direction for a vertical distance of about 200 feet to a transverse valley, beyond which it again gradually rises to above 400 feet above sea.

Four of the wells of the Maritime Oilfields Company are on the steep east front of the hill, the remaining nineteen are scattered over the top of the hill, the transverse depression, and beyond on the second rise.

Along the river front, at low water, strata of the Albert series are visible, apparently arranged in a flat anticline whose axis presumably strikes in a westerly direction. To the north, following westerly up Stony creek, are outcrops of gently dipping strata of what are regarded as the lower division of the Millstone Grit group. To the south, in the valleys of several minor streams and in those of Weldon creek and its tributary, Hiram creek, beds belonging to the Intermediate group are exposed; these measures in the neighbourhood of the wells are almost horizontal, a short distance south they are inclined at high angles. The top of the hill and the country to the west are believed to be floored by the upper portion of the Millstone Grit group. Thus the Albert series outcropping along the eastern base of the hill, extends westward into it, as shown by the borings, and is overlain towards the south by strata of the Intermediate group, towards the north by strata of the lower division of the Millstone Grit group, while in the area of the main hill, these two overlying divisions are themselves covered by the upper division of the Millstone Grit. The exposures indicate, in general, that the measures of all the divisions have relatively gentle dips.

The wells stand at elevations varying between 250 feet and 460 feet above sea-level, and in depth they range from 1,200 to 2,060 feet. After passing through a thickness of overlying formations usually amounting to about 350 feet, they enter the Albert series, of which a maximum thickness of 1,800 feet has been penetrated without encountering any signs indicating the approach of the base of the formation.

The strata of the Albert series, as found in the various wells, consist mainly of thinly-bedded, shaly beds, usually black or dark green in colour and varying in composition from an argillite to a limestone. Besides the shaly strata, fine-grained quartzose sandstones are comparatively common, the number of individual sandstone beds in a single well varying between 3 and ·15. In thickness the individual sandstone beds vary from a few feet to 100 feet or more. There is a rather general tendency for the sandstone beds to occur in groups, in a number of instances three such groups separated by intervals of from 150 to 350 feet of shales, being encountered in a single well. The aggregate thickness of a single group of sandstones may rise to 180 feet, but more often lies between 30 and 90 feet. The individual beds of a group of sandstones may be separated by shaly layers varying in thickness all the way from a few feet to 30 or more.

Though slight traces of oil or gas have been found in the shaly beds and, in one instance, in strata overlying the Albert series, the oil and gas are confined, practically, to the sandstone beds in the Albert series. In the case of one well which the drillers recorded as apparently passing through disturbed, broken strata, practically all the sandstones are free from oil or gas. In the producing wells, a small number of sandstone beds do not afford any trace of oil or gas. Usually the number of such dry beds is small in comparison with the total number of sandstone beds in a well; and the dry beds, as a rule, occur towards the top of the well, but such beds are also recorded as occurring beneath others with showings of oil or gas. Usually by far the greater number of the sandstone beds are recorded as at least showing oil or indicating the presence of gas, and in some of the wells, sandstone beds of two different horizons yield large volumes of gas.

In the case of about one-half of the number of the wells, all the sandstone beds (except such as are dry) of each well are recorded on the logs as being either all oil sands or all gas sands. In the remaining cases, oil and gas sands irregularly alternate or they occur in two groups of which, in some wells, the oil sands form the higher group while in others the gas sands form the higher groups.

In two wells, strong flows of salt water were recorded. In one case the salt water was struck near the bottom of the well, being first met in a 12 foot sandstone bed lying 68 feet below an oil sand that, with other immediately overlying sands, yielded oil at the rate of 5 barrels per day. In the second instance, after having passed through two sands, both giving indications of oil, and one giving a small show of gas, a salt water sand was struck at a depth of about 810 feet. This well was continued to a depth of 1,250 feet, and in the additional distance of 440 feet passed through four beds of sandstone with an aggregate thickness of 245 feet, but which were barren of oil or gas except in the case of the lowest bed which was said to give a "show of gas."

At present the study of the logs and samples of drillings of the wells is not sufficiently far advanced to permit of drawing deductions bearing on the general structure of the oil and gas-bearing strata, or on the question of the possible equivalency of the various sandstone beds of the different wells. Possibly, as certain lines of reasoning at least suggest, it may be found that the sandstone beds are of the nature of lenses.

### *Mode of Origin of Oil and Gas.*

A consideration of the question of the possible extension of the area of the field or of the existence of other gas and oil-fields in adjacent regions, inevitably leads to the postulating of some mode of origin and method of accumulation for the crude oil and gas. In the present report it would be inadvisable to write at length on the subject or to review or attempt to weigh the various theories that have been propounded concerning the origin of oil and gas. The writer may only state that to him, the most satisfactory hypothesis concerning the origin of oil and gas in this particular field, is that which premises a common origin for the two and a derivation chiefly or wholly from the destruction of animal remains. It is also believed that world-wide experience has shown that, whatever the reason or reasons may be, oil and gas tend to accumulate near the axis of the anticlines or where sudden changes of dip occur in strata otherwise possessing a uniform dip, although instances are on record where the situation of accumulations of oil and gas seem to bear no reference to the structure of enclosing strata. A third assumption, perhaps involved in the preceding one, is, as experience has shown to be the case in many districts, that individual pools are usually much longer than broad and usually are grouped along rudely parallel straight or curving lines.

In describing the Albert series, the presence of oil-shales, rich in hydrocarbons and carrying numerous fossil fish remains, was pointed out, and it was stated that there were reasons for believing that the hydro-carbons are indigenous to the shales. Such conditions, or such assumed conditions, naturally favour the assumption that in the present case at least, the oil has been derived from organic remains and, probably, principally from animal remains.

Adopting the hypotheses and applying the assumptions made above, the conclusion is reached that the oil-shales proper and the associated dark shales, so characteristic of the Albert series, are the original source of the crude oil and gas now found in the oil and gas sands of the Albert series. In other words, it is concluded that the true home of the oil and gas accumulations is within the Albert series; this conclusion does not negative the possibility of oil or gas pools existing in some places in strata other than the Albert series since it is possible that parting or fracture planes, etc., may in places have afforded a channel whereby the oil or gas may have passed into other strata.

The above statement of conclusions is, perhaps, only a circuitous method of expressing the fact that, in New Brunswick, so far as experience goes, crude oil, natural gas, and oil-shales are confined to the Albert series.

## Possible Existence of Other Gas and Oil-fields.

The extension of the Stony Creek oil-field or the finding of other oil-fields in this part of New Brunswick would, for the reasons outlined in the preceding section, depend on the distribution and extent of the Albert series; on whether the oil-shales and allied strata are co-extensive with the Albert series; and on the presence or absence of conditions favourable to the formation of pools.

Until the study of all available information is completed, it would be unwise to attempt to state how far these general conditions appear to be complied with in the case of the areas where the Albert series is actually exposed. It seems permissible, however, to put forward some generalized conclusions dealing with the possibility of oil or gas accumulations existing in regions adjacent to the Stony Creek field, but over which the surface rocks belong to the flat-lying Millstone Grit group and so effectually conceal the underlying strata.

The fact that the Albert series is known to outcrop at intervals over a length of more than 30 miles, and possibly over a much greater distance, and since, though locally closely folded, the strata on the whole have low angles of dip—indicating that through crumpling there has not necessarily been much narrowing of the original width of the basin of the Albert series—it seems not improbable that the strata or remnants of the strata may extend in a northerly direction beneath the covering of younger strata to a much greater width than the present outcrops show.

Furthermore, on the hill known as Lutz mountain lying a few miles north of Moncton, there are exposed tilted strata resembling the Albert series. Though from the lack of good exposures and the lack of fossil evidence it has not been possible to settle beyond doubt that these beds of Lutz mountain do belong to the Albert series, yet they may be held to furnish corroborative evidence indicating that the Albert series does extend at least that far north beneath the covering of Millstone Grit and other formations, and that the basin of the Albert series has a width of at least 25 or 30 miles.

As regards the extension of the Albert series in an east and west direction, the late R. W. Ells has recorded[1] his belief that the Albert series are the equivalents of certain strata exposed as far west as the neighbourhood of St. John city and possibly even farther west. If this correlation holds true it is also equivalent, in some measure, to setting a limit to the extension of the oil region in that direction, for there oil-shales no longer occur in the strata, but that the bituminous strata do extend beyond Elgin is indicated by the report long ago of the finding of small veins of albertite (solidified petroleum?) 30 miles southwest of Elgin. The possibilities of the extension of the Albert series to the east beyond the outcrops in the valley of the Memramcook, the last in this direction, can only be definitely determined by borings, since in that direction the Albert series disappears under a continuous mantle of Millstone Grit and overlying younger strata that extend to Northumberland straits. It would, however, be a rather remarkable coincidence if the eastern limits of the outcrops of the Albert series should also mark the eastern end of the basin of this series. It seems more probable that the Albert series does occur for some considerable distance to the eastward beneath the cover of younger measures.

There thus seems to be good grounds for supposing that the basin of the Albert series extends for at least 50 miles from beyond Elgin on the west to beyond the valley of the Memramcook on the east and, less certainly, that it has a width of at least 25 or 30 miles from the foot of Caledonia mountain northwards. Of course, during the periods of erosion in early Carboniferous time, the Albert series may have been swept away from a considerable part of this area once possibly occupied by it.

Granting that the Albert series was and is still present, though largely concealed, over a region as large or larger than the one rudely outlined above, it does not follow that oil-shales and the associated bituminous beds occur everywhere in the Albert series of this area. Not only may the richer bituminous shales have been removed by erosion from considerable areas, but also since the oil-shales possess rather exceptional characters, it is entirely probable that their distribution is more limited than that of the containing strata. There are indications that in a westerly direction, Elgin approximately marks their limit, for in the western part of the field the quality and amount of the oil-shales seems to decrease. On the other hand, the oil-shales of the Memramcook valley in the easternmost exposures of the Albert series, are as rich in hydro-carbons as any found elsewhere, and, therefore, it seems safe to assume that if the Albert series continues eastward beneath the there continuous covering of Millstone Grit and younger strata, the oil-shales will also extend eastward.

As to what are the conditions necessary for the accumulation of gas and oil in pools, other than the presence of the oil-shales and a suitable reservoir, it is difficult, if not impossible, to state. Doubtless an anticlinal or analogous structure and the absence of unsealed partings, fissures, and fractures, and other channels by which the oil or gas might be dissipated, are also necessary factors.

As to how far these conditions prevail in those areas where though the Albert series may exist it is hidden by younger formations, it seems impossible to say, and positive proof of the presence or absence of oil and gas can only be obtained by drill-

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia, Part II, pp. 10-21; Canada, Dept. of Mines, 1910.

ing. The only conclusions of practical value that it seems possible to arrive at are doubtless such as have already suggested themselves to, and have influenced the officials of the Maritime Oilfields Company: (1) The existence of oil and gas having been proved in the Stony Creek field, future development work should first take the form of a carefully planned attempt to develop the full extent of the field; (2) in anticipation of the future exhaustion of this field, exploratory work carried on by drilling should eventually be commenced in an endeavour to locate another field in adjacent regions; in carrying out this exploratory work it would be necessary to sink a certain number of wells, not altogether in the hope that they might produce oil or gas, but in order to obtain a knowledge of the structure and character of the underlying strata. In attempting to extend the limits of the present field and in attempting to find new fields, advantage should be taken of the widely applicable rules that individual fields are usually much longer than broad, and that the individual fields or pools are usually grouped along rudely parallel lines. In the present instance, there is a strong probability that some such policy as the above may be carried out, since all the prospective oil and gas territory of New Brunswick is held under a single control.

# GYPSUM OF NEW BRUNSWICK.

(*H. E. Kramm.*)

## INTRODUCTORY.

The writer spent the latter part of June, all of July, and the greater part of August investiagting the origin of the gypsum deposits of New Brunswick.

In all eight weeks were spent in the field, of which three were devoted to a study of the deposits at Hillsborough, two weeks were spent in investigating and mapping the deposit at Petitcodiac, ten days were consumed in visiting other quarries and outcrops in New Brunswick, and the remainder of the time was devoted to a comparison of the gypsum of Nova Scotia with that of New Brunswick. The quarries visited in Nova Scotia were those near Windsor, at McKinnon Harbour, at St. Ann, and Eastern Harbour. During the greater part of the time the writer was efficiently assisted by Mr. A. K. Willis, of St. John.

## HILLSBOROUGH.

The Hillsborough deposits are mentioned in a number of the earlier publications of the Geological Survey, the most complete descriptiou being given by Bailey[1] in 1898. He has also described the general geological relations which were verified by the writer.

The deposits are associated with the rocks of the lower Carboniferous series and occupy a position in the upper portion of this group.

Red conglomerates composed of slightly waterworn angular fragments of metamorphosed rock, fairly well consolidated, carrying interbedded thin strata of a red sandstone, outcrop along the western bank of the Petitcodiac. South of Edgett Landing a slight dip towards the south can be observed in the interbedded sandstone. Near Hopewell cape the action of the tides in the Petitcodiac has undermined the banks of conglomerate, isolating portions of it and causing them to stand out in grotesque and fantastic shapes, that are locally known as "the rocks."

The conglomerate is overlain by a limestone which reaches a thickness of about 40 feet. It is of a greyish colour, due to impurities, is well crystallized, and has almost slaty cleavage. A slight dip about 5° to the south can be observed at a place near Edgett Landing where the limestone has been quarried. No indication of fauna or flora was observed by the writer in this limestone, and if such originally were present, they have been obliterated during the crystallization of the limestone. At the point of exposure noted above, the limestone is seen to dip under the bed of gypsum and anhydrite, but the direct contact is masked by the mass of overburden. Anhydrite and gypsum overlie the limestone. The total thickness of the bed is perhaps 250 feet. Gypsum usually forms a capping of varying degrees of thickness on the anhydrite.

While all of the above beds are apparently in conformity with each other, the gypsum and anhydrite bed is unconformably covered by quartz conglomerate and interbedded, coarse-grained, grey freestone of the Millstone Grit. In places red conglomerate, sandstones, etc., intervene between the gypsum beds and those of the Millstone Grit.

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[1] The Mineral Resources of the Province of New Brunswick, No. 661, 1898, pp. 84-100.

The surface in general is covered by an overburden of residual soil, and this, together with the unconformity and considerable faulting, make geological relations somewhat obscure.

The area of gypsum and anhydrite which actually outcrops covers approximately 1½ square miles. Considerable quantities of gypsum are, however, covered up by Millstone Grit or carry an overburden of soil and rock debris, the presence of the gypsum being indicated by numerous sink holes. A fault line which runs approximately north and south appears to limit the deposit towards the west, while other fault lines probably limit it towards the south.

The gypsum is usually of the massive crystalline variety, although it is possible to find other varieties in the deposit. It ranges in colour from colourless to pink and grey. The colour is the result of impurities of which calcium carbonate, oxide of iron, and organic matter are the most prominent. The bedded nature of the deposit is shown by seams of impurities, which can be found in the anhydrite as well as in the gypsum and which were laid down along parallel planes.

Considering the gypsum deposit in a general way, four zones may be recognized.

The first zone is on and near the surface and is in evidence only where gypsum outcrops, being thus exposed to the action of the atmosphere. The gypsum is brittle, more or less broken up, and crumbles easily into small fragments. The action of surface waters has caused a concentration of impurities by carrying off the pure gypsum, which is comparatively soluble, and by carrying in matter mechanically. This zone is not pronounced where the gypsum is covered by clay or soil.

In the second zone the gypsum is more massive and tough. Within the solid mass can be found numerous crystals of selenite which are of a secondary nature. It is found most abundantly along joint fissures, and because it cleaves into plastic plates which resist fine grinding it is considered as "not desirable" by the quarryman. The quantity of these crystals gradually diminishes with depth.

The third zone consists of the crystalline massive variety of gypsum. The lower part of it contains lenticular bodies of anhydrite, in some cases entirely surrounded by gypsum, in others leading into the solid mass of anhydrite which underlies the gypsum and constitutes the fourth zone.

Gypsum is exposed to the south of Hillsborough in a number of places. The following places were visited and samples of the gypsum obtained.

### Curryville.

To the north of Curryville the limestone which underlies the gypsum comes to the surface and has been calcined and is utilized.

A gypsum quarry is being operated at the present time in close proximity to the Salisbury and Harvey Railway track. The rock is massive in character, rests upon anhydrite, and is covered by an overburden of considerable thickness carrying the characteristic pebbles of Millstone Grit.

Outcrops of anhydrite and gypsum are also found a fourth of a mile to the southwest of the above quarry. They cover a considerable area and reach a maximum height of about 100 feet. Here the surface waters have leached out a cavity in the anhydrite, which is partly filled with water and is said to have an extent of 6 acres.

### Woodworth Settlement.

Two quarries were being operated on a small scale several years ago on the gypsum outcrops of this locality. All that remains to be seen at the present day are the cavities from which the gypsum was taken, and in one of them some boulders of anhydrite are exposed. Aside from these there are no indications of the presence of calcium sulphate, the whole being effectually covered up by Millstone Grit.

### Hopewell Cape.

Gypsum occurs at Hopewell Cape, but is not exposed through the overburden of soil and Millstone Grit. Prospecting work, to determine its quality, has been done, and about 200 tons of the rock have been quarried and are on the dump. The gypsum is massive and of excellent quality.

To the southeast of Hopewell Hill, on the Salisbury and Harvey railway, about one-half mile from the shore of Shepody bay, gypsum was mined on a small scale, but no work is done at the present time and no gypsum is exposed.

### New Horton.

Gypsum is also known to occur at New Horton. It is covered by Millstone Grit, and at the time of the writer's visit about 20 tons had been taken from two short cuts which exposed a white massive variety.

### Petitcodiac.

A succession of beds similar to those at Hillsborough was found at Petitcodiac in connexion with the gypsum outcrops. A bed of crystalline limestone stands out very prominently and can be followed for a distance of about 3 miles. Its trend is approximately northeast-southwest with a dip of 60° to the southeast.

To the southeast of the limestone, and adjoining it, gypsum is exposed. The area covered up by it is approximately 700 feet wide and can be traced for 2½ miles, having the same trend and always adjoining the limestone. Still farther to the southeast Millstone Grit conglomerate and freestone are encountered, the latter overlying the former with a slight dip to the southeast.

To the northwest of the limestone is found a red calcareous shale, dipping with an angle of 80° to the northwest. The line of contact between limestone and shale is a fault line.

The surface-gypsum has been utilized in past years for land plaster. Very little development work has been done to show its quality in depth, but in several places where exposures have been made a good quality of white massive gypsum was found.

### Upham.

The gypsum area near Upham, which lies on the railway connecting Hampton with St. Martin, can be traced for several miles by sink-holes and small ponds. The gypsum is covered by Millstone Grit and only at a few places does it outcrop.

The geological conditions are similar to those at Petitcodiac. A fault with approximately the same trend as that at Petitcodiac has brought the crystalline limestone underlying the gypsum to the surface. The limestone is of a greyish-black colour, is exposed in a few places only, and has a dip of 19° to the southeast.

Mining of the gypsum was begun in 1907 and several carloads were shipped to St. John. Owing to heavy freight charges the venture did not prove a success and was given up.

At Upham as well as at Petitcodiac no anhydrite was observed.

### Plaster Rock.

While all the gypsum deposits noted in the preceding showed a great similarity in character as well as in their stratigraphic relations to other rocks, the gypsum found at Plaster Rock on the Tobique river differs from them. It has a decided bedded appearance and breaks easily along horizontal planes. It is impure and its colour varies from a hematite brown to a light green with now and then layers which carry an abundance of red shale. to which crystals of selenite give a mottled appearance. The different colours do not, as a rule, blend into each other, but are sharply defined. Thus a greyish white variety may be found overlying and sharply separated from a red variety, the plane of separation being one of easy cleavage. The thickness of these layers varies from an inch to a foot or more and their character suggests constantly changing conditions of deposition. Secondary deposition has given rise to numerous veins of satin-spar which are approximately parallel to the bedding planes and the fibres are arranged perpendicular to them. No anhydrite is found nor is there any evidence of change from anhydrite to gypsum.

The gypsum beds are horizontal or have a slight dip, the direction of which is variable. They are exposed for a distance of about 1 mile along the eastern bank of the Tobique, which exposes a maximum thickness of about 125 feet. An overburden of residual soil covers the gypsum which overlies and is interbedded with a red calcareous shale, carrying seams of a greenish-white siliceous limestone, which on account of its colour stands out prominently.

The gypsum is too impure to be utilized for wall plaster, but is ground into a fine powder and used as a fertilizer. Its principal use, however, is in the manufacture of cement.

## Nova Scotia.

Gypsum is being mined in Nova Scotia on an extensive scale, and consequently the facilities for a study of the conditions under which it occurs are excellent. On the whole, the gypsum of the localities visited resembles that of New Brunswick (with the exception of the Tobique River gypsum) to such an extent that it would be difficult to tell one from the other in hand specimens.

Anhydrite is very prominent and has been found, wherever it does not outcrop directly, to underlie the gypsum. While some of the quarries which work near the surface are entirely in gypsum, in others, lenses of anhydrite which are capped by gypsum are encountered, while still others have reached and are working upon the floor of solid anhydrite. A few examples will illustrate.

At the Eagle Swamp quarry, about 4½ miles to the east of Windsor, anhydrite is encountered in lenses of variable size surrounded by gypsum or capped by it.

The Frazer quarry is three-fourths of a mile to the southwest of the Eagle Swamp quarry, and is not being worked at the present time. According to information received from the manager, Mr. N. Dimock, a diamond-drill hole in this quarry from its drainage level, about 100 feet below the gypsum outcrops, passed through 110 feet of gypsum, 140 feet of anhydrite, and at this depth was still in anhydrite.

At the Mosher quarry, about 6 miles to the southeast of Windsor, a capping of gypsum is being removed from the anhydrite, which constitutes the floor of the quarry.

Conditions similar to the above were found to exist in quarries visited in Cape Breton.

It is a comparatively simple matter to ascertain the conditions of gypsum occurrence where a deposit has been opened up, but some large areas may show little or no development work, and the investigation of the commercial possibilities of such properties becomes a difficult if not an impossible problem. The nature of the deposit as to colour and amount of impurities is likely to change suddenly even within the limited area of a quarry. The general conditions prevailing within a given district in which such properties are located can, however, usually be applied and are of great help.

As an example we may cite the Wilken's, Redden, and Thompson properties, which adjoin each other, and are located about 3 miles to the southeast of Windsor, in Hants county, Nova Scotia. They have been opened up to a limited extent only, but enough to permit a comparison with quarries in the same neighbourhood.

The general conditions which obtain in these quarries are in the main those pointed out in connexion with the deposits at Hillsborough, N.B. Thus four zones as described in the preceding may be recognized, with the solid mass of anhydrite constituting the fourth one. The anhydrite may crop out at the surface or may have a gypsum covering up to 200 feet in thickness. Calcite grains in varying amounts are distributed throughout the gypsum and anhydrite masses, and the quantity at a given level may increase to such an extent that a seam of limestone is formed. The amount and occurrence of calcite and limestone cannot be predicted, but more than a certain small percentage must not be present if the gypsum is to be used in the manufacture of wall plaster. Other impurities besides calcite are oxide of iron and organic matter. Varying proportions of these will tint the gypsum differently. The quarryman thus recognizes a blue, a grey, a green, a white, etc., gypsum. All of these varieties have been utilized in the manufacture of wall plaster, but the white variety is preferred because it yields the whitest plaster.

These conditions apply in a general way to the Wilken's, Redden, and Thompson properties. While all of the areas covered by these adjoining properties appear to be underlain by gypsum, there is some variatiou in the kind of gypsum.

The northern portion is occupied by a blue variety cropping out in many places, whereas in the southern portion there is found a white variety.

The blue gypsum compares favourably with that mined in neighbouring quarries, and an analysis of what may be considered an average sample shows it to be of good quality chemically. In appearance it does not differ, except perhaps in colour, from the ordinary gypsum mined at Hillsborough. It has been quarried to some extent in past years, there being three quarries, each having a working face of from 20 feet to 25 feet in height.

White gypsum probably occupies all of the southern portion of the property, but outcrops are few in number and the gypsum is of high quality and obvious purity.

What the thickness of the gypsum on these properties is, cannot even be surmised, because in the case of practically all undeveloped properties this is entirely a matter of test work. Since no anhydrite outcrops anywhere, it may well be assumed that the gypsum reaches below the level of the present drainage system, that is, the level to which it can be economically worked. The difference in elevation, as determined by aneroid, between the level of the road leading into the quarries and the highest point in the northern part of the properties is 90 feet, while the highest point in the southern part is about 160 feet above the same road. If it is assumed that the gypsum extends to the level of the drainage system, and if the unknown thickness of the overburden and the drainage slope necessary in operation of quarries be disregarded, the maximum thickness possible of the gypsum deposit is 160 feet.

The conditions affecting the above-named properties have been described somewhat at length since, in general, they represent the conditions prevailing throughout the Windsor district; moreover the same conditions affect all undeveloped gypsum properties both in New Brunswick and Nova Scotia.

## Origin of Gypsum.

The evidence obtained in the field relative to the origin of the gypsum points towards a derivation from anhydrite. Such evidence is summarized in the following:—

(1) The solid mass of the gypsum is always found overlying the anhydrite. It is true, that lenses of gypsum which may be several feet in thickness are encountered

within the anhydrite mass, but they are not bedded, and follow the irregular system of joint fissures.

(2) The experience at Hillsborough has been that the thickness of the gypsum varies in a general way with the topography. "The bottom rises as we drive into a hill" is a common saying.

(3) Specimens of gypsum which still contain a core of anhydrite are common. The outer layer of gypsum has a tendency to split and break off in scales which seems to be caused by the expansion which gypsum undergoes when changing from anhydrite.

(4) Specimens of pure anhydrite are comparatively rare. The freshly-broken pure specimen is of a bluish-green colour and has an intense vitreous lustre. Exposed to the sun and atmosphere for a few days the lustre is destroyed and a white film of gypsum forms on the surface of the anhydrite.

While thus the field evidence shows that at the present time the gypsum is being formed by hydration of anhydrite, no one could say that it was originally laid down in the form of anhydrite. There is no doubt that the calcium sulphate deposits originated by being deposited from sea-water. Their distinctly bedded character and enormous quantities are proof of it. It is well known, however, that under ordinary conditions of temperature and pressure calcium sulphate is deposited in the form of gypsum. If Van't Hoff's results are accepted, at 36° C., in a saturated sodium chloride solution, calcium sulphate is laid down in the form of anhydrite, but such high degrees of temperature of sea-water extending over great areas are not observed at the present time even in our most tropical countries. Since gypsum, according to Van't Hoff, when subjected to a temperature of 63½° C. turns, within a few weeks, into anhydrite, a much simpler solution seems to be that calcium sulphate was laid down as gypsum, and that it later was dehydrated. We know that enormous layers of sediments were deposited on the calcium sulphate beds, and the resulting pressure could easily have produced a temperature of 63½° C. or more. With the removal of the sediments a rehydration began, which is going on at the present time.

As to the Tobique River deposit, its dissimilarity mineralogically and in character of deposition from other deposits of New Brunswick, suggests a different period of deposition.

# JOGGINS CARBONIFEROUS SECTION OF NOVA SCOTIA.

(*W. A. Bell.*)

## Introduction.

During the field season of 1911, the writer spent three months in the field, making a palæontological study of the Carboniferous rocks exposed along the shores of Chignecto bay, Nova Scotia. The main object of the work was to secure a collection of the flora and fauna from the various fossiliferous horizons, for the purpose of working out the chronogenetic history, and the physical conditions of deposition of the Carboniferous of the Cumberland and adjacent basins, and further of correlating these deposits with the Carboniferous elsewhere.

The greater part of the time was spent in gathering collections from the numerous beds composing the coal measures of the widely-known Joggins section, and considerable material was collected, all of which awaits final study. Some time was also spent along the opposite shore of the bay in Albert county, New Brunswick, as well as in the vicinities of Springfield and Windsor, Nova Scotia, for the purpose of establishing the geological age of the rocks in these places.

The present report presents some of the results attained in the field and in the geological laboratory of Yale University, after a rapid preliminary survey of the fossils.

## Previous Work.

The Joggins section early attracted the attention of geologists by the reported occurrences of many fossilized trees still standing erect in the sandstones. Lyell visited the locality in 1842, at which time he wrote his first impressions:[1] "Whither I went to see a forest of fossil coal-trees, the most wonderful phenomenon, perhaps, that I have seen, so upright do the trees stand, or so perpendicular to the strata . . . . trees 25 feet high, and some have been seen of 40 feet, piercing the beds of sandstone and terminating downwards in the same beds, usually coal. This subterranean forest exceeds in extent and quantity of timber all that have been discovered in Europe put together." In 1852-53 he restudied the section in the company of Dawson. Since then his drawings of these logs and those of Dawson have appeared in many text books on geology. In 1885 Dawson, in his Acadian Geology, published an excellent account of the general geology of the district, with detailed description of the stratigraphic succession, but particularly of the Productive Coal Measures. Later editions of the same work contain additional supplementary matter. The fauna and flora have been described at various times by Lyell,[2] but more especially by Dawson.[3]

The section was first measured in detail by Logan[4] in 1843, while Fletcher[5] later, in 1896, completed the measurements from Shulie to Spicer cove. Both Fletcher

[1] Life of Sir Charles Lyell, Vol. II, 1881, p. 65.

[2] Lyell—Am. Jour. Sci. 1843, pp. 353-356; ibid., 1853, pp. 33-41; Travels in North America, 1845, pp. 148-187.

[3] Dawson—Acadian Geology, 1st ed., 1855, 4th ed., 1891, pp. 150-212. Quart. Jour. Geol. Soc. Lond., 1853, p. 58; ibid., 1894, pp. 435-437; Am. Jour. Sci. (3), V, 1873, pp. 16-24; Can. Rec. Sci., 1894, pp. 1-7, 117-131; ibid., 1897, pp. 316-323; ibid., 1898, p. 396; Can. Roy. Soc., Proc. and Trans., 1895, pp. 71-88; ibid., 1898, pp. 58-78.

[4] Logan,—Geol. Surv., Can. Ann. Rept., 1845, 92-156.

[5] Fletcher,—N. S. Inst. Sci., Proc. and Trans., XI, 1902-1906, pp. 417-550.

and Ells have done valuable work in mapping and in working out the geological structure in this and adjacent regions. Their results may be found in the Canadian Survey reports cited below.[1]

TABLE OF FORMATIONS.

*Recent.*—Marsh alluvium, drift sands, stream gravels.

*Pleistocene.*—Fluvio-glacial gravel, sand, clay, glacial till.

*Great depositional break.*

*Pennsylvanian (Upper Carboniferous):*—

Upper Coal Measures (Permo-Carboniferous of Fletcher)—

Greenish grey, buff-weathering sandstones and conglomerates with drift logs or plants aggregating 947′, alternating with beds of dark red argillaceous and arenaceous shales (670′). Total thickness, 1,617′.

Erect Calamites were found in two beds.

Upper Grindstone division—

Grey or drab coloured massive sandstone (300′) with reddish-yellow sandstones (28′) and alternating beds of chocolate (204′) or grey (118′) argillaceous and arenaceous shales. Total thickness, 650′.

Erect Sigillarian tree here in one bed, erect Calamites in another bed.

Middle Grindstone division—

Includes twenty-two small seams of coal, a total of 5′, with associated carbonaceous shale (4′). Underclays (174′) having generally the appearance of fireclays underlie all the coal seams. Interbedded sandstones, many of grindstone quality, grey (739′), reddish (204′); and shales, grey (137′), variegated (669′); concealed (202′). Total thickness, 2,134′.

Five erect Sigillarian trees and fourteen beds with upright Calamites.

Middle Coal Measures—

Upper division predominantly grey. Coal in thirty-two small seams, total of 35′, associated with carbonaceous shale (27′) and bituminous limestone (17′). Associated underclays, with ironstone nodules (67′), without ironstone (246′); sandstones, greenish-grey (428′), brick-red (12′); shale, grey with ironstone (166′), without ironstone (338′), variegated (95′), reddish (16′), brick-red (87′), brick-red with ironstone (48′). Total thickness, 1,582′.

Twenty erect trees were observed and fourteen beds holding erect Calamites.

Lower division predominantly reddish or red. Coal in thirteen small seams, totalling 3′ with carbonaceous shale (9′) and bituminous limestone (6′); underclays, with ironstone (127′), without ironstone (64′); sandstone, greenish grey (68′), reddish (124′), brick-red (14′); shale, grey with ironstone (63′), without ironstone (73′), variegated with ironstone (122′), without ironstone (106′), brick-red with ironstone (34′), without ironstone (144′). Total thickness, 957′.

Four erect trees were observed in this division.

[1] Geol. Surv., Can. Ann. Rept., I, 1885, Part E; ibid., V, 1890-91, Part P. Summary Reports, 1891, pp. 52-55 AA; 1892, pp. 59-64 A; 1899, pp. 162-168 A; 1902, pp. 390-401 A.

Millstone Grit or Lower Coal Measures—

Upper red measures consisting of shales, brick-red (937′), greenish-grey (4′); sandstone, brick-red (121′), reddish (151′), reddish associated with concretionary limestone (53′), greenish-grey (28′), greenish-grey associated with concretionary limestone (20′); concealed, probably red shale (768′). Total thickness, 2,082′.

Lower Grindstone division: Shales, brick-red (200′), variegated (63′), greenish-grey (45′), greenish-grey with ironstone (11′); coal and carbonaceous shale (2′), underclays (58′); sandstone, greenish-grey (200′), greenish-grey with patches of concretionary limestone (5′), variegated (8′), brick-red (57′); concealed (101′). Total thickness, 750′. Underlaid with shale, greenish-grey (97′), greenish-grey with ironstone (38′), brick-red (114), concealed red (108′), associated with coal and carbonaceous shale (9′), bituminous limestone (1′), underclays (42′); sandstone, greenish-grey (1,647′), light buff (25′), brick-red (31′), greenish-grey with lenticular beds of concretionary limestone (102′). Total thickness, 2,214′.

Lower Conglomerate division: Brick-red pea and egg-sized conglomerates (164′) with siliceous pebbles; sandstone, greenish-grey (9′), variegated partly calcareous (20′), brick-red (113′); shale, brick-red (228′), associated with bituminous limestone (2′); concealed (357′). Total thickness, 893′.

*Probable great depositional break.*

*Mississippian:—*

Windsor series: Shale, brick-red micaceous (1,204′); sandstone, brick-red (209′), reddish (36′), greenish-grey with comminuted plant remains (156′), greenish-grey with lenses of concretionary limestone (88′). Total thickness, 1,693′.

The plant fragments are frequently coated with green carbonate of copper or grey sulphuret of copper. These measures are underlaid by at least 100 feet of drab dolomitic and bluish-black fossiliferous limestones, interbedded with light yellow calcareous sandstone and brick-red marls. The limestone beds carry a marine fauna identical with that found at Windsor in beds of similar lithologic character. Gypsum does not outcrop in this section, but occurs in abundant quantity a few miles to the north on Cape Maringouin, associated with similar beds of limestone.

## General Geology.

The rocks of the Joggins expose an oblique transverse section through the broad Cumberland synclinal trough, which extends in a general east-westerly direction, parallel with and to the north of the Cobequid range of hills. The simplicity of the structure is interrupted by a few minor longitudinal transverse folds, and by local faulting.

The base of the section begins with the Windsor series (lower Carboniferous) which forms an anticline across the country from the Bay of Fundy, opposite Shepody mountain, to the neighbourhood of Minudie, Nova Scotia, and to Pugwash on the Straits of Northumberland. The highest beds lie in the axis of the syncline, which strikes the shore of Chignecto bay near Shulie. Between Shulie and Spicer cove there is a partial repetition of the measures downwards to a thick formation of conglomerate which flanks the Cobequid igneous rocks. This conglomerate was correlated by Fletcher with the New Glasgow conglomerate and assigned to the Permian, but from the palæobotanical evidence derived from the overlying beds, and gathered by the writer, appears to be of a much earlier Carboniferous age.

STRUCTURAL RELATIONS.

Minor folding and faulting is frequent in the Cumberland basin, but the displacements are in most cases of a few feet only. In the Joggins section faulting is common in the upper portions with a resulting partial repetition of outcrops. At Spicer cove a displacement of considerable amount has taken place, and there is also a distinct brecciated fault zone, bringing the Coal Measures unconformably against the red New Glasgow conglomerate. The downthrow of the northern side has been estimated by Fletcher at 500 feet. At the base of the Joggins section a fault of unknown displacement occurs near Minudie, apparently in the line of the anticline which defines the northern limit of the basin. This anticline is well exposed on the shores of Shepody bay or Cape Maringouin, where the strata are tilted to a vertical position. Near Hard ledge, on the same shore, occurs a small syncline dipping about 15° towards Shepody mountain.

NATURE OF THE DEPOSIT.

The fauna of the marine dolomitic limestones of the Windsor series at the base of the Joggins section indicates broad, clear-water, shallow, and warm seas. The succeeding and widely distributed deposits of gypsum were undoubtedly accumulated in shallow pans of the sea under a sub-arid and probably warm climate. The interbedded and overlying red shales and marls, barren of life, with an abundance of mud cracks and ripple marks, together with the general unleached condition expressed by the calcareous concretions and high alkali content, denote similar climatic conditions and a general retreat of the sea, followed by estuaries or wholly fresh-water deposition. The environmental conditions at this time appear to have been especially favourable for the formation of fresh-water subaqueous delta deposits, adjacent to very shallow seas, having had, it is thought, the forms of narrow but long basins, situated between mountain masses that had their origin in Devonian times.

A complete withdrawal of the sea with consequent relative uplift of the land prevented further deposition in this area, but possibly an extensive period of erosion again brought about conditions favourable for fluvial deposition early in Pennsylvanian time—conditions which seemingly persisted to the beginning of Permian time, as no truly marine or even estuarine fauna occurs in the Coal Measures of the Joggins area.

The sediments of the Millstone Grit were laid down under more fluvial conditions, an environment attested by the presence of occasional coal seams, the increasing importance of dark to black shales, and the lighter coloured, though still imperfectly leached, sandstones. The interbedded red shales, barren of fossils, may represent the muds of fluvial flood flats, that subsequently were oxidized sub-aerially, while the irregular lenticular beds of concretionary limestone associated with the grey sandstones apparently add their evidence in favour of fluvial conditions and a warm climate.

During the early Coal Measures the strata were laid down under more fluvial and swamp conditions, as expressed by the many thin coal seams, the predominant dark shales, and the more perfectly leached sandstones.

In later Coal Measures time there is no evidence for a continued abundance of water, as the red shale beds indicate seasons of aridity when all of the carbonaceous elements were removed through oxidation under sub-aerial conditions. There was at this time probably a return to more arid conditions, very similar to those of the Millstone Grit.

ERECT TREES.

The great number and erect condition of fossil trees in the Joggins section is good evidence that they are preserved in the position of their growth, *i.e.*, growth in situ. Thirty-five Sigillarian upright trees were observed in the Coal Measures of the Joggins section. Of those examined, three contained the remains of land reptiles or of land snails, while three others were observed with Stigmarian roots still attached. The general absence of roots may be explained by the fact that most of the trees have their bases directly over a thin underlying coaly or carbonaceous seam, indicating a probable decay of the roots and reduction into coaly matter. All of the erect Sigillaria had their basal terminations in shales which have little or no drift material other than fragments of leaves and Stigmarian rootlets.

Forty-one different beds in the Joggins section were noticed having upright Calamites, which in every case were confined to the sandstones or arenaceous shales.

CORRELATIONS.

The Coal Measures of the Joggins section are relatively poor in the abundance and variety of their flora and fauna when compared with the Carboniferous elsewhere. Another striking character is the lack of normal marine faunas, and divisional classification by means of organisms is here impossible. The classification and correlation of these deposits is, therefore, dependent largely on the stratigraphic sequence and lithologic characters, fortified by the more or less sparingly preserved flora and the land animals. On account of the continued vertical recurrences of similar lithologic characters, of abrupt local changes in sedimentation, and of the difficulties attendant on minor faulted and folded structure associated with discontinuous outcrops, such a classification is open to errors. A more restricted zonal classification than that given in the generalized section is also desirable, and such appears to be possible after further collecting and study of the fossil flora.

*Windsor Series.*

The correlation of the limestone beds at the base of the Joggins section with the dolomite gypsum series at Windsor is based on the occurrence of an identical fauna in both localities. The same fauna has recently been discovered by Clarke on the Magdalen islands and is described by Beede,[1] who agrees with Schuchert[2] that the age of the Windsor fauna is that of the lower Mississippian, or more specifically, about that of the Kinderhookian.

The overlying red beds may then represent either an estuarine or fresh-water phase of later Mississippian time.

*Disconformity.*

Undoubtedly there is a great depositional break between the beds of the Windsor series and the overlying Millstone Grit. Schuchert[3] has pointed out the fact that there is no reliable evidence for the presence of the lower Tennesseean deposits and none at all for the upper Tennesseean in the Maritime Provinces. The writer believes that this depositional break occurs at the base of the red conglomerate series, but further field work will be necessary to fix the horizon of disconformity (non-apparent unconformity).

[1] Beede. N. Y. State Mus., Bull. 149, 1911. pp. 156-186.
[2] Schuchert. Bull. Geol. Soc., America, 20, 1910, p. 551.
[3] Ibid., p. 554.

### *Millstone Grit.*

The name Millstone Grit is retained with its customary broad application in the Maritime Provinces to those deposits underlying the Productive Coal Measures of the Pennsylvanian (upper Carboniferous) and overlying the Mississippian (lower Carboniferous). It is here divided into three members, each representing a distinct kind of sedimentary deposit: a lower red member of conglomerates, sandstones, and shales; a middle grey sandstone member with subordinate shales and thin coal seams; and an upper red member consisting mainly of shales with some sandstones. Scarcely any plants are found in the red beds, but the massive grey sandstones frequently contain abundant drift logs and floral fragments in poor condition. It is probable that the Millstone Grit may be in whole or in part equivalent to the Pottsville of the Appalachian region.

### *Coal Measures.*

Further study of the floral evidence will probably furnish data for a more detailed correlation with the established subdivisions of the American Pennsylvanian.

A rapid review of the flora, as given by Dawson, from the highest members in the Joggins section, failed to reveal any plant not found in the undoubted Pennsylvanian (Carboniferous) below, a condition demonstrating the probability that there are no deposits of Permian age in this thick section.

The conglomerate at Spicer cove, correlated by Fletcher with the New Glasgow conglomerate and assigned to the Permian, underlies beds which apparently have the Pennsylvanian Coal Measures flora. Should this observation prove correct, then this conglomerate represents a portion of the Millstone Grit.

## Economic Geology.

### COAL.

Coal occurs in marketable quantities in two areas in the Cumberland basin—in the Joggins, or Northern area, and in the Springhill or Southern area. Mining operations are carried on in the Joggins area by the Maritime Coal, Railway, and Power Company, Limited, in the Springhill areas by the Dominion Coal Company.

### GRINDSTONE.

At present no stone is being worked, but in all probability there still remains much good material which could be worked at a profit were the demand increased. The material has largely been exhausted from the reefs where production was cheapest.

### GYPSUM.

Extensive deposits of gypsum of good quality occur in Maringouin peninsula and in the neighbourhood of Nappan, Nova Scotia. Quarrying is now carried on at the latter place, and intermittently at Cape Maringouin.

## GOLDBEARING SERIES OF THE BASIN OF MEDWAY RIVER, NOVA SCOTIA.

(*E. R. Faribault.*)

### Introduction.

The district topographically and geologically surveyed by the writer during the field season of 1911, lies in the southwestern part of Nova Scotia, immediately west of that surveyed in the two preceding years. It comprises the lower portion of the basin of the Medway river, extending from Medway to Ponhook lake, and includes a part of the Atlantic coast from Vogler Cove, in Lunenburg county, to the town of Liverpool, in Queens county. The area of this district is about 276 square miles, 12 miles east and west by 23 miles north and south. This completes the Vogler Cove sheet No. 90, Greenfield sheet No. 94, and the eastern part of Liverpool sheet No. 93. More field work is still required, however, to work out the geological structure and the altitudes of the western part of sheets Nos. 90 and 94.

An additional area, further inland, of about 50 square miles, was also surveyed, of a portion of the basin of Pleasant river—a tributary of the Medway river—comprised between the Annapolis County line on the north and the Caledonia branch of the Halifax and Southwestern railway on the south.

The examination of the geology and mineral occurrences was carried out by the writer; while the work in connexion with the topographical surveying was for the most part accomplished by the two assistants, J. McG. Cruikshank and M. H. McLeod, who were engaged from the beginning of June until the end of October, and performed their duties in a painstaking and satisfactory manner.

The main control lines to tie in the surveys of that region consist of the transit-chain survey made in 1905 by L. N. Richard of the highway road between Annapolis Royal and Liverpool, and of the Caledonia Branch railway with connexion at Lows landing on Lake Rossignol; the location plan of the Halifax and Southwestern railway between Bridgewater and Liverpool; the transit-stadia traverses made in 1907 by F. O'Farrell of the main road between Bridgewater, Pleasant River, and Middlefield; and the charts of the Atlantic coast made by the British Admiralty. In the settled regions, all the wagon roads were surveyed with a self-registering one-wheel odometer and the compass; while in the unsettled parts chain and compass traverses were run mostly along wood roads and county lines as tie-lines. Between points thus established the main rivers and lakes were surveyed with the Rochon telescope-micrometer and compass; while the smaller streams, lakes, etc., were filled in by compass and pace traverses.

The elevations were taken with a 3 inch surveying aneroid barometer checked by half-hour readings of a similar instrument stationed at central points, using for base the mean sea-level, the profiles of the three branches of the Halifax and Southwestern railway, and O'Farrell's transit-stadia levelling of the roads above referred to.

Special detailed examination and surveys were also made of the gold-mining districts of Blockhouse, Mill Village, Vogler Cove, and Fifteenmile Brook; of the important tungsten deposits exploited by the Scheelite Mines Limited Company at Scheelite, near Moose River Gold Mines, Halifax county; of the recent discoveries of scheelite at Waverley, Baker Settlement, and Fifteenmile Brook; and of the prospects of tin and tungsten ore at Mill Road near New Ross.

### Physical Features.

The district under examination is drained by the lower part of Medway river, which flows in a southeasterly direction for 15 miles along almost a straight course from the outlook of Ponhook lake to Medway on the Atlantic coast. The greater part of the waterway has a gentle descent with occasional rapids, and it runs along a narrow valley between undulating hills of glacial drift, the elevations of which do not exceed 300 or 450 feet above mean sea-level. Transverse rocky ridges, however, cross the river at a few places along its course, forming important waterfalls and cascades that would afford good water-powers. The river has a total descent of 302 feet in the 15 miles between Ponhook lake and the head of tide at Mill Village.

The following data on the principal water-powers of the Medway river were collected in 1910 by A. V. White, hydrographer, and tabulated for the Commission of Conservation.[1]

| Site. | A. Sq. miles. | B. Feet. | C. Horse-power | Remarks. |
|---|---|---|---|---|
| Mill Village.... .. .... | 602 | 9·7 | 730 | Old saw-mill: Davison Lumber Co. |
| Salter fall ... . ........ | 545 | 16·0 | 1,100 | Nova Scotia Pulp and Paper Co., 1,800 H.P. developed. |
| Big Salmon fall.... ... .. | 532 | 4·9 | 330 | Fall in about 300 feet. |
| Poultice fall..... .... .. | 508 | 9·0 | 570 | Fall in about 750 feet. |
| Glodes fall . ..... ....... | 486 | 8·3 | 500 | Fall in about 300 feet |
| Big Rocky fall .... .... | 486 | 12·0 | 730 | Fall in about 800 feet. |
| Bear fall ... . ..... ... | 453 | 5·8 | 330 | Fall in about 300 feet. |
| Bangs fall....... ... | 453 | 7·0 | 400 | Shingle mill; possible to obtain 16 feet. |
| Ponhook fall .......... | 437 | 17·6 | 960 | Saw and shingle mill. |
| Harmony pulp mill .... | 125 | 30·0 | 470 | Pulp mill; 1,000 H.P. developed. |

A.—Approximate area of watershed in square miles.
B.—Approximate head in feet.
C.—Estimated low water 24 hour H.P., 8 months, theoretical.

The measurements of flow of Medway river, metered on October 10, 1910, at Mill Village bridge, gave:—

| | |
|---|---|
| Width of river, where metered.. .. .. .. .. .. .. .. .. .. .. .. .. | 100 feet. |
| Area of river section .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | 175·8 sq. ft. |
| Discharge per second.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | 109 cubic ft. |
| Effective drainage area above section.. .. .. .. .. .. .. .. .. .. | 602 sq. miles. |
| Discharge per sec. per sq. mile.. .. .. .. .. .. .. .. .. .. .. .. | 0·18 cubic ft. |

Several streams empty into the river from both sides and drain a succession of lakes, lagoons, and stillwaters which have a general southerly and southeasterly trend through a generally flat country with occasional low undulating hills of glacial drift largely made up of granite debris carried from the north. In the southern part of the basin and as far west as Liverpool the surface covering is very heavy and rock exposures are scarce; but the bed-rock is well exposed along the sea-shore between Medway and Liverpool harbour.

Much of the surface is strewn with numerous angular blocks of rock detached from the thick beds of quartzose-sandstone of the region. These blocks often attain very large dimensions and stand out conspicuously above the surface, which on this account is rendered very rough and much different to that of Lahave basin adjoining to the east, where the slates predominate.

The district is covered over in part with woods, young growths, burnt woods, or barrens; and in part with numerous swamps and hay-marshes along the streams, and some peat-bogs. It is unfit for agricultural purposes. With the exception of Greenfield at the foot of Ponhook lake and a few scattered habitations along the river, the interior is altogether uninhabited. Along the shore, between Vogler cove and Liverpool, are scattered several small villages of fishermen, the most important of which

[1] Water-powers of Canada, Report Commission of Conservation, 1911, pp. 217 and 227.

are Mill Village, Medway, Eagle Head, Beach Meadows, and Brooklyn. Medway has an excellent harbour, free of ice in winter, and from which much lumber was shipped at one time by the Davison Lumber Company, but it is now used exclusively as a fishing station. The Nova Scotia Pulp and Paper Company has a pulp-mill in operation at Charleston, 2 miles north of Mill Village, situated at the head of tide on the river. A few small saw and shingle mills are also located on the river.

The river is considered one of the best in the Province for the fishing of salmon and trout, which are caught with the fly in the months of April, May, and June as far up the river as Harmony, 30 miles above tide-water. At many points along the river between Mill Village and Greenfield fishing rights have been leased by sportsmen who have erected summer cotttages and club-houses on the river bank.

The region is reached from Halifax and Yarmouth by the Halifax and Southwestern railway to Medway station, which is also a stopping place for moose hunters in the autumn on their way to the interior hunting grounds, more especially to Indian Gardens on the Mersey river.

The small area surveyed on Pleasant river is rocky, swampy, and unsettled, and it is unsuitable for agriculture. It is largely covered with forest, burnt woods, or barrens. Spruce and pine are lumbered on a small scale on the upper part of the river. Beaver dams and houses were observed at the outlet of Beaver lake, a western tributary of the river, showing the presence of a colony of beavers. Beaver cuttings were also observed in 1902, near the outlet of Lower Shingle lake, 2½ miles south of the railway. This is probably the farthest east locality where beavers are known to exist on the southern watershed of the Atlantic coast. The information is worth recording as the beaver is fast becoming extinct in the Province and should be more vigorously protected.

## General Geology.

The portion of the Medway basin surveyed last summer is entirely underlain by the quartzite and slates of the Goldbearing series which cover the seaward half of the peninsula of Nova Scotia between Canso and Yarmouth. In the absence of fossils and other conclusive evidence as to their age, it has been customary to provisionally refer these rocks to the lower Cambrian, though on account of their similarity to the quartzites and slates of the Avalon peninsula of Newfoundland, which have been assigned on fossil evidence to the Pre-Cambrian, as well as for other reasons, it is possible that they may be Pre-Cambrian.

On the Atlantic slope of Nova Scotia, between Medway and Canso, these sedimentary deposits have been found everywhere to form one conformable sequence of strata, the total known thickness of which has been estimated at 27,700 feet. This great series of rocks has been divided into two distinct lithological divisions: a lower one, called the Goldenville quartzites, and an upper one called the Halifax slates. The Goldenville formation as exposed at Moose river, has a thickness of over 16,000 feet of strata largely made up of thick beds of metamorphic quartzose-sandstone or quartzite interstratified with numerous layers of slates. The Halifax formation has a thickness of 11,700 feet and is entirely composed of argillaceous and siliceous slates with occasional flinty layers. In this sequence of strata is not included, however, the upper slate series of the Gaspereau valley which conformably overlies the two prominent bands of Whiterock quartzite, which in turn apparently overlie conformably the Halifax slates, as described in the Summary Report for 1908. The upper slate series of the Gaspereau valley has a thickness of 2,800 feet which, added to the 27,700 feet of the Goldbearing series proper of the Atlantic coast, would give a total known thickness of 30,500 feet of probably conformable strata.

After deposition, the Goldbearing series was uplifted and sharply folded into a succession of huge anticlinal ridges and intervening synclinal troughs which have a general east and west direction roughly parallel with the Atlantic coast. During and after the folding, extensive erosion truncated the crest of the folds and gradually planed down the surface to its present level, exposing the uptilted, once deep seated, strata. The anticlinal folds seldom lie horizontally, but generally pitch to the east or west, and where they pitch in opposite directions anticlinal domes are formed. Much economic importance is attached to the location and structure of the anticlinal folds and domes, because practically all the gold and tungsten deposits in Nova Scotia are situated on anticlinal domes, where they occupy zones of interbedded fractures caused by the folding.

In the eastern part of the Province, the folds are sharper, and pitch to the east or west at lower angles then to the westward of Halifax; as a result, in the east the domes are very narrow and much elongated, while in the west they are broader and more circular in shape. This latter form of domes is especially well developed in the Medway and Lahave districts, where the folds have a pronounced pitch to the eastward as far as the transverse north-south syncline along Lahave river, while towards the west they form broad elliptical domes which indicate the existence of a general transverse upheaval or anticline. As a result of this geological structure the Halifax slates cover the greater part of the Lahave basin and extend westward in narrow infolds along the synclines; while the Goldenville quartzites are brought up to the surface over the greater part of the Medway and Mersey basins and extend eastward into the Lahave basin in narrow belts along the crests of the anticlines. The great extent of the slate formation in Lahave basin is the principal cause for the predominance of the fine soil and smooth surface of that district contrasting with the characteristic stony and rough nature of the lower Medway and Mersey basins.

In many cases the structure is rendered still more complex by the occurrence of several small subordinate folds along the apex of the major anticlines, as well as along the bottom of the major synclines. This complex structure is well exposed along the sea-shore between Medway and Liverpool bay, but inland the rock exposures are scarce and widely scattered, and, on this account, more detailed field work is still required to make out in detail the geological structure of that section.

The only igneous rock observed in the district is an important dyke of diabase, 200 to 500 feet wide, extending along the sea-shore in a westward direction for at least 25 miles, from West Ironbound island at the mouth of Lahave river to Liverpool, beyond which it was not traced. It outcrops on West Ironbound island immediately north of E. DeWolf's house, crosses Cape Lahave island along Halibut and Bantam bays, where it shows prominently above the surface, then it strikes the mainland at Cherry cove where it is deflected southerly along Back and Apple coves, then resumes its westerly course along the north side of Conrad beach and crosses Medway between Selig and Great islands, beyond which it is concealed by soil for a few miles but outcrops again on Great hill and on a small knoll one-fourth of a mile north of the railway station at Liverpool.

The area surveyed last season on Pleasant river is covered on its southern portion by the Goldbearing rocks which extend south to the sea, while its northern portion is occupied by the granite which forms part of the main batholith constituting the South mountain. The granite boundary has been traced westward from where it crosses Lahave river, 1 mile below Meisner bridge and 3 miles north of New Germany, to the old Liverpool road, 2 miles north of the Halfway brook, crossing Rocky and Pleasant River lakes and passing a short distance to the north of Beaver and Cranberry lakes.

The greater part of the area covered by the Goldbearing rocks is occupied by the Halifax slate formation spreading westward along a deep and broad syncline, the axis of which passes half a mile north of New Germany and Hemford Railway station. A good section of these slates and the syncline is well exposed on the West Lahave river. The Halifax slates are underlain on the north by the Goldenville quartzites which are cut a little farther north by the granite and form a narrow belt, from half a mile to 1 mile in width, extending westward.

The granite is for the most part light grey, coarse, and porphyritic with large feldspar crystals. A fine-grained biotite granite, generally dark grey or reddish grey, also occurs in small irregular lenticular masses throughout the coarser variety. This latter phase of granite intrusion sometimes sends dykes into the older granite in the form of aplite dykes and quartz veins which are often mineralized and similar to those already described at New Ross.

## Economic Geology.

At the present time it is thought advisable to offer only a few general remarks on some of the mineral deposits examined last summer, since a large part of the surveys are not yet compiled and, in some cases, more field work is still required.

Gold and tungsten-bearing veins are the only deposits of economic value so far discovered in the lower part of the Medway basin. Gold quartz has been mined quite extensively for many years at Molega and to a limited extent at Vogler Cove, Mill Village, and Fifteenmile Brook; but no actual mining was in progress at these mines last summer, except some exploratory work at Molega and Fifteenmile Brook.

The valuable tungsten-bearing mineral scheelite was discovered in quartz veins at Molega in 1894 and also at Fifteenmile Brook and Baker Settlement in the last two years.

As a general rule, the character of the country is unfavourable to the prospector, since the bed-rock is, in most places, deeply covered with drift. This is especially the case at Mill Village and Fifteenmile Brook where some rich float of gold quartz found in the drift could not be traced to its source. Hence, to guide the prospector, it is important to map out as accurately as possible the position and structure of the anticlinal domes on which the gold and tungsten deposits generally occur.

Attention may be drawn here to the excellent road material afforded by the diabase dyke, already described, crossing the district from east to west along the shore and passing at Great hill, a short distance north of the town of Liverpool, where it might be advantageously utilized to macadamize the streets. From experiments made in the States of Massachusetts, Maryland, and Wisconsin[1] on the comparative wearing and cementing values of different materials generally used for road macadams, diabase was found to be one of the best for strength and durability.

### MOLEGA.[2]

A detailed survey was made in 1904 of the gold mining district of Molega, and a plan was published on the scale of 250 feet to 1 inch. The plan shows the extent of the mining and development work done on numerous interbedded quartz veins occurring in the Goldenville quartzites, over a large area, on the northeastern side of an anticlinal dome. Since then, some exploratory work was done on the South Rabbit lode and on the anticline where superimposed saddle-veins were uncovered pitching east 15°. These saddle-veins determine the exact position of the anticlinal axis which is 58 feet farther south than that indicated on the published plan.

### FIFTEENMILE BROOK.

This gold district is situated on the road to Brookfield, 15 miles north of Liverpool and 2 miles north of Middlefield post-office. The Goldenville quartzites are

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[1] Highway Construction in Wisconsin, by E. R. Buckley, Bull. No. X, 1903, Wisconsin Geological Survey.

[2] Molega is the name of the post-office, but Malaga Barrens is sometimes used by the Department of Mines of Nova Scotia to designate the mining district.

exposed here at the surface for a width of over 1 mile on the eastern part of an anticlinal dome, on which they dip to the north at high angles and to the east and south at lower angles, and are conformably overlain by the Halifax slate. At a distance of 2,100 feet north of the major anticline, rich float of gold quartz has been found along the north side of Fifteenmile brook for a distance of 1,000 feet east and 1,600 feet west of the road. The exploratory work done so far has failed to discover the veins from which the float was derived, on account of the heavy soil covering the bed-rock. Several interbedded veins have been cut on both sides of the road, but so far none of these have been found to carry payable ore. On the western side of the road a small ore-shoot pitching west at a low angle, was worked for a while on a "fissure" vein cutting the strata at a slight angle. Apparently on this same vein and 690 feet east of the road, several pieces of scheelite associated with arsenopyrite were discovered last October while examining the quartz taken from a trial pit dug by Ells. This new discovery of tungsten may prove of economic importance, for at a short distance to the southwest several loose pieces of the same mineral were discovered last year in drift by W. H. Prest, of Bedford, N.S., indicating a widespread distribution. It may be observed that, on this vein, the scheelite will probably occur in ore-shoots formed at the intersection of the fissure vein with the interbedded veins and will pitch to the west at a low angle; while in the interbedded veins the ore-shoots will more probably pitch westward like the rolls and anticline.

BAKER SETTLEMENT.

The new discovery of scheelite made last spring at Baker Settlement, Lunenburg county, is situated 12 miles northwest of Bridgewater and half a mile north of Huey lake. Eight interbedded quartz veins, from 2 to 18 inches thick, occur here within a space of 300 feet in bluish-grey siliceous slate of the Halifax formation. The veins dip south 35°, and occupy a zone of fissures on the southern side of an anticline which is followed a short distance farther north by a syncline, forming a double crumpling of the strata pitching to the east at a low angle. Scheelite was found on two of these veins, in pockets and in thin veinlets along the walls. One of the veins is 4 to 8 inches and the other 2 to 3 inches thick. Both veins are crinkled in rolls and contain much massive mispickel and some crystals of quartz, mispickel, and pyrites mostly along the centre and in the rolls. The slate forming the walls is also spotted with small crystals of mispickel. Scarcely any prospecting has yet been done; the two scheelite-bearing veins having been stripped only a few yards where the surface is shallow. Prospecting should be extended farther north across the anticline and syncline, and also east and west along these two folds. The ore-shoots will probably be found to pitch eastward at low angles, following the lines of intersection of the bedding with the cleavage, or the plunge of the rolls or folds, as at Moose river.

No minerals of economic value have been found yet in the Goldbearing rocks or granite covering the Pleasant River district. A few small dykes of aplite and quartz slightly mineralized with iron pyrites have been observed in the granite, however, which may also contain useful minerals like those discovered at New Ross.

Outside of the area surveyed last summer, special examinations were made, in Lunenburg county, of the gold mines of Blockhouse, the tin prospect of New Ross, and the gypsum and limestone deposits of Chester Basin; and, in Halifax county, of the tungsten deposits being developed at Scheelite, near Moose River Gold Mines, and those prospected by A. L. McCallum 1 mile north of Waverley.

NEW ROSS.

At Mill Road, 4 miles north of New Ross, two shafts, 100 feet apart, have been sunk on the tin-bearing vein of quartz discovered by E. Turner, in the granite. The south shaft is 55 feet and the north one 25 feet deep. At the surface, where first discovered, the vein was 2 feet wide and showing good tin ore, but the development work has proved the vein to be irregular and to pinch out horizontally and in depth, and the prospect has been abandoned. The associated minerals observed in the vein besides cassiterite were chalcopyrite, stannite, wolframite, scheelite, tungstite, zinc blende, molybdenite, mispickel, purple fluorspar, pale green serpentine, white mica, and reticulated veinlets of opalescent and smoky quartz and of red feldspar. Crossing the river below the bridge, a short distance west of the tin-bearing vein, is a large dyke of pink feldspar which may be of economic value.

### CHESTER BASIN.

Lower Carboniferous deposits of shell-limestone, gypsum, sandstone, and shales were observed on several islands in Chester basin, where their presence was hitherto unknown; notably on the mysterious Oak island, renowned for the extensive excavations that have been made from time to time during the last 60 years searching for Captain Kidd's fabulous hidden treasures which are supposed to have been buried somewhere along the Atlantic coast. It is said that several hundred thousand dollars have been spent already in sinking shafts and driving tunnels, and further work is still contemplated. There is strong evidence to prove that the supposed artificial openings which originally led to such undertakings were really but natural sink-holes and cavities formed by the gradual dissolution of gypsum deposits underlying thin layers of soft sandstone and shales which gave way under the pressure of the superincumbent covering of glacial drift. Similar sink-holes may still be observed on the shore of the main land nearby.

It is interesting to record the information received by the writer from Mr. H. S. Poole, Spreyton, Guildford, England, who was for several years in Nova Scotia as superintendent of the Acadia Colliery at Stellarton, that in 1862, he found float of tungsten in Guysborough county, about 3 miles south of Sherbrooke, behind the cottage of—Lynch, on the east bank and within half a mile of the river.

Float of scheelite is reported to have been found in Halifax county, some distance south of Pockwock lake, to the west of Sackville, by W. H. Prest; also some distance back of Oldham, by Charles Donaldson, of Enfield.

## LAHAVE VALLEY AND STARRS POINT, NOVA SCOTIA.

(*W. J. Wright.*)

Two weeks were spent in the Lahave valley, Lunenburg county, Nova Scotia, studying the rocks in the field, collecting specimens for thin sections, and examining in more detail several minor problems that arose during the work in 1910.

The topography of the area is due largely to the work of the continental ice-sheet on the surface of an uplifted and dissected peneplain. Immediately before the glacial period, the country had a low relief and a gentle regional slope of less than 15 feet per mile towards the Atlantic, with a marked river valley where the Lahave is now located. Glaciation removed the loose material from some parts, and accumulated it in others. Consequently, large areas are denuded of soil, while other areas are covered with great amounts of drift in the form of irregular groups of hills elongated in the direction of ice-movement. The rearrangement of material has had a marked effect on the country. For not only has it interfered with the drainage, even going so far as to pond up the waters of the Lahave to form two large lakes, but also, since the drift forms most of the farming land in the country, its distribution determines the location of most of the country villages.

While the location of much of the present drainage has been influenced by glaciation, Lahave valley existed in preglacial times. A probable explanation of its location grows out of the study of the fault system of the area. There are no faults large enough to be shown on the map; but there are numerous small fractures, striking parallel to the valley, in which the western side always seems to be downthrown, and shifted to the south. This movement has been concentrated along the Lahave. Consequently, we have here a zone of weakness, which has yielded more readily to erosion, and along which the valley has been excavated.

In this connexion, it is interesting to note that the greater part of the drainage lines of the Atlantic slope of Nova Scotia, fall into a parallel system, which lies across the folded structure of the rocks, and is independent of the initial slope of the peneplain. The completed structural maps show a system of major northwest and southeast faults; there has been displacement of the western side towards the south. It seems probable also that the strain producing these faults must have produced other lines of weakness like that in Lahave valley, where the movement was too small to be shown on the maps. The drainage system is parallel to the fault system and some of the rivers are located on major fault zones throughout the whole, or greater part, of their courses.

The suggestion at once arises that there is a close relation between the two systems; and that the direction and location of drainage have been influenced by the fault zones. Furthermore, the system of parallel valleys probably influenced the direction of movement of the ice-sheet, and the consequent shape of the drift hills. These, in turn, have influenced the directions of minor drainage and roads. And the remarkable parallelism between the roads, streams, and faults, shows how structural lines laid out in a remote geologic period, may influence later geologic agencies, and be reflected, even to-day, in the topography and human activities of the country.

The general geology of this area has been discussed by Mr. Faribault in his summary report for 1910; but a few words more may be said about the granite. The main mass of the granite is coarse-grained, porphyritic rock, made up chiefly of plagioclase, quartz, and biotite. The feldspar crystals, often an inch or more in length, give the rock its porphyritic texture. This rock is cut by numerous dykes, which appear to grade from typical pegmatites, through a light-coloured aplite, made up chiefly of plagioclase, quartz, and muscovite, to a darker rock in which biotite is abundant.

Besides the coarse-grained granite, there is at least one area of a younger granite, which lies just east of Woodworth brook, with its southern boundary about half a mile north of the sedimentary rocks. Near the contact, the younger granite is a light-coloured rock, with a fine, even, texture, made up chiefly of plagioclase, quartz, and muscovite. Away from the contact, the rock is coarser grained, and biotite becomes the predominant mica. The main body of the younger granite has about the same mineral composition as the older granite; but the two rocks differ in texture and general appearance. There is a marked similarity between the younger granite and the dykes which cut the older granite. It seems probable that they are closely related, and that both are differentiated parts of the magma which formed the older granite. If this be true, it is probable that in places one granite grades into the other, and that the two cannot be completely separated.

The Triassic sandstones at Starrs point, Kings county, were visited in order to obtain some information regarding the manner of their deposition. The Triassic sandstones of the Connecticut valley are fluvial deposits in a region having a semi-arid climate. In Nova Scotia, the predominant red colour, presence of gypsum, mud cracks, sub-angular pebbles, crossbedding, and the unsorted nature of the material, all indicate a similar mode of deposition. But further study is necessary to decide the question.

The sea-wall at Starrs point rises perpendicularly above the level of high tides, and shows erosional forms which are not commonly associated with moist climates. The sandstone is poorly cemented and decomposes readily to a fine sand. The wind carries much of this sand against the cliffs and has carved them into forms characteristic of dry climates where wind erosion predominates.

## BORE-HOLE RECORDS. (WATER, OIL, ETC.).

(*E. D. Ingall.*)

Since the period occupied by the last annual report a large proportion of the time of the officer in charge of the branch has been occupied in the clerical and routine work involved in the collection of boring records, sets of drillings, and the geological data necessary to the elucidation of the material collected.

The packing up and removal of the drillings, etc., from the old to the new museum necessarily resulted in the consumption of considerable time in the unpacking and rearrangement of the specimens so as to have them accessible for further study, reference, and comparison. Very effective assistance in unpacking was rendered by Mr. F. J. Barlow for a few weeks previous to his departure for the field, and later, for a similar period, by Mr. F. Hallam.

A number of sets of drillings from wells drilled throughout the peninsula of Ontario are still packed away in boxes. These represent material collected by Mr. Brumell many years ago, the logs of many of which are to be found in his report on gas and oil (Part Q, Vol. V). There are also some collected by Mr. Chalmers, whose death prevented the information therein contained from becoming available.

When time and space permit of the unpacking of these drillings and they can be placed in series with the other sets illustrative of various sections of Canada, they should be very useful for purposes of corroboration and comparison as well as for study by drillers and operators contemplating similar operations in the future.

Whilst the additions to our collection of records have not, during the year, been as numerous as might be wished, it is believed that, judging from the statements of various drillers, a considerable improvement in this regard can be expected when it is found possible to have a fund out of which some slight recognition can be made of their goodwill and efforts on behalf of the work.

As in previous years, the branch has been able to render service to those interested in boring operations in different parts of the country in the way of information embodied in memorandum, or given verbally, relating to the general geological conditions where boring operations were contemplated or proceeding.

The sets of drillings and logs of numerous wells bored by the Maritime Oil Fields Company of Canada, near Moncton, N.B., are being studied by Dr. G. A. Young and utilized in connexion with the working out of the geological map he is making of that district.

As a result of the epidemic of typhoid which developed in Ottawa last autumn public attention was directed toward the possibility of obtaining pure water from deep borings. In response to inquiries by the Senate, as well as by the management of the Chateau Laurier, a preliminary study was made and a memorandum prepared of the conditions of occurrence of the crustal waters as far as shown by the available records of deep bores already made in the district. The evidence was not very extensive or final either as to quantity or quality of the water thus to be obtained. At most of the producing wells the water is used mainly for cooling purposes in connexion with dairy, cold storage, brewing, and sulphite plants. The chemical composition of the water being unimportant for the above purposes no effort has been made to case off the water of the different depths at which it has been encountered, so that the borings so far made give no definite data as to the quality of the supply in the different strata pierced.

The information regarding the occurrence of water in the sedimentary strata underlying the Ottawa district then is as yet quite incomplete and inconclusive, but our knowledge of the general conditions would lead to the surmise that there will be found to be no essentially water-bearing stratum except, possibly, that of the sandy shales below the limestones of the Trenton and Black River age which may prove to have somewhat greater porosity than the other members of the series. In the limestones mentioned there are doubtless many water-worn channels and enlarged joint systems, but it could only happen that such would be encountered by chance. Furthermore, the water in the limestones would perhaps be more likely to carry a higher content of mineral salts than that in the sandy shales. The fact that the water from many of the borings so far made has carried considerable mineral salts casts no light upon these questions, as it always represents a mixture from several different horizons.

The rocks of the district being considerably faulted, a condition favourable to the existence of water supplies may exist in certain sections where these faults are plentiful. Investigations were commenced during the summer to trace out these features of the geology, especially in view of the considerable amount of rock excavation now in progress in connexion with the extension of the city drainage system throughout the newly annexed districts.

Other interesting problems which have been under consideration during the year are those connected with the operations of the Canadian Standard Oil Company which has put down a number of holes in search of oil and gas, both in the vicinity of Ottawa and in the county of Kent. Through the courtesy of the officials of this Company valuable and complete sets of drillings were obtained from three wells in the Ottawa district and from two in Kent county. Thanks are due to Mr. F. H. Simmons of the staff of this corporation for his assistance in helping the branch to keep in touch with operations, as well as to Messrs. E. W. Mooney and J. Bowlby of the drilling staff for their courteous co-operation.

In their operations in Kent county the Company could use the information contained in various published reports of the district as well as the experience of numerous operators in the vicinity. In the Ottawa district, however, although a certain amount of spasmodic boring has been done over a wide area, the search for gas and oil is yet in the pioneer stage. In initiating operations, therefore, the choice of localities for boring became one of a summing up of the general conditions of the region as elucidated by the geological studies of the officers of the Geological Survey and of the results of previous borings as far as known.

As in the case of the boring previously made at Plantagenet, the evidence in the case was thoroughly reviewed with the interested parties in order to give all possible assistance in the selection of the most likely places to bore.

Amongst the various factors to be taken into account are the presence of anticlines and synclines; the porosity or storage capacity of the different strata; the presence or absence of adequate cover for holding in the gas or oil; the presence of faults, etc. The geological maps of the eastern Ontario area contain a large amount of information of a general nature on most of these points, but a very detailed re-survey would be necessary to define the minor structural features which have so important an influence in determining the limits of the pools, although a short memoir might be written summarizing the data at present available and in discussion of their bearing on the problems under consideration.

The operations of the Standard Oil Company in the eastern Ontario field consist of three holes covering a triangular area some 5 miles in extent in the township of Cumberland, about 14 miles easterly from Ottawa along the line of the Grand Trunk railway to Montreal.

The importance to the Capital of success in finding an adequate supply of natural gas within piping distance of the city gives added interest to these explorations. In the first hole the whole sedimentary series was penetrated down to the Potsdam, when drilling was discontinued on account of the very slow progress made, due to the great hardness of the sandstone encountered. In the other two no attempt was made to penetrate below the upper beds of the Trenton. In all of the bores gas was obtained in varying quantities, the last made giving the most encouraging result; no measurements of the quality were made, however, by the owners.

As a result of the operations of the Company in western Ontario, large yields of oil are reported.

The search for gas and oil throughout the northwest provinces of Canada is known to have been active, but unfortunately under present conditions few returns can be obtained.

With the sanction of the Director, field work was prosecuted during the latter part of the summer in Ottawa, Hull, and environs in tracing out the fault systems in extension of the work done by Dr. R. W. Ells in previous years. Advantage was taken, as before-mentioned, of the considerable amount of excavation being prosecuted by the city. An area of some 5 square miles, covering the western parts of the above-mentioned cities, was gone over very closely in search for evidence both positive and negative of the existence of lines of faulting and their extension, and of other structural features, having in mind especially the possible connexion of water-bearing borings with zones of disturbance. The section of the strata in the cliffs along the water-front of the Ottawa river, from above the Chaudière falls to Rockcliffe, was carefully gone over, and fossils were collected and referred to the palæontological branch for determination of horizons. Especial care was taken to study many places left bare by the exceptionally low water, which would perhaps not again be accessible for a long time.

Pursuant to the understanding arrived at in conversation with the Director just previous to his departure for the west, field work was extended outside of the Ottawa and Hull district proper.

## PALÆONTOLOGICAL DIVISION.

### I

### Vertebrates.

*(Lawrence M. Lambe.)*

The removal of the fossil collections from the Sussex Street building of the Geological Survey to the Victoria Memorial Museum was effected between December 29, 1910, and January 4, 1911, the old cases being temporarily utilized for the display of the fossils on the ground floor of the new building. The office assigned to me in the Victoria Memorial Museum was occupied on January 5.

The greater portion of my time, during the past year, has been devoted to the study of recent accessions to the Museum, and to preparations for the arrangement, and proper public display, of the collections of fossil vertebrates.

In this connexion work on the catalogue of the fossil vertebrata, begun in 1908, was continued. By the addition of the species in our possession belonging to the Agnatha, the Amphibia, those sections of the fishes not already recorded, and the numerous accessions, principally of mammals, made to the collections during the past two years, the catalogue has been almost completed and could be put in shape for publication within a short time.

Descriptive labels have been prepared for the principal specimens which illustrate different vertebrate orders, and the life of definite geological periods. These are written in a popular style and are intended specially to interest and instruct the public. Labels of a similar character have also been written descriptive of the evolutionary changes illustrated by series of fossil forms (Horses, Proboscidea, etc.) lately acquired by the Department.

These labels are to be supplemented by a list, which has been prepared, in tabulated form, of the "Orders of Vertebrate Animals" both fossil and recent. It was also thought desirable to have for exhibition with the fossil vertebrates a table of geological formations as developed in Canada, giving the animals characteristic of the various horizons and successive vertebrate life zones, and illustrating the gradual change from low to higher forms. Such a table is now in course of preparation.

During the past year a descriptive and illustrated popular guide to the fossil vertebrate collections was begun, and will be continued as time permits.

A valuable addition to the vertebrate palæontological collections consists of the lately acquired Pleistocene mammal remains from Yukon, mentioned in the list of accessions to the Museum for the year. These remains include, besides those of mammoth, horse, deer, etc., the greater portion of the bones of one individual of *Bison crassicornis* which could be mounted with little restoration to make a complete skeleton.

Other important specimens received during 1911 are enumerated below, and serve to illustrate, in the general scheme of evolution, forms not hitherto represented in the collections of the Geological Survey.

The series of casts of skulls, feet, and type specimens of fossil Equidæ, illustrating the evolution of the horse, which the American Museum of Natural History, New York, has lately presented to the Geological Survey, is a most welcome addition to our palæontological collections and forms in itself an exhibit of great interest and value. Dr. W. D. Matthew, Acting Curator, in formally presenting the series, on behalf of the American Museum, writes that the donation is made in appreciation of the many courtesies received from members of the Survey staff, and of the "splendid scientific work which the Canadian Geological Survey has accomplished and is now continuing."

Miss A. E. Wilson has continued, in a most satisfactory manner, the work of cataloguing the type and figured specimens of fossils in our possession. This included the recording of information relative to type material subsequent to a full examination of all literature bearing on the subject. She has also attended to the cataloguing of lately acquired fossil vertebrate material.

As recorded below a number of mounted skeletons of recent vertebrates have been added, during the past year, to the "Osteological collection" which is primarily intended for use in connexion with palæontological studies.

The following papers were written during the year:—

"On Arctotherium from the Pleistocene of Yukon:" descriptive of the new species *A. yukonense* and published in the May number, vol. XXV, of the Ottawa Naturalist.

"The Past Vertebrate Life of Canada," being the Presidential Address of Section IV, Royal Society of Canada, at its annual meeting in Ottawa in May.

"Bibliography of Canadian Zoology for 1910 (exclusive of Entomology): presented at the annual meeting of the Royal Society in May.

"On the occurrence of Helodont teeth at Roche Miette and vicinity, Alberta," describing the new species *Helodus subtuberatus* from upper Devonian rocks. (In press.)

A small, detached fish tooth of the genus Helodus, collected by Mr. D. B. Dowling during the past season, from the limestones of the summit of Roche Miette. Alberta, is described and figured in the last-mentioned paper. The genus Helodus has not hitherto been recorded from Canada, and the species represented is apparently new. For the species the name *subtuberatus* is proposed, with reference to the inconspicuous swelling observed on either side of the central prominence of the crown. The limestone beds at the summit of Roche Miette are apparently of uppermost Devonian age. A portion of a second tooth, referred to this species, was also obtained last summer by Mr. Dowling, 6 miles north of Roche Miette, from limestones presumably of the same geological age as those forming the summit of this mountain.

### ADDITIONS TO THE VERTEBRATE PALÆONTOLOGICAL COLLECTIONS DURING 1911.

*Collected by Officers of the Geological Survey.*

Dowling, D. B.—
Two teeth of Helodus, Agassiz, from the upper Devonian of Roche Miette and vicinity, Alberta. Acc. No. 35.

MacKay, B. R.—
Portions of humerus, radii and tibia of *Bison americanus,* from Pleistocene terrace gravels, Crowsnest river, Alberta, one mile west of Coleman. Acc. No. 36.

*Received by Purchase.*

*Portheus molossus,* Cope. Mounted composite specimen from the chalk beds of the Niobrara Cretaceous, Gove county, Kansas. Acc. No. 26.

*Stylemys sp.*, carapace. Miocene. Acc. No. 10.

*Naosaurus claviger*, Cope. Permian, Texas. Restoration model in plaster, one-fifth natural size. Acc. No. 20.

*Ichthyosaurus quadriscissus*. Quenstedt. Lias, Würtemberg, Germany. Fossil on slab. Acc. No. 33.

*Phytosaurus (Belodon) cylindricodon*. Jäger. Trias, Würtemberg, Germany. Plaster cast of skull with lower jaw. Acc. No. 11.

*Steneosaurus bollensis* (Jäger). Lias, Würtemberg, Germany. Head and front portion of body on slab. Acc. No. 12.

*Steneosaurus bollensis* (Jäger). Lais, Würtemburg, Germany. Specimen complete on slab. Acc. No. 32.

*Pterodactylus antiquus* (Sömmering). Lithographic stone (Kimmeridgian). Bavaria. Plaster cast, natural size. Acc. No. 30.

*Archæopteryx macrura*, Owen. Lithographic stone (Kimmeridgian). Bavaria. Plaster cast, natural size. Acc. No. 29.

*Dinornis maximus*, Owen. Quaternary: alluvial deposits, New Zealand. Complete skeleton. Acc. No. 13.

*Protæuglodon atrox*, Andrews. Middle Eocene, Fayum, Egypt. Restored model of the skull and mandible, natural size. Acc. No. 28.

*Arsinoitherium zitteli*, Andrews. Lower Oligocene, Fayum, Egypt. Plaster cast of skull with lower jaw. Natural size. Acc. No. 23.

*Dinotherium giganteum*. Kaup. Lower Pliocene, Eppelsheim, Germany. Skull with lower jaw: coloured plaster cast, natural size. Acc. No. 14.

*Mastodon (Tetrabelodon) longirostris*, Kaup. Miocene, Eppelsheim, Germany. Cast of mandible with incisors: natural size. Acc. No. 24.

*Mastodon (Dibelodon)* giganteus, Cuvier. Pliocene. Scotchtown, New York. Cast of cranium with mandible; natural size. Acc. No. 25.

*Elephas (Stegodon) ganesa*, Falconer and Cautley. Pliocene, Siwalik hills, India. Skull without mandible; coloured plaster cast; natural size. Acc. No. 15.

*Elephas imperator*, Leidy. Lower Pleistocene, western United States. Restoration model. Acc. No. 21.

*Elasmotherium sibiricum*, Fischer. Pleistocene, Nouvonsenck, Russia. Plaster cast, natural size, of cranium. Acc. No. 31.

*Titanotherium* sp. Skull without lower jaw. Miocene, Chadron, Nebraska. Acc. No. 9.

*Titanotheres*, series of heads of; illustrating the evolution and polyphyletic development of the lower Oligocene forms, as under:—
- a. *Brontotherium platyceras* (Scott and Osborn).
- b. *Megacerops robustus*, Marsh.
- c. *Titanotherium ingens* (Marsh).
- d. *Symborodon acer*, Cope.
- e. *Diplacodon emarginatus*, Hatcher.

Restoration models, one-sixth natural size. Acc. No. 22.

*Merycoidodon culbertsoni,* Leidy. Miocene, Chadron, Nebraska. Two skulls with lower jaws. Acc. No. 16.

*Ungulate remains:* purchased through Mr. D. D. Cairnes. Pleistocene. Last Chance creek, Yukon. viz:—

Mammoth *(Elephas primigenius).* Portion of mandible with teeth, occiput, limb bones, vertebræ, etc.

Horse *(Equus caballus).* Part of lower jaw with teeth; separate teeth.

Deer *(Rangifer).* Parts of antlers, and leg bones, of *R. caribou* and probably of *R. grœnlandicus.*

Sheep *(Ovis montana).* Back of skull with bases of horn-cores.

Bison *(B. crassicornis).* Horn-cores with back portion of skull: most of the vertebral column of one individual; separate vertebræ, foot bones, etc.

The above specimens were from about 35 feet beneath the surface, and within a distance, up and down the creek, of 50 feet. Acc. No. 34.

*Ungulates,* a series of fifty-five coloured casts of the crowns of upper molar teeth of: illustrating the lines of differentiation from the simple tri-tubercular to the more complex forms. Acc. No. 27.

*Ursus spelæus,* Rosenmüller. Pleistocene. Europe. Skull with lower jaw. Acc. No. 17.

*Homo neandertalensis, King.* (Palæolithic man.) Pleistocene, near Hochdal, Germany. Plaster casts, natural size, of—the roof of the skull, right and left femora, parts of the hip-bone, collar-bone, and shoulder-blade, arm bones, etc. Acc. No. 18.

*Recent skeletons,* mounted, of—

*Amia calva,* L. Bowfin; in alcohol. Acc. No. 2.
*Perca fluviatilis,* L. European perch. Acc. No. 3.
*Didelphis virginiana,* Kerr. Opossum. Acc. No. 4.
*Felis catus,* L. Domestic cat. Acc. No. 5.
*Canis familiaris,* L. Dog. Acc. No. 6.
*Erinaceus europæus,* L. Hedgehog. Acc. No. 7.
*Sphenodon punctatum,* Gray. The "Tuatara" of New Zealand. Acc. No. 8.
For comparison with fossil forms.

*By Presentation.*

American Museum of Natural History, New York, through Dr. W. D. Matthew, Acting Curator, Department of Vertebrate Palæontology.

Casts of skulls, jaws, fore and hind-feet, and type specimens of fossil Equidæ, forming a series illustrating the evolution of the horse. The series includes twenty-one species, representing eleven genera, from Eocene, Oligocene, Miocene, and Pliocene deposits in the United States. Acc. No. 19.

Grant, Sir J. A., K.C.M.G., Ottawa, Ont.—

Three specimens of *Mallotus villosus,* Cuvier, in one clay nodule, from Green creek, below Ottawa. Pleistocene. Acc. No. 37.

ADDITIONS TO THE INVERTEBRATE PALÆONTOLOGICAL COLLECTIONS DURING 1911.

Dr. Raymond reports the following additions to the collections of invertebrate fossils:—

*Collected by Officers of the Geological Survey.*

Dresser, J. A.—
A large collection of graptolites from the lower Trenton at Castle brook, Quebec. Acc. No. 63.

Harvie, R.—
Large collection middle Silurian fossils, mostly trilobites, from Knowlton Landing, Lake Memphremagog, Quebec. Acc. No. 74.

Johnston, W. A.—
Large collection from the Lowville, Black River, and Trenton, from various localities east of Lake Simcoe. Acc. No. 73.

Lawson, A. C.—
Richmond fossils from a point 6 miles west of Fort Frances, Ontario. Acc. No. 62.

Leach, W.—
Small collection from the Benton and Mississippian near Blairmore, Alberta. Acc. No. 75.

Raymond, P. E.—
Several collections from Ordovician formations in southern and eastern Ontario and western Quebec. Acc. Nos. 55, 56, 60, 61, 66, 67.

Raymond, P. E., and Johnston, W. A.—
Collections from the Lowville and Trenton east of Mud lake and north of Kirkfield, Ontario. Acc. Nos. 57, 58, 59.

Raymond, P. E., and Whittaker, E. J.—
Collections from the Ordovician formations in eastern Ontario, western Quebec, and near Clayton and Watertown, New York. Acc. Nos. 64, 65, 68, 69, 72.

Whittaker, E. J.—
Several lots of fossils from localities in eastern and southern Ontario. Acc. Nos. 70, 71.

Wilson, W. J.—
Marine fossils from the Mississippian near Norton station, Kings county, New Brunswick. Acc. No. 49.

*By Presentation.*

Grant, Col. C. C.—
Three small collections from the Silurian at Hamilton, Ontario. Acc. Nos. 52, 53, 54.

Grant, Sir James—
Collection fossils, largely from the Trenton in vicinity of Ottawa. Acc. No. 51.

Narraway, J. E.—
Box invertebrate fossils from the Richmond at Stony Mountain, Manitoba. Acc. No. 48.

Wilson, Miss A. E.—
Twenty-five specimens from the Trenton at Cobourg, Ontario, and a collection of Pleistocene shells from Lampton Mills, near Toronto. Acc. Nos. 45, 47.

Wilson, W. J.—
Large collection fossils from the lower part of the Utica, between Rochester and Preston streets, Ottawa, Ontario. Acc. No. 77.

*By Purchase.*

Bassler, Dr. Ray S.—
A collection of 400 species of bryozoa. Acc. No. 50.

Comer, Capt. George—
Fifteen specimens from the Silurian at Southampton island, Hudson bay. Acc. No. 46.

ADDITIONS TO THE PALÆOBOTANICAL COLLECTIONS DURING 1911.

Mr. W. J. Wilson reports that collections of fossil plants were received, during the past year, as follows:—

*By Presentation.*

Mr. James Crawford, Ottawa, per W. J. Wilson—
Four large segments of a fossil tree and twelve small fragments of same, from Wallace quarry, Cumberland county, Nova Scotia (Coal Measures).

*Collected by Officers of the Geological Survey.*

Keele, Joseph—
Twenty small specimens of Tertiary fossil plants from the Dirt hills, Saskatchewan.

Leach, W. W.—
Four small specimens of Cretaceous fossil plants from Blairmore creek and Ma butte, Alberta.

Malloch, Geo. S.—
Thirty-four specimens of fossil plants (Kootenay) from the Groundhog coal basin and Upper Skeena river, British Columbia.

Dowling, D. B.—
Twelve specimens of fossil plants (Kootenay) from Jasper Park collieries and near Folding mountain, Jasper Park, Alberta.

Reinecke, L.—
Twelve specimens of fossil plants (Miocene) from Beaverdell district, British Columbia.

## II

### Invertebrate.

(*Percy E. Raymond.*)

FIELD WORK.

OTTAWA VALLEY.

The months of June, July, and a part of August were spent in an investigation into the stratigraphy of the Ordovician formations of the Ottawa valley. The principal rock exposures about Ottawa, Hawkesbury, Montreal, Cornwall, Brockville, and Kingston were studied, and a short trip into New York state at Clayton and Watertown was made under the guidance of Professor H. P. Cushing of Western Reserve University. A week was also spent with Mr. W. A. Jonhston, in going over some of the better sections at localities on the Brechin and Kirkfield sheets, Simcoe district. These sections are described in Mr. Johnston's reports. Mr. E. J. Whittaker acted as assistant throughout the season, and did very excellent work.

The Ordovician formations of the Ottawa valley usually rest upon the Potsdam sandstone, which is supposed to be of upper Cambrian age, and formations of the following ages occur, beginning with the oldest: Beekmantown, Chazy, Pamelia, Lowville, Black River, Trenton, Utica, Lorraine. The result of the season's work on each of these may be summarized briefly.

### *Beekmantown.*

In the vicinity of Brockville and Smiths Falls the Beekmantown is divisible into two formations. The older formation has two members. The lower part is a rather soft calcareous sandstone, usually thin-bedded. In places, however, the cement is siliceous and the beds very hard. These beds are especially well exhibited about the railway station at Smiths Falls, and in the cuttings south of the station on the line to Brockville. Fossils are there fairly common, and the presence of *Ophileta complanata,* and a gastropod very like *Pleurotomaria canadensis* indicate the Beekmantown age of the formation. The upper member of this formation is a thin-bedded bluish dolomite which weathers to a rusty yellow colour. These beds contain obscure gastropods and crinoidal remains. At Smiths Falls the thickness of the whole formation is above 70 feet, but it seems to thin northward, for it appears to be only about 20 feet thick at Rockland, where it also contains gastropods, and only the lower, sandy member is present. At Ste. Anne de Bellevue this formation seems to be absent, and the layers which are above it at Smiths Falls rest directly upon the Potsdam sandstone.

This formation appears also in New York state, in the vicinity of Clayton, and has been given the name Theresa by Prof. Cushing. This name may be adopted in Canada also.

Above the thin-bedded dolomite of the Theresa there are heavier-bedded limestones and dolomites with a rather large fauna. The greater part of the species are found also in the lower part of the Beekmantown section in the Champlain valley, thus fixing the age rather definitely as lower Beekmantown. It will, however, be necessary to give a new formational name to these beds, and Beauharnois may be suggested, from the classic exposures along the Beauharnois canal between Valleyfield and Beauharnois. In the upper beds at Grenville and at the mouth of the Little Rideau, there is a rather peculiar fauna, dominated by *Bathyurus angelini,* which has heretofore been incorrectly referred to the Chazy.

### *Chazy.*

The investigation of the stratigraphy of the Chazy formation, started last year, was continued, and it was found that the so-called Chazy of the Ottawa valley was composed of two formations, separated by an unconformity which represents a time interval during which the eastern sea withdrew to the east and the interior sea advanced from the southwest.

The beds in the Ottawa valley which are really of Chazy age are those referred to as the Chazy sandstone in the various reports on the district. In the vicinity of Ottawa, this formation has a thickness of 125 to 150 feet, the upper 20 feet being an impure limestone, and the lower part sandstone and shale. The limestone at the top contains fossils characteristic of the upper Chazy. Although this limestone is thin, it can be traced eastward along the south side of the Ottawa river, through Rockland, L'Orignal, and Hawkesbury, becoming thicker, purer, and more fossiliferous as one proceeds eastward. At the Ross quarry on the Little Rideau, 6 miles east of Hawkesbury, it is a massive coarse-grained limestone, with a very abundant and characteristic upper Chazy fauna.

The name Aylmer formation has been applied to this development of the upper Chazy in the Ottawa valley.

*Pamelia.*

At Ottawa, the thin limestone of the upper Chazy is followed by a formation which is shaly and sandy in its lower portion, but consists for the greater part of limestone. There are two easily recognizable divisions, the lower composed of dark blue and grey limestone full of ostracods, with sandy shales at the base. The second consists of light buff, fine-grained, pure limestone alternating with beds of bluish magnesian limestone, which weathers yellow. At the base of the upper division is a bed of coarse sandstone. Neither division contains any greater variety of fossils, but such species as are found are more nearly akin to the Lowville and Black River faunas than to the Chazy. As this formation is traced eastward it becomes thinner. The last actual outcrop seen in that direction is at L'Orignal, and at Montreal the Lowville rests directly upon the limestone of the Aylmer formation.

In northern New York there is a formation beneath the Lowville which is lithologically similar to this. It, too, consists of two members, the lower of rather pure dark limestone, and the upper of alternations of pure buff limestones and "cement beds." Through the kindness of Prof. Cushing the writer was able to see some of the best exposures of this formation, and found the upper beds identical in lithology and fauna with the beds in a similar stratigraphic position at Ottawa. The dark limestone of the lower division in New York has, however, a very different fauna from the beds in a similar position at Ottawa. The characteristic fossil of these beds in New York is a species of *Tetradium*, still undescribed. This coral has not yet been found in the Ottawa valley, but the writer found it to be abundant in the lower Pamelia of southern Ontario, at Kingston Mills (near Rideau station) and at Rush bay on Wolfe island. At the latter locality, the limestone holding the *Tetradium* is underlain by a brown and black shale with an abundance of ostracods, among them *Isochilina? clavigera*. This ostracod is abundant in a similar black shale beneath the dark limestone at Ottawa, and it is believed that the shales at the two localities represent the same horizon. If this be so, then the name Pamelia can be adopted for the formation in the Ottawa valley.

*Lowville.*

As at present restricted, this name is applied only to the buff, fine-grained limestone characterized by *Tetradium cellulosum* and *Bathyurus extans*. During the season very good collections of the fossils of this formation were made at Pointe Claire, Rockland, and Ottawa. The formation is from 15 to 30 feet thick in the Ottawa valley, but thins northward and eastward, being entirely absent at Joliette, where the Black River rests upon the upper Chazy.

*Black River.*[1]

In the Ottawa valley the Black River formation proves to be from 30 to 40 feet in thickness, and consists of two portions. The lower 15 feet consists of fine-grained,

[1] The name Black River is here used in the sense in which it has been accepted in New York until recently, i.e., as including those beds between the 'Birdseye' and Trenton which contain Columnaria, Gonioceras, Hormotoma, etc. It may be well to use the term as was done by Vanuxem in 1842, in which case a new name must be given to the formation, and it, with the Lowville and Pamelia, would constitute the Black River group.

black, earthy limestone with a large fauna, while the upper part is usually coarser-grained, blue limestone with very few fossils. The lower member is unlike the Leray formation of the typical Black River at Watertown, New York, in that it lacks the chert which is so abundant there, and the upper part differs from the Watertown limestone in its fauna. The question of the nomenclature of this formation is too complicated to be entered upon here.

### *Trenton.*

The various exposures of the Trenton around Ottawa were studied with great care, in an attempt to correlate the various beds and make out a complete section of the formation. In spite of the numerous and good exposures, the faulting has so obscured the relationships of the various beds that it is difficult to ascertain the exact thickness of the formation. The following zones have been recognized, beginning with the lowest:—

(1) Thin-bedded pure blue-black limestone characterized by *Orthis tricenaria, Phragmotites compressus*, etc. These beds are very poorly exposed at Ottawa, and have an estimated thickness of about 40 feet. They are well shown above the Black River in the Stewart quarry at Rockland, and were also seen at Fenelon Falls, and at Kirkfield lift-lock, in the region surveyed by Mr. Johnston.

(2) Thick and thin-bedded blue limestone with a large amount of chert, developed as flat plates parallel to the bedding. These beds are particularly well shown in Hull, and furnish a large part of the building stone and crushed stone used in Ottawa. Just at the top of these beds are the layers from which a large part of the crinoids found in Hull have been obtained. Strata with the same fauna as these beds occur in central Ontario at Fenelon Falls and the Kirkfield lift-lock, where they occupy the same stratigraphic position as at Ottawa. The thickness of these beds is about 65 feet.

(3) Massive, coarse-grained, blue-grey limestone with few fossils. This is the horizon in which are located the large quarries on Montreal road, 3 miles east of Ottawa. The same beds are exposed in Hull, but are not quarried at the present time. They seem to be absent from the section in Simcoe district, central Ontario. The most common fossil is a species of *Tetradium*, very like *T. cellulosum*. The thickness is about 35 feet.

(4) Very thin-bedded limestone with thick shale partings. Characterized by abundant large bryozoans of the genus *Prasopora*. This bed seems to have a very wide distribution, and the fossils are beautifully preserved. Specimens were collected from it this season at Brechin, Kirkfield lift-lock, and Fenelon Falls in central Ontario, at Ottawa and Finch in eastern Ontario, and at Montreal, Charlesbourg, Beauport, and Chateau Richer in Quebec. In spite of their thin-bedded and shaly character, the strata of this zone are extensively quarried. The thickness of the zone is small, usually not more than 25 feet, and frequently less.

(5) Rather thin-bedded light-grey limestone with thin shale partings. This is the zone with *Pleurocystites, Agelacrinites*, and a crinoid fauna similar to that found in No. 2. Thickness, about 75 feet.

(6) Heavy-bedded, fine-grained limestone with clay irregularly distributed through it. These layers weather into an irregular rubbly mass. Characterized by *Hormotorma trentonensis, Rafinesquina deltoidea*, sponges, and, at the very top, by a great abundance of *Cyclospira bisulcata*. Thickness, about 75 feet.

### *Utica.*

*Lower Utica (Collingwood formation)*.—The rubbly-weathering limestone at the top of the Trenton is succeeded by a thin formation consisting of layers of fine-grained, rather pure blue limestone alternating with thick beds of soft brown shale. The total thickness of the formation is not definitely known, but it appears to be less than 50 feet. The fauna of this formation differs from that of the typical Utica in many respects. Graptolites are practically absent, and the characteristic species are *Ogygites canadensis* (Chapman), *Dalmanella emacerata*, Hall, *Triarthus becki*, Green, and *Oxoplecia calhouni*, Wilson. This Atlantic fauna is well developed at the same stratigraphic horizon at Collingwood, Ont., and that name is suggested for the formation.

*Typical Utica.*—The shales above the Collingwood formation are much darker than those in the lower formation, and contain the graptolite fauna of the typical Utica.

### QUEBEC AND VICINITY.

The time from August 15 to October 8 was spent in the study of the Ordovician formations in the vicinity of Quebec. Mr. Whittaker devoted his time with marked success to the study of the upper formations north of the St. Lawrence and east of the St. Charles river, making especially fine collections from the Trenton. In spite of the large amount of work which has been done on these particular strata, and the abundance of fossils, there still seems to be some uncertainty as to the age of these relatively undisturbed beds, and a brief account of the results obtained by Mr. Whittaker and the writer this season will serve to set forth the data.

The oldest beds now exposed in this area are those in the gorge at Lorette, where the basal layer contains Parastrophia hemiplicata, Phragmolites compressus, and other fossils. This layer is followed by 10 feet of limestone with numerous straight cephalopods and Receptaculites, and then comes the bed with the coiled cephalopods, Trocholites canadensis and Plectoceras halli, in abundance, and Tetradium fibratum. This section is very similar to the basal portion of the Trenton on Lake Champlain, the Parastrophia hemiplicata fauna being the oldest in the Trenton there.

The oldest beds exposed in the bed of the Montmorency river are a half mile above the falls. At this locality *Plectoceras halli* and *Trocholites canadensis* are abundant, as is *Tetradium fibratum*, and thus correlate this bed with the third zone at Lorette. In passing southward to the brink of the falls, beds higher than these are seen resting on the granite with a basal arkose which has frequently been described. Groups of sponges in situ, attached to the granite, show that this was a granite ridge in the Trenton sea, as was pointed out long ago by Bigsby.

Above the *Trocholites* zone there is a considerable thickness of limestone, probably about 250 feet, of Trenton age. The lower half is characterized by an abundance of *Triplesia nuclea* and *Trinucleus concentricus*, well shown at Montmorency, Chateau Richer, and Beauport. In the middle is the zone with *Prasopora*, and at the very top, at Point Trembles, is a zone with *Cyclospira bisulcata*, as at Ottawa. The presence of this zone is important, as it indicates that the base of the black shale (Utica) can not be much older here than at Ottawa.

Above the *Cyclospira* bed are about 100 feet of thin-bedded, clayey limestone containing a few Trenton survivors, and the first Utica invaders, *Triarthus becki* and graptolites. These beds are best shown in the eastern ravine below the falls at Montmorency, and at Point Trembles. Above these beds are black and brown shales with graptolites which Dr. Ruedemann very kindly examined and which he finds to be typical expressions of the Utica species.

These black shales are about 200 feet thick, and they are followed at Montmorency and along the north shore of the St. Lawrence, west of Cap Rouge, by several hundred feet of soft brown micaceous shales with graptolites, brachopods, and trilobites. From their positions above the Utica and the presence of *Climatograptus bicornis*, *Triarthus becki*, *Trinucleus concentricus*, and *Catyzyga erratica*, these beds are thought to be of Frankfort age, possibly shading upward into the Lorraine. In the upper part are thin layers of sandstone and limestone conglomerate.

### QUEBEC CITY.

A considerable time was spent in a search for fossils in the limestone and shale of the Quebec City formation, but although a number of new localities for graptolites were found, no fossils other than graptolites and inarticulate brachiopods were obtained, except in the pebbles of the conglomerates.

A band of conglomerate with very fossiliferous limestone pebbles is well exposed in the axis of an anticline at the foot of Mountain hill, and a similar conglomerate, with the same fossils, can be traced from the foot of the hill at Dambourges street along the northern bluff to Côte de la Negresse. The pebbles of this conglomerate, and the higher one back of the Montcalm market, have afforded numerous fossils to Mr. T. C. Weston, Dr. H. M. Ami, and the writer. The more important species are:—

*Nidulites*, sp. ind.,
*Christiania trentonensis*, Ruedemann.
*Plectambonites pisum*, Ruedemann.
*Hebertella bellarugosa*, (Conrad).
*Rafinesquina champlainensis*, Raymond.
*Parastrophia hemiplicata*, Hall.
*Ampyx hastatus*, Ruedemann.
*Ampyx* cf. *A. halli*, Billings.
*Tretaspis reticulata*, Ruedemann.
*Isoteloides* cf. *I. augusticaudus*, Raymond.
*Sphærocoryphe major*, Ruedemann.

This is the fauna described by Ruedemann from the conglomerate at Rysedorph hill, near Albany, and the fossils have more recently been found in place in the Chambersburg limestone of eastern Pennsylvania by Ulrich and Stose. There seems to be no doubt that this fauna is of the age of the lower Trenton, but no such fauna has been found in the more "normal" Trenton rocks north of the St. Charles.

### LÉVIS.

A detailed study of the stratigraphy of the closely folded shales and limestones of the Lévis formation was made, in an attempt to locate the various graptolite zones in a section. The results of the surveys and measurements have not yet been compiled. About ten days were also spent in studying localities in the vicinity of the Champlain-St. Lawrence fault in northern Vermont, at Philipsburg, Bedford, Mystic, and St. Dominique. It was found that there were no strata of Chazy age in the section at Philipsburg, and that the so-called Chazy shales which overlie the Beekmantown at Bedford are probably the equivalent of the Lévis shales at Lévis.

### OFFICE WORK.

The work on the catalogue of the types in the collection of invertebrate fossils has been actively prosecuted by Miss A. E. Wilson, and the identifications checked by the writer. The portion of the collection containing the Cambrian, Beekmantown, and Chazy fossils has been practically completed. This portion presented more difficulties than can be expected from any other part of the collection, as the specimens were poorly figured, frequently not figured at all, or the types were not marked, and the collection has suffered by passing through many hands. In this part of the collection many of the types appear to be lost.

Besides the routine work of the office, the writer undertook the study and revision of the species of the trilobite genus *Bathyurus*, a genus whose real stratigraphic value has been destroyed by the incongruous assemblage of forms which have been referred to it. This work can not be carried further until the illustrations are made for it.

In speaking of the accessions to the collection during the year, especial mention should be made of the liberality of Sir James Grant in presenting his collection to the Museum. This collection contained the type of *Harpes ottawaensis*, Billings, and several especially fine cystids from the vicinity of Ottawa.

Collections have been examined and reported upon for the following members of the staff:—

Mr. D. D. Cairnes—
Large collection from the upper Ordovician, Silurian, and Carboniferous from the Yukon-Alaska boundary, south of the Porcupine river.

Mr. C. Camsell—
Specimens of *Aucella piochii* from Lightning creek, Yale district, British Columbia.

Mr. D. B. Dowling—
A large collection of middle Cambrian, upper Devonian, and Mississippian fossils from Jasper park, Alberta.

Mr. R. W. Ells—
A large collection of middle Silurian fossils from Charlotte county, New Brunswick.

Mr. E. R. Faribault—
A small collection from the Mississippian on Birch island, Chester basin, Lunenburg county, Nova Scotia.

Mr. R. Harvie—
Large collection of middle Silurian fossils from Knowlton Landing, Lake Memphremagog, Quebec.

Mr. W. A. Johnston—
Large collection of lower Ordovician fossils from central Ontario.

Mr. A. C. Lawson—
Collection of Richmond fossils from 6 miles west of Fort Frances, Ontario.

Mr. W. Leach—
Small collection from the Benton shale and a single specimen from the Mississippian, near Blairmore, Alberta.

Mr. George S. Malloch—
Small collection of Mesozoic fossils from the Skeena district, British Columbia.

Mr. S. J. Schofield—
Small collection of Mississippian fossils from Wardner, East Kootenay district, British Columbia.

Mr. G. A. Young—
Collection of lower Devonian fossils from western New Brunswick.

# III.

## PALÆOBOTANY.

(*W. J. Wilson.*)

The first part of the year was occupied in packing fossils preparatory to moving them to the Victoria Memorial Museum, and in unpacking them and placing them temporarily in cases in the new Museum. Continuing work begun last year, considerable time was spent in the preparation of a catalogue of the type specimens in the Museum. A large collection of Carboniferous plants from New Brunswick was labelled, and labels were prepared in manuscript for all the fossil plants in the Museum so far catalogued. These labels were prepared for the printer so as to be ready when the specimens are placed on exhibition in the new cases. This list required considerable research as the synonomy of each species had to be carefully examined.

There were several collections of Tertiary plants from British Columbia stored in drawers under the exhibition cases, that had been identified by Sir J. W. Dawson. These were numbered and catalogued, also some small recent collections identified by Dr. F. H. Knowlton. A collection of Oligocene plants from British Columbia, containing several hundred specimens collected by Mr. L. M. Lambe and identified by Dr. D. P. Penhallow was also numbered and catalogued. Miss A. E. Wilson assisted with this lot.

Among the Carboniferous plants from Minto, New Brunswick, were the section of a cone and several separate bracts belonging to the same species. These I have described under the name *Lepidostrobus mintoensis*, sp. nov., and the description will be published in the bulletin soon to be issued by this Department.

During the present year different members of the staff brought in small collections of Cretaceous and Tertiary plants from British Columbia, Alberta, and Saskatchewan. These specimens were studied and named in part and were afterwards forwarded to Dr. F. H. Knowlton, of Washington, who revised my list and extended it by adding several species. The following species are from the list as revised.

The largest collection was obtained by Mr. G. S. Malloch from the Groundhog coal basin and vicinity, Skeena river, B. C. In this collection the following genera and species were identified:—

*Cladophlebis virginiensis*, Fontaine.
" *fisheri*, Knowlton,
" ? sp.,
*Nilsonia parvula*, (Heer) Fontaine.
" sp. ?,
*Oleandra graminæfolia* ?, Knowlton,
*Zamites montana*, Dawson,
*Equisetum phillipsii* ?, (Dunker) Brongn,
*Baiera multinervis*, Nathorst,
*Podozamites lanceolatus* ?, (L. and H.) Br.
*Gleichenia*, sp. ?.

Of these *Cladophlebis virginiensis*, *C. fisheri*, *Equisetum phillipsii*, and *Baiera multinervis* are reported from Canada for the first time.

The plants of this collection are of Kootenay age except *Baiera multinervis* and *Podozamites lanceolatus* which indicate the Jurassic.

In Mr. Leopold Reinecke's collection of about a dozen specimens from the Beaverdell district, B.C., there are only two specimens sufficiently well preserved to admit of specific identification, and these apparently belong to a new genus which will be described later. The general appearance of these plants indicates the Tertiary.

In Mr. D. B. Dowling's small collection of plants from Jasper park, Alberta, there are only two species, viz.:—

*Sequoia reichenbachi,* (Gein) Heer.
*Sphenolepidium kurrianum,* Heer.

The latter is new to Canada and both species are of Kootenay age.

In Mr. J. Keele's fragmentary collection from the Dirt hills, Sask., the following species were identified:—

*Equisetum,* sp. nearest *E. oregonense,* Newb., but smaller, and probably new.
*Glyptostrobus europæus,* Brongn.
*Leguminosites arachioides,* Lesq.,
*Onoclea sensibilis fossilis,* Newb.,
Fragments of dicotyledonous leaves but not determinable.

These plants belong to the Fort Union group.

A few specimens brought in by Mr. W. W. Leach from Blairmore, Alberta, contain the impression of rootlets and are indeterminable.

## MINERALOGICAL DIVISION.

(*Robt. A. A. Johnston.*)

The work performed in this section has not differed materially in character from that of previous years. About four hundred and fifty specimens have been examined and reported upon. The removal of the Geological Survey from the old building on Sussex street to the Victoria Memorial Museum has entailed a serious handicap in the matter of laboratory facilities, and it has not been possible to give the attention to details in many cases in which it has been desirable. It is hoped though that with the installation of a small laboratory equipment in the Museum building this difficulty will be in large measure removed.

### MINERALOGICAL NOTES.

#### DIAMOND.

The finding of microscopic diamonds in association with the chromite of Olivine mountain (Summary Report of the Geological Survey, 1910, p. 262) suggested the possibility of finding this mineral under similar circumstances elsewhere, and at the suggestion of Mr. J. A. Dresser, examinations were made of a number of specimens from the vicinity of Black Lake, Megantic county, Quebec. Specimen No. 1 consisted of massive chromite from the Montreal pit, and was found to contain 0·06 per cent of microscopic diamonds similar in all respects to those which have been described from Olivine mountain; specimen No. 2 consisted of serpentine, but the presence of diamond in it was not detected; a third piece consisting of peridotite also gave negative results.

A very interesting occurrence of diamond was noted in connexion with the chrome picotite of Scotty creek, Bonaparte river, Cariboo district, British Columbia. From a specimen of this material a mass was obtained which measured $\frac{3}{16}$ of an inch in diameter. This mass rapidly broke up into a number of pieces which, under the microscope, could be seen to be made up of minute octohedral crystals arranged in parallel position; in the course of few days the mass had completely disintegrated.

During the summer season Mr. Charles Camsell made a collection of eleven samples of concentrates from the gravels of Tulameen river and tributaries, Yale district, British Columbia. Time, however, did not permit of the examination of more than three of these, all of which came from the vicinity of Eagle creek. One sample consisting of 5 grammes of fine concentrates, about a third of which was magnetite, did not yield any diamonds; another labelled "Concentrates from loose sand" weighed 7 grammes, and yielded two minute diamonds along with a number of minute rubies; the third sample, which was labelled "Conglomerate river-gravels," weighed 391 grammes and yielded a number of minute diamonds along with a few rubies.

#### TOPAZ.

This mineral was first noted in some specimens sent to Mr. E. R. Faribault by Mr. Samuel Freeze, Doaktown, N.B. The locality of occurrence was given as "One-half mile up from mouth on Burnthill brook (S. W. Miramichi), N.B." These specimens had evidently been taken close to the surface, as they were all rather heavily coated with rust and otherwise showed the effects of exposure to the weather. Subsequent to the receipt of these specimens the locality was visited by the Director of the Geological Survey, Mr. R. W. Brock, who observed the same mineral occurring at other places in the neighbourhood, particularly on a hill on the south side of the Southwest Miramichi river, opposite to and about a fourth of a mile distant from the mouth of Burnthill brook (The Canadian Mining Journal, vol. 32, 1911, p. 549). Here, as elsewhere in the district, the mineral is generally very much weathered and it is only rarely that material of gem quality has been observed. The topaz occurs either as crystalline masses or as individual crystals ranging from those of minute dimensions to others having a diameter of ¾ of an inch. The colour, where it can be observed on a fresh surface, is generally milk white; in the case of a few of the smaller translucent crystals the colour is smoke grey. The associations are quartz, wolframite, molybdenite, and cassiterite. The wolframite and molybdenite are reported to occur in considerable abundance; the cassiterite has so far not been noted in any appreciable amount.

## Work Performed by Members of Division.

### MR. R. L. BROADBENT.

Excepting short periods in which he was engaged in securing specimens for the Festival of Empire Exhibition in London, Mr. Broadbent was employed continuously during the first half of the year in preparing mineralogical specimens for the Museum, and the excellent order in which the collections now are bears testimony to the diligence and patience with which he carried on this work.

Mr. Broadbent died on the 16th day of July after a brief illness. He had been continuously in the employ of the Geological Survey since 1881, and had superintended the arrangement of the mineral exhibits in the Canadian sections at a number of the World's Fairs. In the interval between 1903 and 1908, his time was devoted almost entirely to this work under the direction of the Canadian Exhibition Commissioner, Mr. Wm. Hutchison. His experiences at these exhibitions rendered him particularly well fitted for the duties which would have devolved upon him in arranging the collections in the Victoria Memorial Museum, and his death at this juncture entails a serious loss in the Mineral Section of the Museum.

### MR. STANLEY P. GRAHAM.

The vacancy created by the death of Mr. Broadbent was filled in October by the appointment of Mr. Stanley P. Graham.

Since his appointment Mr. Graham has for the most part been engaged in the extension of the Index of Canadian Minerals, and has made very satisfactory progress in this connexion.

### MR. A. T. McKINNON.

As in previous years, Mr. McKinnon has continued to render most faithful service in connexion with the duties that have been entrusted to him. In addition to the materials which he has collected for the educational series, he has also made important additions to the Museum collections. During the season just closed over 10 tons of material have been assembled for use in the educational collections. Collections have been distributed by provinces as follows:—

| | Grade 1. | Grade 2. |
|---|---|---|
| Alberta | 1 | 2 |
| British Columbia | 1 | |
| Manitoba | 3 | 2 |
| New Brunswick | 3 | 3 |
| Nova Scotia | 11 | 21 |
| Ontario | 16 | 11 |
| Quebec | 11 | 15 |
| Saskatchewan | 2 | 2 |

The thanks of the Department are due to the following gentlemen for much kindly assistance in assembling materials for these collections:—

Captain Lawson, Copper Cliff, Ont.; Messrs. J. G. Sipprell, and B. R. Gordon, and Captain Church, Cobalt, Ont.; Mr. W. A. McMurray, Gilmour, Ont.; Mr. Thos. Momson, Bancroft, Ont.; Mr. Wilson Bailey, Madoc, Ont.; Mr. Bush Winning, Ottawa, Ont.; Mr. James McCabe, Notre Dame du Laus, Que.; Captain Johnston, St. George, N.B.; Messrs. C. M. Hoyt and A. M. Reid, Middleton, N.S.; Mr. John Wasson, Two Islands, N.S.

## Additions to Mineral Collection.

The following additions have been made to the Canadian section of the mineral collections:—

### DONATIONS.

Mr. Samuel Freeze, Doaktown, N.B.—Topaz, molybdenite, and wolframite from Burnthill brook, York county, New Brunswick.

Mr. S. R. Lanigan, St. Rénê de Amherst, Que.—Group of quartz crystals from Amherst, Labelle county, Quebec.

Mr. J. A. Leamy, Ottawa, Ont.—Native silver from near Wallace mountain, Osoyoos division, Yale district, British Columbia.

Mr. M. Lodge, Moncton, N.B.—Wolframite from the parish of Stanley, York county, New Brunswick.

Mr. James McEvoy, Toronto, Ont.—Coke made from a 12 inch seam, north end of Folding mountain, Jasper park, Alberta. Coal from lot 133—above Groundhog mountain, head-quarters of the Skeena river, British Columbia—6 foot seam.

Mr. Thomas Gough, Nelson, B.C., per O. E. LeRoy.—Auriferous pyritous quartz from the Poorman mine, Eagle creek, Nelson, British Columbia.

Mr. H. G. Stillwell, Nelson, B.C., per O. E. LeRoy.—Pyrargyrite from the Hewitt mine, Silverton, West Kootenay, British Columbia.

Mr. James Matheson, Stornoway, Quebec.—Fetid quartz from Winslow, Compton, Quebec.

Mr. Robert Musgrave, Victoria, B.C.—Diatomaceous earth from a point about 2 miles from Quesnel, Cariboo district, British Columbia.

Mr. H. G. Tucker, Owen Sound, Ont.—Sphalerite from the township of Keppel, Grey county, Ontario.

### COLLECTED BY OFFICERS AND EMPLOYES OF THE DEPARTMENT OF MINES.

Mr. R. W. Brock.—Topaz, molybdenite, cassiterite, and wolframite from Burnthill ridge, parish of Stanley, York county, New Brunswick.

Mr. D. D. Cairnes.—Native gold in quartz from Bear creek, Dawson district, Yukon. Ankerite from near the intersection of the Alaska-Yukon boundary with the Arctic circle. Magnesite from near the intersection of the Alaska-Yukon boundary with the Arctic circle. Knot from lignite deposit, Sloko lake, Atlin Mining division, Cassiar district, British Columbia.

Mr. D. B. Dowling.—Rock showing casts of salt crystals from the yellow band at the foot of Roche Miette, Jasper park, Alberta. Three samples of coal from the Castor Coal Company's property, sec. 3, tp. 38, range 14, west of 4th meridian, Alberta.

Dr. Eugene Haanel.—Collection of sixty-five specimens to illustrate Dr. W. A. Parks Report on the Building and Ornamental Stones of Ontario.

Mr. A. T. McKinnon.—Wire silver from the Cobalt Lake mine, Cobalt, Ont. Chromite, Coleraine, Que. Staurolite, Publico, N.S. Chrysotile in serpentine, Thetford, Que. Garnet crystals, Tudor, Ont. Anhydrite, Hillsborough, N.B. Alabaster with crystals of selenite, Hillsborough, N.B. Alabaster (pink), Hillsborough, N.B. Gypsum showing bedding, Hillsborough, N.B. Fluorite coated with barite, Madoc, Ont. Olivine sps., Bigelow, Que. Spinels in olivine, Bigelow, Que. Crystals of pyroxene, Hull township, Quebec. Zeolites, including heulandites, chabazites, analcites, stibnites, and geodes containing each of these minerals, Two Islands and Minas basin, N.S. Agates, Two Islands and Partridge island, N.S. Native copper, Horseshoe cove, N.S. Apatite crystals, Hull township, Quebec. Pyroxene crystals, Hull township, Quebec.

Mr. Hugh S. de Schmid.—Przibramite from North Burgess, Lanark county, Ontario.

Mr. Stewart J. Schofield.—Pyromorphite and cerussite from the Society Girl Claim, Fort Steele Mining division, East Kootenay, British Columbia.

Mr. Joseph Keele.—Kaolinite from St. Remi de Amherst, Labelle county, Quebec.

Mr. O. E. LeRoy.—Series of eight specimens of the ore from the Sunlight mine, Anderson creek, Nelson Mining division, West Kootenay, B.C. Specimen of slickensided ore from the Queen Victoria mine, Beasley, Nelson Mining division, West Kootenay, B.C. Two specimens of quartz crystals with dependent pyrite crystals from the Sunlight mine, Anderson creek, Nelson Mining division, West Kootenay, B.C. Calamine from the Hudson Bay mine, Sheep creek, West Kootenay, B.C.

PURCHASES.

Sebastopol, Renfrew county, Ont.—Two large crystals of titanite and series of large crystals of red apatite.

Per Mr. A. A. Cole, Cobalt, Ont.—Large sheet ($7\frac{1}{2}$ lbs.) of leaf silver from the Nova Scotia mine and three specimens of native silver from the Cobalt Lake mine, Cobalt, Nipissing, Ontario.

Evans collection.—This collection, which was made by Mr. J. W. Evans, Belleville, Ont., has now been acquired for the Museum. It contains a large series of Canadian minerals as well as many from foreign localities.

The following additions have been made to the foreign division of the mineral section of the Museum:—

Mr. Henry T. Buie, Murfreesboro, Arkansas, U.S.A.—Four specimens of diamondiferous peridotite from Pike county, Ark.; greenockite on quartz from Marion county, Ark.

Mr. J. H. Haslam, Hebron, N.D., U.S.A., per D. B. Dowling.—Coke made from lignite found near Hebron, N.D.

METEORITES.

Purchase.—Model of the Willamette meteorite.

Purchase.—The "Blithfield" meteorite. This is a small siderolite which was found August 13, 1910, by Joseph Legree, Renfrew, Ont., on lot 20, con. II, Blithfield tp., Renfrew county, Ontario.

# TOPOGRAPHICAL DIVISION.

(*W. H. Boyd.*)

## PART I.

### Field Work.

The field work during the past season was allotted as follows: Messrs. R. H. Chapman (in charge) and K. G. Chipman, the Alberni and Cowichan Lake sheets, Vancouver island, B.C. The work was divided along the 49th parallel of latitude: Mr. Chapman mapping the Alberni sheet and Mr. K. G. Chipman the Cowichan Lake sheet; Mr. W. E. Lawson, the Moncton, N.B., map-area; Mr. A. C. T. Sheppard, the completing of the Slocan, B.C., map-area; Mr. S. C. McLean, the triangulation of the Moncton map-area and Windermere, B.C., area. The reports relating to the above work are submitted separately.

The writer took charge of the Blairmore-Frank, Alta., map-area and of the detail map of Turtle mountain and Frank landslide. Field work on these areas was started on June 10 and closed on October 17.

#### BLAIRMORE MAP-AREA.

The Blairmore-Frank map-area lies between latitudes 49° 30′ and 49° 45′, covers an area of about 195 square miles, and includes the towns of Coleman, Blairmore, Frank, Hillcrest, Bellevue, Passburg, and Burmis. The publication scale is $\frac{1}{62500}$, or nearly 1 mile to 1 inch, contours are shown at intervals of 100 feet. The methods employed were triangulation control from a measured base at Blairmore, plane-table intersection, camera, plane-table and stadia and telemeter. The work on this map-area was discontinued on August 1, the detail mapping of Turtle mountain being started in order to have it completed before the Commission appointed to investigate the condition of Turtle mountain arrived at Frank.

The detail map of Turtle mountain and Frank landslide was made on the scale of 800 feet to 1 inch with contours at 20 foot intervals. The map-area is 3½ square miles. The methods employed were triangulation control from measured base at Frank, plane-table intersection, transit, and stadia, the greater part of the detail being put in by plane-table and stadia. The camera was also used for part of the broken rock detail on the lower slope of the mountain and was found to give very satisfactory results for this particular subject on the scale used. The following figures will give some idea of the quality of work done on this map: 13,870 points were fixed and used for the control of the detail over the map-area, this gives an average of 89 points per square inch of map surface. This map was completed about the end of September; blue-print copies, profiles along certain sections as well as a cardboard model of the mountain, were supplied to the Commission. During the remainder of the field season the work on the Blairmore-Frank map-area was continued.

Messrs. B. R. McKay, D. A. Nichols, and A. G. Haultain were attached to the party as topographical assistants and rendered efficient services. The field assistants were Messrs. J. R. Cox, D. B. Cole, L. Sewell, H. D. Rogers, F. E. Elliott, and W. C. Murdie. Mr. A. C. T. Sheppard and his party, after completing the Slocan work, joined the party at Blairmore on July 25 and remained until the close of the field season, greatly assisting with the work of the general and detail mapping.

The weather conditions during the whole summer were very unfavourable for field work: the large amount of rainfall and the very high winds greatly retarded the progress of the work. A quantity of snow fell about the middle of September, causing considerable delay.

During the early part of May, the writer spent a week in the vicinity of Moncton, N.B., in connexion with the topographical mapping of that area.

The writer's thanks are due to Mr. R. W. Coulthard, general manager of the West Canadian Collieries Company at Blairmore, Alta., and to his staff, for information and kindly assistance.

(*a*)

## ALBERNI SHEET, VANCOUVER ISLAND.

(*R. H. Chapman.*)

The field season of 1911 was spent in mapping the Alberni sheet, the map-area extending from longitude 124° W. to longitude 125° W., and from latitude 49° N. to about latitude 49° 45′ N., and lying north of the territory mapped by K. G. Chipman.

Field work was not begun until the first week in July and continued until October 25. This region has many peaks rising between 4,000 and 6,000 feet, having bare rocky tops, separated by low grade, densely-timbered valleys. The party was constantly handicapped by smoke, seldom working at more than 60 per cent or 70 per cent efficiency.

The whole area has been greatly eroded by major ice-streams and locally modified by smaller isolated glaciers. The drainage is complicated and largely hidden by timber growth.

The method employed was essentially plane-table survey. Many stations were located from carefully plotted points which had been determined by triangulation in 1909 and 1910. Many miles of traverse were run, in the timber and rough mountain country paced distances were used, while the wagon roads were run by "wheel" traverse methods. These traverses were checked by the plane-table control. Micrometers were used on lake and sea-shore lines, which were also controlled by plane-table location.

The total area mapped is 1,435 square miles. The field scale adopted is 1:192000—almost precisely 3 miles to 1 inch—for publishing at 1:250000, or approximately 4 miles to 1 inch, and contours with an interval of 200 feet were drawn.

Satisfactory assistance was given by W. H. Davies and W. C. Griesbach.

(*b*)

## COWICHAN SHEET, VANCOUVER ISLAND.

(*K. G. Chipman.*)

The field season of 1911 was spent in mapping the Cowichan Lake sheet. Field work was started the last of May and continued to the end of October. During this time 1,370 square miles were mapped for publication at 4 miles to an inch with a contour interval of 200 feet. J. J. Phillips rendered efficient assistance.

The map area extends in longitude from 124°-125° W., and in latitude from 49° —about 48°-25 N.—and is south of that mapped by R. H. Chapman. It includes Cowichan and Nitinat lakes and the drainage of San Juan. Gordon, Carmanah, Sevenmile, and Clanewah rivers, with part of the Jordan. North of Cowichan lake the greater part of the country is almost alpine in character, while that to the south is lower in relief and everywhere heavily timbered.

The method employed was plane-table intersection. The micrometer eye-piece was used in connexion with the alidade for traversing shore-lines. The area is without roads; trails were put in from pace aneroid traverses or route sketches, the latter also furnishing considerable detail in the country where there were no trails.

The work along the coast was much delayed by fog and the rest of the work to a lesser extent by rain. Because of the heavy timber, stations were very few, while the undergrowth and scarcity of trails made travelling difficult.

The meetings in Trail of the Western Branch of the Canadian Mining Institute were attended on May 18 and 19.

(c)

## TRIANGULATION WORK.

*(S. C. McLean.)*

The early part of the field season of 1911 was spent near Moncton executing a local triangulation for the primary control of the Moncton map-area. This work was begun on May 5 and finished June 10. The remainder of the season was spent in the Columbia-Kootenay valley executing a secondary triangulation of this valley from a point near Golden towards the International Boundary.

### *Moncton Triangulation.*

This was of a purely local character, meant solely to furnish the primary control of the Moncton map-area. Accompanied by W. H. Boyd, chief topographer, and W. E. Lawson, the area included in the sheet was visited and the scheme of triangulation, afterwards executed, was planned. This comprised the measurement of a base-line about 1½ miles in length, just below Moncton, on the south side of the Petitcodiac river, an expansion therefrom to the necessary control points and the tieing in of the whole to our initial position, an astronomic pier established in Moncton in 1908 by the Astronomic Branch of the Department of the Interior. Twelve stations, including two towers, one 40 and the other 15 feet high, were found necessary and these were signalled and observed. When observing, any prominent points such as church steeples, factory chimneys, etc., which promised to help the control, were cut in. An observation was made on polaris for azimuth, and the geodetic positions of all the points were computed and handed to W. E. Lawson (in charge of the topography) before leaving the field.

A 4½ inch Berger transit reading to 1 minute was used for this work, the angles being read by repetition, three direct and three reverse. The weather throughout was very favourable.

### *Columbia-Kootenay Triangulation.*

This is a secondary triangulation to serve the double purpose of connecting the trigonometric survey of the railway belt, executed by the Topographic Branch of the Department of the Interior with the triangulation of the International Boundary

Survey, and of furnishing the primary control for the proposed Windermere and East Kootenay Topographic sheets.

Stations XXI (Spillimacheen) and C of the railway belt triangulation were chosen as base and, using the mountain ranges of each side of the valley, eleven other stations were selected and signalled, thus carrying the triangulation south as far as Sheep creek. This work took until about September 1, when it was decided to begin revisiting and observing the stations signalled. The weather for the remainder of the season was very unfavourable and only seven of these stations were reoccupied.

The instruments used were—for obtaining the approximate position of the stations when planning the triangulation, a 15 × 15 inch plane-table—for reading the angles, a 6¼ inch Berger theodolite with horizontal circle graduated to 10 seconds, vertical circle to 30 seconds. The horizontal angles were read by repetition, 6 direct and 6 reverse. For the vertical control, double zenith distances were taken. The centre of all stations was marked by a C.G.S. Standard brass plate B.M. fixed in a drill-hole in the rock. The signals are cairns of rock and were covered with white or black cloth as seemed best.

The season was wetter than is usual in this district. The first week or ten days of both July and August were passed in enforced idleness due to continuous rain and fog. The remainder of each month was fine. September, being a month of low-lying clouds with considerable snow on the mountains, was almost wholly lost for triangulation, one station only being occupied. October, after the first few days, proved fine and it was then that most of the observing was done. The new snow at this time on the mountains made the climbing of the more difficult points dangerous, so the easier points having been observed the season closed on October 24.

J. Lanning, technical assistant, proved specially well adapted for the work.

(*d*)

## SLOCAN MAP-AREA, BRITISH COLUMBIA.

(*A. C. T. Sheppard.*)

The writer's instructions for the field season of 1911 were to finish the topographical mapping of the Slocan district, and on the completion of this work, to join Mr. Boyd at Blairmore, Alta., on the mapping of that area. Owing to the dense smoke caused by the fire which swept a portion of the Slocan in 1910, it was found impossible to finish in that year, and to complete the work it was necessary to occupy some seventeen camera stations and traverse about 40 miles of trails and railways this season.

Work was commenced on June 10. The spring was late, heavy snow remaining on the higher peaks until the end of June, so it was considered advisable to leave the stations on these peaks to the last. During the latter half of June and the first week in July, rain fell almost continually. All traverses were run by plane-table and stadia. Mr. F. S. Falconer proved a valuable topographical assistant, and Mr. W. H. Losee, as field assistant, did his work in a satisfactory manner.

Field operations in this area were completed on July 24, and the party joined Mr. Boyd at Blairmore on July 25. The balance of the season was spent on the Blairmore sheet and on the detail map of the Frank landslide.

(e)

## MONCTON MAP-AREA, NEW BRUNSWICK.

(*W. E. Lawson.*)

Field work during the season of 1911 in connexion with the topographic map of the Moncton map-area commenced about the middle of May and continued without interruption up to the end of October. The area mapped is somewhat larger than the standard fifteen-minute sheet, being 12·3 miles in an east and west, and 18·7 miles in a north and south direction, covering a total area of approximately 230 square miles. The astronomic boundaries are roughly as follows: latitude, 45° 51′ N. to 46° 07′ 30″ N.; longitude, 64° 37′ W. to 64° 52′ W. This includes portions of the counties of Albert and Westmorland; the city of Moncton and suburbs; a portion of the oil-field worked by the New Brunswick Petroleum Company; the producing oil and gas fields of the Maritime Oilfields Ltd.; the large gypsum quarries at Hillsborough; the gypsum deposits on Wilson creek (not being worked at present); Albert Mines; and the oil-shale belt south and west as far as Rosevale.

The field scale used was 4,000 feet to an inch; the scale of publication to be $\frac{1}{62500}$ or approximately 1 mile to an inch. A 20 foot contour interval was adopted, as being best suited to the topographic features of the district.

Primary control of the area was obtained by triangulation worked up by S. C. McLean, of the topographical division, and tied to the astronomic pier at Moncton, which latter was observed in 1908 by the Astronomic Branch of the Department of the Interior. The scheme of triangulation including base expansion gave eighteen fixed points, all of which were used as tie-points for road traverses. It was also found necessary to run about 45 miles of transit and stadia control traverse to govern a section in which it was impossible to get a triangulation station.

Thirty-nine miles of primary levels run during the early part of the summer gave good vertical control. The elevations used were obtained from bench marks left by the Astronomic Branch when levelling over the Intercolonial railway from St. John to Moncton, and which in turn are based on mean sea-level. Permanent iron posts, brass-capped (Standard bench mark posts), were sunk at intervals of every 3 miles along the line of levels, the elevation to the nearest foot being stamped on the cap. The exact location and adjusted elevation correct to tenths of a foot are on record in this office and are available should they be required in local engineering work.

The plane-table traverse method was used almost entirely in filling in detail: only a few sections being favourable for plane-table intersection work. Stadia traverses were run along all roads, all shore-lines, and wherever possible across open country, being tied in to the triangulation points mentioned above, or to some previously located traverse station. Between stations on these main traverses, minor traverses with plane-table, tape and aneroid were run along all creeks, all bush roads, or straight across country at an average distance apart of 1,200 feet. On all traverses, the contouring and delineation of topographic features was done by the traverseman when in the field. The past season was especially favourable for aneroid work, the 2¾″ aneroids reading direct to 20 feet, giving negligible errors on a majority of the shorter traverses. The following figures, approximately correct, may prove of interest as giving some idea of the amount of traversing necesary:—

| | | |
|---|---|---|
| Transit and stadia.. | 50 | miles. |
| Plane-table and stadia.. | 406 | " |
| Plane-table, 300 foot steel tape and aneroid.. | 893 | " |
| Total.. | 1,349 | " |

My thanks are due to officials on the engineering staff of the Intercolonial railway, and to the City Engineer of Moncton for blue prints and data supplied, assisting materially in mapping Moncton and the immediate vicinity. The corps of field assistants was composed of the following men: A. G. Haultain, F. H. McCullough, W. G. Hughson, S. D. Robinson, N. A. Thompson, L. H. Badgley, M. B. Heebner, A. M. James, J. Messervey, and M. O'Brien. The manner in which these men performed their work was highly satisfactory.

Weather conditions during the season were exceptionally favourable, May, June, July, and August being uniformly warm and dry, though considerable time was lost through heavy rains during September and the early part of October.

## PART II.

### SPIRIT LEVELLING NEAR MONCTON, N. B., 1911.

The route followed was from Moncton, south along the shore road on the east side of the Petitcodiac river to its crossing with the Salisbury and Harvey railway at Weldon, thence along this railway to Boundary Creek station on the St. John branch of the Intercolonial railway. A short line connecting Grey Island wharf with the Salisbury and Harvey railway was also run. The instrumental work was done by Mr. A. G. Haultain.

#### *Instruments and Methods.*

A 15 inch Y level and New York target rod were used. The line was run only once. Sights were limited to 300 feet. Backsights and foresights were of equal length, or were equalized daily. Both levelman and rodman read the rod independently and kept separate records. While running the line temporary bench marks were established about every mile, later a permanent standard pipe bench mark was put in at intervals of about 3 miles. The standard pipe B.M. is a heavy 3 inch iron pipe about 5 feet long, the lower end of which is split for about 9 inches and spread out to form a T-bearing surface; on the upper end is rivetted a brass cap bearing the inscription, "Geological Survey of Canada. Elevation above sea." This pipe is buried to within 8 or 10 inches of the surface of the ground, the elevation being stamped thereon to the nearest foot. The brass nail and washer used for temporary B.M.'s consist of a round-headed brass nail, 1 inch × ½ inch, with a brass washer 1 inch in diameter stamped C. G. S. B. M.

#### *Datum.*

The elevations are based upon mean sea-level as determined by a tide-gauge of the United States Coast and Geodetic Survey at Calais, Me., and carried to Moncton by the precise levels of the Geodetic Survey of Canada. The Geological Survey line starts from B.M. 132 B and connects with B.M. 128 B of these precise levels of the Geodetic Survey.

The precise levels of the Geodetic Survey are connected at Moncton with B.M. CCCXXXVI of the precise levels of the Public Works Department. The relations between the different lines with the closing errors are given below.

| | Elevation. |
|---|---|
| B. M. No. CCCXXXVI—Moncton—Public Works Department......... ........... | 51·42 feet. |
| B.M. " " Geodetic Survey of Canada ........................ | 51·38 " |
| B.M. 132 B, Moncton—Geodetic Survey (reference for Geological Survey line).. | 51·41 " |
| B.M. 128 B, Boundary Creek, Geodetic Survey .................................. | 92·84 " |
| B.M. 128 B, " " as per Geological Survey line...................... | 92·95 " |
| B.M. 129 B, " " Geodetic Survey ............. ......... ........ | 67·54 " |
| as per Geological Survey line................................. | 67·65 " |
| Closing error of Geological Survey line..................... | 0·11 " |

The above figures and those in the following list of bench marks are actual readings without adjustment.

*From I. R. C. Station, Moncton, to Weldon platform on the Salisbury and Harvey railway; via road east side of Petitcodiac river.*

| | |
|---|---|
| Moncton—I.C.R. station—brass plug in the stone water table course at S. end of E. wall; Geodetic Survey of Canada, B.M. No. 132 B, reference................ | 51·41 |
| Moncton—on turn of road by the round house—4" wire nail driven in supporting brace of first braced telephone pole north of bridge.......................... | 27·98 |
| Moncton—2·4 miles from—200 ft. east of Bridgedale school house; in root of willow tree, fourth tree from east end of row of trees on north side of road; small brass nail and washer ...................... .................................. | 79·96 |
| Moncton—3·3 miles from—1 mile south of Bridgedale school house; 1,250 ft. N. of N. end of earth fill over Mill Creek flats, on west side of road, about 1½ ft. wide; 10 ft. S. of spruce tree blazed at base of trunk facing B.M. Standard pipe B.M.............. ............................ .................. | 70·94 |
| Moncton—3·7 miles from—Centre of bridge over Mill creek...................... | 26 |
| Moncton—4·1 miles from—2,200 ft. N. of Mud creek; 1,560 ft. N. of Mud Creek church; on east side of road, in root of a double trunked spruce tree opposite red house, third tree from N. end of row of trees, small brass nail and washer. | 64·87 |
| Moncton—5·2 miles from—0·6 miles S. of Mud creek; 0·5 miles N. of Lower Coverdale school house; 500 ft. S. of Bobs creek; a knob of quartz (distinguished by chisel marks) on granite boulder on east side of road, opposite grey and white house ................ ............ ................ ...................... | 103·03 |
| Moncton—6 miles from—on southern lot line of Lower Coverdale church, about 2 ft. inside of road allowance, 90 ft. S. of centre of road to Niagara, 36 ft. W. of centre of road to Hillsborough, 63·6 ft. S. of corner of church; Standard pipe B.M............ ............... ........... ............ .................. | 182·22 |
| Moncton—7.3 miles from—1·3 miles S. of Lower Coverdale church; 340 ft. N. of spring and watering trough on west side of road; head of large nail in telephone pole on west side of road ............................................ | 142·17 |
| Moncton—8 miles from—2 miles S. of Lower Coverdale church; top of Stoney Creek hill, white house on west and deserted house on east side of road; cross chiselled on sandstone slab under fence on west side of road, first slab N. of rood-gate of white house ................. .......................... ............... | 195·27 |
| Moncton—9 miles from—185 ft. north of a point on Stoney Creek bridge directly over centre of creek, 24 ft. east of centre of road, 39·6 ft. west of maple tree with crooked trunk, tree blazed and notch cut in root on side facing B.M. Standard pipe B.M............ ........................................ ......... | 44·61 |
| Moncton—10 miles from—1 mile S. of Stoney Creek bridge; 600 ft. S. of white house with red barn and flag pole, on west side of road on top of stump of small tree at foot of larger one; small brass nail and washer................. | 171·21 |
| Moncton—11·1 miles from—2 miles south of Stoney Creek bridge; 1·4 miles N. of Weldon school house; 860 ft. N. of white house on east side of road; small brass nail and washer on stump on west side of road......................... | 225·14 |
| Moncton—12·1 miles from—3 miles south of Stoney Creek bridge; 0·4 miles N. of Weldon school house; almost directly opposite residence of F. W. Miller, 28 ft. west of centre of road and 1½ to 2 ft. inside road allowance. Standard pipe B.M........ ............. .......... ............ ........................... | 133·88 |

*From Weldon platform to Boundary Creek, via Salisbury and Harvey railway.*

| | |
|---|---|
| Weldon—1 mile from—22·8 miles from Boundary Creek; nail in guard stringer on N. side of trestle over branch of Weldon creek, 4 ft. from west end............ | 67·47 |
| Weldon—1·9 miles from—21·9 miles from Boundary Creek; top of rail opposite Salem platform.......... ............. ................. ..................... | 112·0 |

| | |
|---|---|
| Weldon—2·9 miles from—20·9 miles from Boundary Creek; 80 ft. N. of the third crossing of the Salisbury wagon road from Weldon, 28 ft. S.W. of the centre of the railway track, 49 ft. W. of the centre of the wagon road, 11 ft. westerly from blazed and pointed 4 inch pine stump; Standard pipe B.M. | 187·89 |
| Weldon—3·4 miles from—20·4 miles from Boundary Creek; switch at branch to Manganese mines; top of rail | 215·2 |
| Weldon—4 miles from—19·8 miles from Boundary Creek; 0·5 miles west of switch to Manganese mines; 1 mile east of Stoney Creek platform; top of east end of centre ground stringer of water tank; small brass nail and washer | 257·23 |
| Weldon—4·9 miles from—18·9 miles from Boundary Creek; 38 ft. S. of centre of track at a point 115 ft. west of centre of road crossing and 150 ft. west of centre of Stoney Creek platform, 16 ft. west and north of a birch tree blazed and with good notch in the root on side facing B.M. Standard pipe B.M. | 340·56 |
| Weldon—5·9 miles from—17·9 miles from Boundary Creek; 1 mile west of Stoney Creek platform; 0·2 miles west of section shanty at old crossing; cross on boulder 3 ft. outside fence on south side of track | 373·82 |
| Weldon—8 miles from—15·8 miles from Boundary Creek; 31 ft. south of centre of track at a point 354 ft. west of centre of Baltimore platform and 343 ft. west of centre of road crossing, 3·3 ft. south of squared witness post (2½ ft. × 4 inches) marked "W"; Standard pipe B.M. | 423·19 |
| Weldon—9 miles from—14·8 miles from Boundary Creek; 1·1 miles west of Baltimore platform; 1,700 ft. east of a section shanty, 110 ft. west of east end of burnt area; cross on sandstone boulder on S. side of track | 377·47 |
| Weldon—11·1 miles from—12·7 miles from Boundary Creek; 97 ft. south of the centre of track at a point 776 ft. east of east end of trestle over Turtle creek; Standard pipe B.M. | 258·49 |
| Weldon—11·8 miles from—12·0 miles from Boundary Creek; at Turtle Creek platform, small nail and washer on centre log west end of platform | 244·24 |
| Weldon—13·6 miles from—10·2 miles from Boundary Creek; 1·8 miles west of Turtle Creek platform; top of rail at road crossing | 284·7 |
| Weldon—17·4 miles from—6·3 miles from Boundary Creek; at Coverdale platform, head of nail driven in S.E. corner post of platform with small brass nail and washer above | 101·67 |
| Weldon—19·6 miles from—4·2 miles from Boundary Creek; 2·2 miles west of Coverdale platform; at Trunk road crossing; top of rail | 68·2 |
| Weldon—20·1 miles from—3·7 miles from Boundary Creek; west end of railway bridge over Petitcodiac river; top of rail | 48·6 |
| Weldon—20·6 miles from—3·2 miles from Boundary Creek; at Moncton and North Shore road crossing; top of rail | 68·9 |
| Weldon—21·7 miles from—2·1 miles from Boundary Creek; on I.R.C. opposite mile post 77 from St. John; top of rail | 102·8 |
| Weldon—22·7 miles from—1·1 miles from Boundary Creek; on I.R.C. opposite mile post 78 from St. John; top of rail | 106·6 |
| Boundary Creek—23·8 miles from Weldon; in top course of stone work of south wall of Baptist church, 2·2 ft. from southwest corner of building, brass bolt B.M. No. 128 B of Geodetic Survey of Canada | 92·95 |
| Elevation according to Geodetic Survey precise levels | 92·84 |
| I. R. C., St. John Branch—2,070 ft. east of mile post 82 from St. John—in second course of stone work below top in west end of north face of north retaining wall of iron pipe culvert under track; brass bolt B.M. No. 129 B of Geodetic Survey of Canada | 67·65 |
| Elevation according to Geodetic Survey precise levels | 67·54 |

*From Weldon platform to Hillsborough, via Salisbury and Harvey railway.*

| | |
|---|---|
| Weldon—top of rail in front of railway platform | 24·7 |
| Weldon—Railway bridge over Weldon creek; top of rail | 25·6 |
| Weldon—0·5 miles east of; in front of section shanty; small brass nail and washer in railway tie | 24·6 |
| Hillsborough—Grey Island wharf—North side, 100 ft. from shore end; small brass nail and washer in log | 24·41 |

# NATURAL HISTORY DIVISION.

## I.

(*John Macoun.*)

Since the date of my last summary report my time has been chiefly devoted to writing in winter and collecting in summer, the routine work being, of course, attended to as usual.

We moved from the old Museum late in January, 1911, and when we were in the new Museum I resumed my work on the flora of the Maritime Provinces; this I finished before spring. After this the manuscript was sent for revision and additions to Dr. G. U. Hay, at St. John. N.B., then to Dr. A. H. MacKay, Superintendent of Education, Halifax, N.S., and then to Mr. Lawrence Watson, Charlottetown, P.E.I., who returned it to me. I then made the necessary additions and corrections and turned the whole completed manuscript over to you for transmission to the printers. In addition to our collections made during several seasons work in the Maritime Provinces, we have a fine series of eastern species in our herbarium; reference is made in the catalogue to all these specimens.

As soon as the flora of the Maritime Provinces was complete, I commenced work on the flora of Ottawa and the district surrounding it. I worked on this until the middle of May and then collected within 30 miles of Ottawa for four months—until the middle of September, when nearly forty species of flowering plants were added to the list as a result of the season's work.

In anticipation of a part of the Museum being set aside for a special collection of the flora and fauna of the Ottawa region, I took out all the specimens that had been collected in the 30 mile radius. These have been placed in new wrappers and in a separate case, so that we have now in a readily accessible form all the species of plants known to occur in this region.

During the winter and spring my assistant, Mr. J. M. Macoun, in addition to his routine duties, worked up the very large collection of plants made by him on the west coast of Hudson bay in 1910, and continued his work on the collections made by him and myself in previous years. This work has also occupied most of his time since last September, and we hope that by the end of 1912 all the old collections will have been worked over. Early in May he went to Washington with Sir Joseph Pope as one of Canada's representatives at the Fur-Seal Conference. He remained in Washington ten weeks, and after his return to Ottawa spent six weeks in collecting and studying the flora of the Gatineau valley, a region that had not been properly studied botanically before. The number of sheets of plants mounted and placed in the herbarium during the year was 3,269, and the number distributed to other herbariums 3,985. The number of letters written up to December 31 in connexion with our work was 790.

Upon the appointment of Mr. P. A. Taverner last May, he was given charge of all the vertebrates. A report of his work appears below. Mr. C. H. Young, with the exception of ten weeks spent collecting in New Brunswick, has been employed during the whole year in cataloguing, rearranging, and relabelling the invertebrates, a work which it will take some time to complete, but the more attractive groups, such as star-fish, crabs, etc., are now ready for exhibition. Miss Stewart has performed her duties in her usual efficient manner.

## II.

## ZOOLOGICAL SECTION.

(*P. A. Taverner.*)

I assumed the duties of Assistant Curator in the Museum, May 1 of the current year. A few weeks were spent in going over the collections and Museum for the purpose of obtaining an idea of the specimens, their number, scope, and general condition; then, June 6, I left Ottawa on an inspection tour of some of the larger museums to the south, visiting in the following order, the Museum of the Boston Society of Natural History; the Agassiz Museum at Cambridge, Mass.; Col. Thayer's private museum at Lancaster, Mass.; the American Museum of Natural History, New York; the Philadelphia Academy of Sciences, Philadelphia, Pa.; the United States National Museum, Washington, D.C.; the Museum of the University of Michigan, Ann Arbor, Mich.; and the Field Museum, Chicago, Ill. During this tour, special attention was paid to the following subjects: organization of staff; general arrangement of exhibitions; detail preparation of habitat and other groups, and displays; and registration, arrangement, and storage of study specimens. While engaged in this work, I received every aid from the various officials of the institutions visited, and wish to thank them all and severally for their courtesies.

Upon my return, the middle of July, plans were studied and matured, and drawings made of same, showing an exhibitional scheme for the Museum halls, embodying a comprehensive series of habitat groups illustrating the distinctive features of the distribution of life in the Dominion, and an arrangement of the systematic collections on public exhibition. Details were also developed for the arrangement of the study and storage laboratories and systems of classification, registration, and storage of the study collections within them.

As soon as these preliminaries were decided upon and approved by the Director, work was commenced on the arrangement and cataloguing of the collection, beginning with the class *aves,* the birds, which, from their relative numbers, required first attention. At this time I was aided by Mr. Frank C. Hennessey for about three months, who was of the greatest assistance in the relabelling of specimens, verifying data, and doing other work on both the old and the incoming collections. He also made a number of water-colour drawings of bills and feet of the birds that Mr. Young sent in from time to time, all of which will be of the greatest assistance to us when we come to finish the Atlantic Coast group now under way.

The relabelling and tracing out of the history of the accessions already in the bird collections was a long and tedious piece of work, involving the most careful deciphering of obliterated labels, searching of maps for little-known localities, and research among the various summary reports and old records scattered through many registers and manuscript lists for years back. At the end of the year this preliminary work is practically finished, and a start has been made on actual cataloguing.

From the latter end of August to late in October, Mr. C. H. Young was on the New Brunswick coast, collecting the material, listed among the accessions, for an Atlantic Coast group. This was sent in, from time to time, in the form of fresh specimens, and their need of prompt attention drew both Mr. Hennessey and myself away from the above work intermittently throughout that time. However, we now have ready mounted, some 84 birds, and a supply of crabs, fish, seaweed, and other accessories, together with photographs of the same in situ, to make a most interesting group. A model of the same has been built to scale, but no further work can be done upon it until a properly trained preparator, experienced in modern museum methods, can be obtained. In fact, no constructive exhibition work of any kind can be prosecuted until such a man is available.

Throughout the summer and autumn a number of short trips were made within the vicinity of Ottawa, more for the purpose of observing the character and resources of the country for future collecting than for actual gathering of specimens at present; but some material was incidentally taken and specimens brought in for experimental and other work in the casting and preservation of the lower forms of vertebrates and accessories for groups. In this way come valuable processes have been either developed or originated for future case work.

Certain members of the Geological Survey staff have also shown their interest in the work of the Museum, notably Mr. D. D. Cairnes, by bringing in collections of specimens made during their work in the field in out of the way and little-known sections of the country. The value of these incidental collections can hardly be overestimated, and it is the hope of the writer that this interest will increase and afford an important source of supply to the growth of the Museum collections. The various members of the staff, covering as they annually do, a great section ot the Dominion in their summer work, have unexcelled opportunities for collecting rare or little-known material, both specimens and notes, that could not otherwise be obtained without elaborate and costly expeditions. A set of printed instructions have been planned, and, at present writing are well under way, for the collection and preservation of zoological material for the benefit of the field staff and others who desire to aid us in the accumulation of knowledge of the Canadian fauna.

During the summer we received from Ward's Natural History establishment, the group of Stone's mountain sheep that was sent them for mounting before my arrival. The work has been done in a very satisfactory manner and it is planned to make it the central feature in our proposed Rocky Mountain habitat group.

The following additions have been made to the zoological collections during the past year (1911):—

*By Purchase.*

Accession Nos.

11-2 —From H. E. Porter, Whitehorse, Y.T.—
One Bull Moose, with skull, collected December, 1910, near Lake Kusawa, Y.T.

11-3 —Through D. D. Cairnes, Geological Survey—
One Canada Porcupine skin, collected about May 1, 1911, near Whitehorse, Y.T.

11-5 —From J. Poole Field, Ross River, Y.T.—
Three Mountain Goat, head and neck, scalps and skulls, collected near heads of South Nahanni, Pelly, and Highland rivers, Y.T., during the winter of 1910-11.

11-32—From W. Simpson, Ottawa, Ont.—
About 3,000 specimens of coleoptera, taken near Ottawa, Ont.

*By Museum Staff.*

11- 7—By Wm. Spreadborough—
One Black Bear, skin and skeleton, collected on Vancouver island, B.C., June 19, 1911.

Accession Nos.

11-18—By C. H. Young—

Bird skins, mostly gulls and waders. . . . . . . . . . . . . . . . . . 227

Marine shells, about. . . . . . . . . . . . . . . . . . . . . . . . . 450

Fish, crabs, sea-weed, and other accessories for an Atlantic Coast group. All collected near Youghall and Inkerman, N.B., during late summer and autumn of 1911. Eighty-four of the birds have been mounted for the above purpose and the remainder placed in the study series.

11-22—By P. A. Taverner—

Two Myrtle Warbler and a Cliff Swallow, skins, collected August 19, 1911, near Ottawa.

11-23—By P. A. Taverner and C. H. Young—

One King bird, one partial albino Song Sparrow, and stump containing nest and eggs of House Wren, collected June 6, 1911, near Ottawa, Ont.

11-24—By P. A. Taverner—

One American Titlark and one Savanna Sparrow, collected September 13, 1911, at Casselman, Ont.

11-25—By P. A. Taverner and C. H. Young—

One Swamp Sparrow and one Garter Snake, collected May 6, 1911, near Ottawa, Ont.

11-26—By J. M. Macoun and P. A. Taverner—

Nests of Phoebe and Chimney Swift, and one Ruffed Grouse skin, collected October 8, 1911, near Meach Lake, Quebec.

11-27—By P. A. Taverner and C. H. Young—

One pair White-breasted Nuthatches, nest and eggs, collected May 19, 1911, near Ottawa, Ont.

11-29—By Wm. Spreadborough—

Bird skins. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

Small mammal skins. . . . . . . . . . . . . . . . . . . . . . . . . 13

All taken during summer of 1911 near Cowichan lake, Vancouver island, B.C.

11-31—By C. H. Young—

Toads. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

Bullfrog. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

Leopard Frogs. . . . . . . . . . . . . . . . . . . . . . . . . . . . 4

Garter Snake. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

All taken during May and June, 1911, near Ottawa, for the purpose of making casts.

11-33—By C. H. Young—

Insects as follows:—

| | | |
|---|---|---|
| Hymenoptera. . . . . . . . . . . . . . . . . . . . | 21 | specimens. |
| Lepidoptera. . . . . . . . . . . . . . . . . . . . | 145 | " |
| Diptera. . . . . . . . . . . . . . . . . . . . | 14 | " |
| Coleoptera. . . . . . . . . . . . . . . . . . . . | 60 | " |
| Hemiptera. . . . . . . . . . . . . . . . . . . . | 12 | " |
| Orthoptera. . . . . . . . . . . . . . . . . . . . | 4 | " |
| Neuroptera. . . . . . . . . . . . . . . . . . . . | 15 | " |
| Total. . . . . . . . . . . . . . . . . . . . | 271 | " |

Accession Nos.

Mostly taken in vicinity of Ottawa during summer of 1911.

11-37—By J. M. Macoun—
One pair of Canada Grouse feet, taken September, 1910, in vicinity of Fort Churchill, Hudson bay.

*By Geological Survey Staff.*

11-8 —By J. A. Allen—
Two Woodchucks, with skulls, from near Field, B.C., collected September 1, 1911.

11-11—By Percy Selwyn—
One Blue Jay, in flesh, collected near Kirk Ferry, Gatineau river, Que., September 24, 1911.

11-12—By D. D. Cairnes—
14 bird skins and one small mammal, from Alaska-Yukon Boundary, lat. 67-30, during the summer of 1911.

11-14—By Percy Selwyn—
One Pileated Woodpecker, in flesh, collected October 21, 1911, in Lynedoch township, Renfrew county, Ontario.

11-20—By R. Harvie—
Nest of Chimney Swift, collected in Bolton township, Brome county, Quebec, during the summer of 1911.

11-21—By A. T. McKinnon—
Two sponges (*Clatheria sp?* and *Tentorium sp?*), collected on Two Islands, N.S., July, 1911.

11-36—Transferred from Ethnological Department—
Three fragmentary skins and one mounted head of Dall's Sheep. No data.

*By Presentation.*

11-1 —By Andrew M. Talyor—
Four Dall's Mountain Sheep, skins, skulls, from British Columbia.

11-4 —By Frank C. Hennessey, Ottawa, Ont.—
One Herring Gull skin, collected August 24, 1909, south of Cornwallis island, Arctic ocean.

11-6—By J. A. Gillies, Gillies Depot, Ont.—
Twenty-nine Hummingbirds' skins, of several species collected near Guayaquil, Equador, South America, about 1906.

11-9 —Thomas Kinsella—
Red-tailed Hawk, in flesh, collected September 14, 1911, at Franktown, Lanark county, Ontario.

11-10—W. Creighton—
Nineteen Eider Duck skins from northern Canada.

11-13—Oliver Trafford, St. Eugene, Ont.—
One Jumping Mouse, in flesh, collected near St. Eugene, October 4, 1911.

Accession Nos.

11-16—Geo. Mulharvey, Simmons, Quebec—
One Snowy Owl, in flesh, taken October 31, 1911.

11-17—J. M. Macoun, Ottawa, Ont.—
Polar Bear skull, collected in autumn of 1910, near Fort Churchill, Hudson bay, by Dr. Borden.

11-19—By Frank C. Hennessey, Ottawa, Ont.—
Two Woodpeckers, in flesh, from near Ottawa, November 1, 1911.

11-28—By Frank C. Hennessey, Ottawa, Ont.—
Two Bird skins, Ottawa, Ont., collected September 20, 1911.

11-30—By Dr. Malte and J. M. Macoun, Ottawa, Ont.—
Fresh Water Sponge, likely *Meyenia fluviatilis,* collected in Gatineau river, Que., October 20, 1911.

# ANTHROPOLOGICAL DIVISION.

## PART I.

## ETHNOLOGY.

*(E. Sapir.)*

### Museum.

All the ethnological material of the Victoria Memorial Museum has been unpacked and carefully sorted out according to culture areas and tribes. Owing to the fact that a large percentage of this material had remained unnumbered, and owing further to the fact that the enumeration of the part already numbered had proceeded on no definite principle of classification, it was decided to renumber the whole collection according to a definitely established scheme. The ethnological material has been divided into five main groups corresponding to as many culture areas of Canada. These are: Eastern Woodlands ethnology labelled III; Arctic or Eskimo ethnology (labelled IV); Plains ethnology (labelled V); Plateau and Mackenzie Valley ethnology (labelled VI); and West Coast ethnology (labelled VII). I and II have been reserved for materials coming under the head of physical anthropology, while VIII-XII have been reserved for archæological material. Capital letters are used as means of sub-classification by tribes; thus V.B. refers to material obtained from the Blackfeet, one of the Plains tribes. By following out this method it is possible to assign any numbered specimen to its proper culture area and tribe without the irksome necessity of looking up a catalogue. The labelling and cataloguing of ethnological specimens is now practically completed, and, after a certain amount of sorting for purposes of exhibition is done, they will be ready to go into cases when these arrive. A set of lantern slides illustrating Canadian ethnology is being prepared as the beginning of a stock for lecture purposes.

An inventory of ethnological material now owned by the Victoria Memorial Museum would show that it is relatively rich in West Coast (particularly Haida, Tsimshian, and Kwakiutl) material, to a less extent also in Eskimo (particularly Alaskan Eskimo) material, but not at all well represented as yet in other ethnological regions of Canada. During the last year, however, systematic efforts have been made to fill this lack for eastern Canada. Iroquois, Huron-Wyandot, Micmac, Malecite, and Montagnais material has been purchased, partly by members of the staff and partly by others conducting ethnological research in eastern Canada under the auspices of the Geological Survey. A standing order has been left with Chief John Gibson of the Senecas for Iroquois material from Grand River reserve; much Iroquois material of value has thus come into the Museum in addition to that already secured by Dr. Goldenweiser and myself, as well as by purchase from Mr. M. R. Harrington. Dr. D. D. Cairnes of the geological staff of the Survey has been helpful in securing museum material from the somewhat inaccessible Athabaskan tribes of the region of Tagish lake, Yukon. Valuable Tsimshian material was purchased from C. C. Perry, of Metlakalitla, B.C.

### Field Work.

Systematic research among various tribes of Canada was undertaken during the year. Dr. A. A. Goldenweiser, lecturer in anthropology of Columbia University, New York, spent part of the summer in studying the social organization of the Iroquois of Grand River reserve; Mr. C. M. Barbeau of the permanent staff made three research trips (Lorette, Province of Quebec; neighbourhood of Amherstburg, Ont.; and Quapaw agency, Oklahoma) for the purpose of studying the Huron-Wyandots; Mr. William H. Mechling, of Philadelphia, spent the summer in ethnologic and linguistic research among the Micmac and Malecite Indians of New Brunswick; Dr. Cyrus MacMillan, of the Department of English, McGill University, spent five months in research, particularly in order to obtain folk-lore material, among the Micmacs of Nova Scotia and Prince Edward Island; the month of August was spent by myself in a reconnaissance of various Iroquois and Algonkin reserves in Ontario and Quebec. Reports of these field trips are appended.

## WORK IN IROQUOIS AND ALGONKIN RESERVATIONS OF ONTARIO AND QUEBEC, 1911.

I spent the month of August, 1911, in a reconnaissance of several of the more readily accessible Iroquois and Algonkin reserves of Ontario and Quebec. The first of these reserves to be visited was Grand River reservation near Brantford. The main purpose of this visit was to secure an Iroquois museum collection, as the resources of the Victoria Memorial Museum were extremely limited for the Iroquois tribes. I was fortunate enough to secure a fairly large and representative group of objects, including such comparatively uncommon specimens as gourd rattles, blow-guns, and feather head-dresses. Moreover, arrangements were made with Chief John Gibson, as noted above, for the forwarding of further Iroquois material to the Museum. The balance of the six days spent at this reserve was taken up in Seneca and Mohawk linguistic work. The chief object of this and other linguistic researches made during the trip was not so much to investigate the structures of the languages concerned, as this would evidently be quite impossible in the time consumed, as to get a clear phonetic insight into them. Great care was taken in the matter of phonetic accuracy, and it soon became apparent that most, if not all, attempts at recording Iroquois had been notably lacking in this regard.

An afternoon was also spent at Smoothtown in the southern part of the reserve in order to obtain linguistic data on Delaware. The material obtained shows Delaware to be a phonetically quite specialized Algonkin language. In pronunciation it is peculiarly lifeless, and it abounds not merely in voiceless final vowels, like several other Algonkin languages, but in voiceless final syllables or groups of syllables. Peculiar to Delaware is also the presence of voiceless vowels in other than final positions, a phonetic trait that I had not met with before except in certain Shoshonean languages of Utah and Arizona.

The next reserve visited was Caughnawaga, opposite Montreal, which is occupied by thoroughly Catholicized Iroquois of Mohawk speech. There is comparatively little of value to be obtained here in the way of museum specimens, most of the native industries catering primarily to the white trade. Linguistic material obtained here, supplementary to the Mohawk material obtained at Grand river, shows conclusively that the Mohawk of these two places is dialectically distinct.

At the Abenaki reserve of Saint Thomas Pierreville conditions similar to those prevailing at Caughnawaga were found, except that while the Caughnawaga Indians rely chiefly on the making of beaded moccasins, the Abenaki do more basketry for purposes of sale. Linguistic material obtained at Pierreville shows Abenaki to be a somewhat specialized Algonkin language. Phonetically it impresses one as being rather lazy in utterance and it makes much use of weakly nasalized vowels. At Rivière du Loup, which was next visited, material obtained on Malecite showed this to be phonetically rather a difficult Algonkin language; there are several phonetic peculiarities to be noted, such as musical cadence (which, however, is perhaps of no etymological significance) and the presence of consonants that are so weakly articulated as to be practically inaudible. A side trip taken to Cacouna resulted in the securing of some Malecite museum material and linguistic material on Micmac. Micmac was found to be far less difficult phonetically than either Malecite or Abenaki.

The last part of the trip was spent at Pointe Bleue, on the west shore of Lac St. Jean. Some valuable Montagnais material was here obtained including several pieces that were said to have come from the region of Lake Mistassini. It is highly desirable that ethnological work be done among these Montagnais, as well as those of Bermis and Escoumains, but this work should be undertaken by one thoroughly familiar with spoken French. Linguistic material was obtained on both Montagnais and Cree, the latter from a woman belonging originally to Rupert House, James bay. It is quite clear that Montagnais and Cree are dialects of one language; this means that what is a single language, all the dialects of which are mutually intelligible, is spoken from the Gulf of St. Lawrence west of the Yellowhead pass of the Rockies. Montagnais seems to be somewhat more specialized phonetically than Cree, yet not enough material was obtained of either to make this statement certain. Cree and Montagnais are evidently more archaic Algonkin dialects than any of the others from which material was obtained; at the same time they offer less phonetic difficulties than Delaware, Abenaki, or Malecite.

(*a*)

## ON HURON WORK, 1911.

(C. M. BARBEAU.)

The ethnographic research on the Hurons or Wyandots of Lorette (Quebec), Amherstburg (Ontario), and Wyandotte (Oklahoma), taken up at intervals from April to December, 1911, has given excellent opportunity for collecting abundant data on their general ethnography, that is, their social statics, social dynamics, and technology. Notwithstanding the widely accredited barrenness of this field of research, owing to the advanced state of civilization prevailing among the few hundred dispersed descendants of the once numerous Huron tribes of Ontario, the results secured have so greatly surpassed, in quantity and quality, our expectations, that it has proved impossible to exhaust the sources of information at disposal.

Among the foremost informants may be mentioned: Messrs. Maurice and Antoine Bastien; Mrs. Etienne Groslouis, and her daughters, of Lorette, Quebec; Rev. Prospère Vincent, of Lévis, Quebec; Miss Mary McKee, of Anderdon, Ontario; Messrs. Smith Nicols, B. N. O. Walker, Hiram (Star) Young, Mrs. Catherine Armstrong, and Catherine Johnson, of Wyandotte, Okla.; and Mr. Eldredge H. Brown and Mrs. Mary Kelly, of the same place, as interpreters and informants on linguistics. Other informants of lesser importance have also contributed valuable information. No mention is here made of information available from other sources, in print or manuscript.

(1)

The data that relate to the social statics or morphology of the Hurons may conveniently fall under the following headings: the phratries, the clans, and a fraternity; the heirarchy of the clans in the phratries, and of the individuals in the clans; and, finally, the ancient villages.

On account of their having long ago been broken up, the phratries have left almost no trace of their existence and would not have been revealed, had it not been for a text recorded in Wyandot and translated into English, and for some survivals in connexion with the seed game. This text gives an explicit account of the origin, at a great council of prehistoric times, of the federation of all the clans but one into two mutually dependent phratries, respectively under the leadership of the Big Turtle and Deer clans. A careful study of the clans and an extensive survey of the clan individual names has led to the conclusion that the notions now generally prevailing on this point will have to be partly revised. The eleven Huron clans, in order of precedence, may be put down as follows: the Moss Turtle (Big Turtle), the Speckled Turtle (or Small Turtle), the Prairie Turtle (or Terrapin), and the Beaver clans constituted the Big Turtle phratry: while the Deer phratry consisted of the Deer, the Bear, the Porcupine, and the Hawk clans. These two phratries in the old tribal councils occupied the opposite sides of the council fire. The Wolf clan was a third unit, all by itself, standing at one end of the fire. Extensive accounts of the subsequent origin of the Snake and Snipe clans have brought an interesting contribution to the much disputed question as to how clans originate. The origin of the Snake clan —vividly described in a text, and in a series of songs recorded phonetically with translation as well as on the phonograph—is still clearly remembered by most of the old Oklahoma Wyandots. Briefly, it runs as follows: At the end of her puberty seclusion a maiden was devoted to a mythical Monster-Snake by her relatives, of the Deer clan, with a view to securing "powers" and a new crest. Thereafter the relatives of the maiden, in collateral line, became the constituent members of the Snake clan, that has held annual feasts until about half a century ago to commemorate this event. The mode of origin of the Snipe clan among the Wyandots, the existence of which has probably not yet been recorded, is radically different, as, about two centuries ago, it was brought from outside into the Wyandot social system. A Seneca woman of the Snipe clan, having married a Wyandot, came to reside among the Wyandots. Owing to her not having been adopted into a Wyandot clan, as was the custom, she retained her own clan and transmitted it to her descendants. The Snipe clan, thereafter assimilated to the other Wyandot clans, has subsequently counted many members, the individual names of whom, framed according to the traditional rules of the Hurons, have been recorded. Three out of these eleven clans—the Prairie Turtle, the Hawk, and the Beaver clans—have been extinct for some length of time; and only a few representatives of the Snake and Snipe clans are still to be found. The number of traditional individual clan names collected in the course of the present study may exceed seven hundred; approximately a sixth of these could not be translated, as their meaning has now been forgotten. A small proportion of the names that could be translated have been found to refer to the mythology of the clans, while the greater number alludes either to various attributes of the clan totems or to a characteristic trait of some deceased ancestor.

With regard to societies devoted to shamanistic and doctoring practices, the former existence of the White Lion fraternity has been demonstrated, while the copious recollections bearing upon the agents of magical, secret, or doctoring arts show these to have stood by themselves as individuals, without the concerted co-operation of human confederates. The origin of the White Lion fraternity seems to have taken place two or three centuries ago, at the time when a number of Huron bands were dwelling in the vicinity of Lake Michigan. A text and a series of ritual songs, duly recorded, and other collateral information describe circumstantially how, in the course of fantastic events, many individuals belonging to three different clans evoked from an awful stream a Monster-Lion, to whom they surrendered a maiden with the definite purpose of getting his blood for magical operations. At the special command of the monster annual or occasional feasts have been held until recent years, in the course of which songs and rituals were performed in conformity with the initial instructions.

In regard to the ancient social hierarchy—that is, the relative standing of the clans in the phratries, and of the individuals in the clans, that of the hereditary chiefs, the elected war chiefs, the seniors, the women and children, the shamans, witches, and doctors—interesting though sometimes conflicting evidence has been obtained.

(2)

But a brief mention can be made here of the various topics that may conveniently be included under the heading of Huron social dynamics, namely: the function of the phratries, clans, and individuals in their social system, and customs and laws connected therewith; their rituals, ceremonials, and other practices; their mythology and folk-lore; and their language.

The Hurons were governed by their tribal and clan councils, the jurisdiction of neither of which conflicted with the other, that of the tribal council being strictly confined to matters of general concern, and that of the clan to affairs of internal and local interest, as each clan had one or more villages of its own. The phratries, the function of which was essentially concerned with tribal government and marriage regulations, were the constituent elements of the tribal council; the clan councils, on the other hand, were mere aggregates of individuals. A consequence of this was that while, in the tribal council, each clan had but one vote, in the clan council the same right was extended to every individual with the exception of those not of mature age. The function of the clan totems was not only connected with various traditional events and associated customs, but also with the graphic and symbolic representation, in the form of a communal crest or emblem, of the people of the clan. It is interesting to note that very little evidence to the same effect obtains regarding the phratry totems, the Big Turtle, and the Deer.

A host of ethnographic data bearing upon the traditional laws regulating the councils and their proceedings, marriage, the formal transfer of clan rights, and other customs, notwithstanding their importance, may scarcely be alluded to here. Matrilinear inheritance of clan rights has been the rule down to the present day in Wyandotte (Okla.) and Anderdon (Ont.), and very few exceptions may be found. The advanced decadence of the Lorette Hurons, having caused this rule, however, to fall into almost complete oblivion, the rigid outlines of the clans have long faded away; a result of which is that, while in Oklahoma very few violated the taboo prohibiting inter-clan marriage, no such taboo is known to the Lorette people. Many interesting customs and ceremonials have lingered almost to the present day in connexion with the ritual of conferring individual names to children or adults in conformity with the rules of matrilinear inheritance, and in connexion with the adoption of distant relatives or of strangers with a view to having them fill the vacant places of direct descendants and thus maintaining the integrity of the clans.

Though an adequate study of the rituals and customs of the Hurons is out of the question at this late day, it has been gratifying to get extensive accounts of rituals and ceremonials performed in the course of feasts, designed either for the fulfilment of rigid traditional duties towards superior beings, the maintenance of clan traditions and integrity, or meant for the ceremonial healing of disease, or merely for social entertainment. Some of these ceremonials have been witnessed, others have been explained by competent informants or described in the myths of folk-lore. Only two of the commemorative feasts have been satisfactorily studied with informants who have often participated, years ago, in their actual performance: the annual fasts of the Snake clan and of the White Lion fraternity. The original directions relating to the rituals of these societies are also respectively embodied in two myths obtained in text form; they are also explicitly referred to in about twenty songs, all of which have been carefully recorded.

The periodical feasts intended to provide for the giving of clan names, the "raising" of hereditary or elected chiefs, and the adoption of foreigners, have been responsible for the preservation, up to recent years, of interesting rituals and customs. At Lorette, Que., the last of the so-called "Sagamité" feasts, in the course of which honorary Huron names were given to distinguished visitors, took place about fifteen years ago; the traditional "Sagamité" supper, songs, and dances, and other ancient customs have, therefore, in this connexion, been saved from entire oblivion; about sixty Lorette Huron dancing songs have been recorded in text and on the phonograph. The same kind of feast has been studied to better advantage in Oklahoma, owing to the annual observance of these ceremonials in their primitive form up to about fifty years ago; a still larger number of naming songs, of which each clan has its own, and of dancing songs connected therewith, have been collected.

The other Huron feasts and ceremonials may be classified, with regard to their various aims, as follows: (1) the new corn or green corn feast, complex in character but primarily a thanksgiving feast; (2) the war dances; (3) the pipe or peace-making dances, connected with warfare; (4) the annual suppers given for the dead by their own clan; (5) a ghost or adoption feast; (6) several ceremonial performances for healing diseases, (*a*) the singing of ritualistic songs, either in choruses by parties assembled by the patient and to whom a supper is subsequently given, or by a masked shaman accompanied by a chorus with the concomitant 'false-face' songs and the scattering of coals and ashes; and (*b*) the lacrosse game, considered until about fifty years ago as an effective remedy; (7) feasts meant for mere entertainment, with accompanying songs, dances, and sometimes games, such as the moccasin, seed, lacrosse, and foot-ball games (besides the game of "la chêvre" at Lorette), gambling being an element of these games. Besides these feasts and ritualistic customs, many others are described implicitly or explicitly in the myths and folk-lore; the most interesting of these are such as relate to puberty seclusion and the getting of "mana" from a manitou, to witchcraft, and to warfare.

Notwithstanding many necessary lacunæ, the study of the mythology and folk-lore of the Hurons has developed, especially in Oklahoma, into gratifying proportions. Their former beliefs are embodied either in myths and tales or in amorphous popular sayings and recollections. From the data yielded by these various sources a fairly good reconstruction of the ancient pantheon of the Hurons is now possible. It reveals plainly the nature of the following categories of superior beings or semi-deities: (1) the human deities of the beginning of the Huron world; (2) the semi-personal deities connected with many phenomena of nature; (3) the giants and dwarfs; (4) the ruling manitous, either monsters or animals (a definite number of animals, classified into a hierarchy, being possessed of "mana," according to arbitrary notions).

The myths seem to be of two kinds: myths of origin and etiological myths. The origin myths give an account of: (1) the origin of the world (two imperfect, although extensive, versions of which have been recorded); (2) the origin of the "mana" or powers of clans and of individuals; the bear, the turtle, the wolf, the white lion, and the two different snake myths, not to speak of many others of lesser importance, belong to this second category. A few etiological myths account for the fantastic origin of many phenomena of nature, such as thunder, earthquakes, autumn, and colour, and form of various animals and birds.

A number of interesting tales have been collected, some meant to be recited by the fireside in winter only, others being devoid of any such restriction. In the present connexion may be mentioned the tales of the Fox and the Racoon, constituting a series of episodes; the many stories relating the deeds and contests of notorious witches and sorcerers of the past, and of Tuñē'tawi'ndi'a; the seven brothers transformed into buffaloes; two other tales dwelling on the ordeals of many adventurous suitors, and a number of others referring to monstrous snakes and other animals, dwarfs, giants, and so on.

It goes without saying that, for lack of time, the study of Huron linguistics, as such, has scarcely been entered upon, notwithstanding that considerable attention has been directed to it.

(3)

The survey of the technology (notwithstanding its not having been completed on account of lack of time) has proved the most fertile field of ethnographic research among the Hurons. As more than half of the time at disposal has been devoted to it, about two hundred specimens have been purchased or ordered for the Museum and explained; descriptive accounts have also been taken down of such other illustrations of their technology, pertaining to the utilitarian and aesthetic arts, that could not be actually secured or conveniently represented in a museum.

(*a*) While the usual concerns of the men constitute certain aspects of the utilitarian arts of the Hurons, others are the result of the occupations of the women. It was the duty and function of the men to build houses, to hunt, to go to war, to trade with foreigners, and to provide for the means of transportation. In regard to their structure, many varieties of houses have been studied, namely: the long log-house, for permanent use; the open log-house; the "sugar-camp" house; the round bark house; and a small triangular structure built by hunters, in the woods, for temporary use. The methods of hunting and fishing have been examined with advantage at Lorette, where six or seven varieties of traps, not to speak of such weapons as bows and arrows and darts, have been used by hunters almost to the present day. The technology of their means of transportation and conveyance consists in the making of two kinds of sled, of many varieties of canoes (the bark canoe, the dug-out, and the skin or emergency canoe), of snow-shoes of five or six different types, and of cradle-boards. Their methods of warfare are illlustrated in the folklore, and especially in the relation of two ancient war adventures, one of which has been recorded in text and translated.

The functions of the women, with regard to technology, were confined to the following industries: agriculture, the making of maple-sugar, the preparation and preservation of food, the dressing and tanning of hides, and the making of dresses and costumes, of baskets, bark-vessels, and other articles of household use.

Other activities, as political, medical, and shamanistic arts, were of a neutral nature and were practised indifferently by men or by women.

(*b*) The non-utilitarian or aesthetic arts of the Hurons consist mainly of their decorative arts, and their music and dances, not to speak of their games. Many of the branches of their decorative arts, with the exception of moose-hair embroidery, could not be satisfactorily studied, on account of their advanced decadence. Moose-hair and porcupine-quill embroidery, ribbon and bead work (or the trimming of garments with fancy ribbon and bead appliqués, were among the attainments of the women, as compared with those of the men, namely: wood carving, silver work, painting, and the making of wampum. Moose-hair embroidery has been illustrated with comparative advantage at Lorette, especially with old Mrs. Etienne Groslouis and her daughters. A few other informants having also been consulted, over twenty-five specimens of various moose-hair patterns have been prepared for the Museum. Fancy ribbon trimming, only a few specimens of which could be secured, is spoken of by the Anderdon and Oklahoma informants as having been a characteristic art of their people.

The songs, over two hundred of which have been recorded on the phonograph, explained, and written down phonetically, illustrate extensively the interesting musical art of the Lorette and Oklahoma Hurons. Most of these songs—with the exception of some satirical, bacchic, flute, and a few ancient folk-lore and ritual songs—are accompanied by various kinds of dances. These dancing songs are either mythological, ritual (as the war songs, the peace-making or pipe songs, the naming, the medicine, and other songs), or simply meant for social entertainment.

It may be noted, in concluding this short account, that it seems advisable, and even most urgent, that the present research should be completed in the near future, and an attempt be made to exhaust the sources now easily accessible.

(i)

## ON IROQUOIS WORK, 1911.

(*A. A. Goldenweiser.*)

In the course of the summer, 1911, I spent six weeks—from July 6 to August 20—at Tuscarora, Brant county, Ontario, among the Iroquois tribes of that district. My main informant as well as interpreter was John Gibson, head chief of the Seneca tribe. Notwithstanding his total blindness, the result of an accident some thirty years ago, his knowledge of the social organization and history of the Iroquois proved extensive and accurate, and I have had no occasion, so far, to question his reliability. In view of the limited time at my disposal I restricted my investigations, so far as was possible, to the subject of social organization. Most of my information was obtained from or with the assistance of Chief Gibson; the conclusions reached must thus be regarded as provisional pending the verification of the data through information from other Indians. The material secured consists, in the main, of facts referring to the clan system, of individual names, and of genealogies. A complete list of clans was obtained for each of the five tribes: Mohawk, Onondaga, Seneca, Oneida, and Cayuga. The list only partly corresponds to that given by other observers. A separate list of clans refers to the period before the formation of the Iroquois League. A tentative analysis of the clan names seems to indicate that, although most of the clans were named after animals, these names were not used except on a few special occasions. The clan names in constant use were generally expressed by a collective term referring to some characteristic of the eponymous animal. As to the number of the clans, my information to date indicates that the Mohawk and Oneida had eight each instead of the three generally attributed to them. This point, most interesting, if true, awaits verification.

The functions of the phratries, the two groups into which the clans were segregated, were manifold: specific data were obtained as to the part played by these social units in camping, burial, feasts, ceremonies, and games. At councils, on the other hand, the phratric division broke down. Instead, the clans (in the tribal councils) and the tribes (in the League Councils) were divided into three groups, one of which had the deciding voice. The elections of chiefs, especially with reference to the part played in them by women, were described by Chief Gibson with considerable detail.

Personal names of men and women, some eight hundred in all, were obtained, in each of the five tribes. The names were taken down in phonetic spelling, and provisional analysis and translation into English were attempted. Each clan, as is well known, was found to own a special set of personal names, but no connexion of these names with the eponymous animal of the clan could be discovered. A list was secured of the fifty "lords" sachems of the Iroquois. The list is interesting in so far as it reveals the dialectic variations of the five languages. It also shows some other peculiarities. Fifty, instead of forty-eight, "lords" seem to have always existed and are still found among the Iroquois tribes of the district investigated. Chief Gibson repudiates the oft-cited tradition of the two seats in the League Council which were left vacant to honour the two mythical founders of the League.

A record of about four hundred marriages, in the form of genealogies, was secured with the assistance of Chief Gibson. The genealogies cover roughly one century, but a few extend a hundred and fifty years back. The genealogies and marriages disclose many interesting facts, although a complete analysis of them will not be attempted until further data are secured. The prohibition of marriage within the clan is still adhered to, although not rigidly, and in varying degrees in the different tribes. A list of the classificatory terms of relationship was secured and partly verified by the genealogies.

Several myths and part of the Bean festival were taken down in text. A fair amount of miscellaneous information on social organization, ceremonies, customs, and other matters was secured, the value of which may appear at later stages of the investigation.

Little attention was paid to material culture, but I purchased for the Victoria Memorial Museum some twenty-five specimens, among them one false face of unusual merit.

(c)

## ON MICMAC WORK, 1911.

*(C. MacMillan.)*

I spent the summer months of 1911 engaged in field work among the Micmac Indians of eastern Canada. The period of my researches extended from the middle of May to October 1. The territory covered included Prince Edward Island, Nova Scotia (including Cape Breton), and part of New Brunswick.

The Micmac Indians are scattered in groups throughout the three Maritime Provinces. In numbers varying from fifty to three or four hundred they occupy reservations at different points, always close to sea, or lake, or river. For my investigations I selected the oldest and most thickly populated of these settlements. The intermixture of the Micmacs with the French, English, and Scotch inhabitants of the eastern provinces has been of long duration. For a period they have been under civilizing forces; and while much of their past still remains for the investigator, much has irrevocably disappeared. Yet, if at best, one can be but a gleaner in this particular field, one's results are nevertheless not inconsiderable.

A careful study was made of the remaining folk-lore and mythology of the tribe. They still possess a great stock of stories. A large number of these were gathered, and local differences in the telling were carefully noted. The most notable figure in their mythology and folk-lore is Glooscap (Kulóscap or Klûskâbe), a kind of culture-hero. Of his doings I obtained a fairly complete record, telling how he created man and became his friend, how he made and named and subdued the animals, how he did many great deeds—victoriously fought and destroyed giants and monsters, brought the summer to Canada, and so forth—and at the last, when the world became evil, how he went away to a happy island, sailing in his canoe, and promising to come back some day. This tale has many points of resemblance with the Arthurian legends. Other stories of animals and birds, of dwarfs and giants, have a close approach to the European folk-tales.

A study was made of other phases of the old Micmac life. I noted, in more or less detail, old Micmac superstitions and religious beliefs, birth, marriage, and funeral customs, occupations and industries, games and amusements, ideas of social and political organization, ways of making dyes and medicines, methods of hunting and fishing, preserving meat and dressing skins, etc. While it is evident that many songs and dances existed among them, these have largely disappeared. I was able, however, to observe some of their dances, and a few of the songs that still remain were written out in text and translation. The highest limit of art among the tribe, seems to have been reached in pictography on birch bark, in quill, and bead work. Their artistic sense seems to have expressed itself, too, in the ornamentation of their clothing with dyes and vari-coloured shells.

A slight attempt was made to do a little linguistic work. A considerable dialectic variation is noticeable according to localities. Verbal forms and grammatic and phonetic peculiarities were observed. The names of plants, and of birds, fishes, and other animals known to the tribe were carefully noted.

Specimens were obtained of typical basketry, bead and quill work, of old dice plates and counting sticks for gaming, and other objects. In places digging for stone implements was attempted, and was sometimes rewarded by a few stone axes, knives, and arrow-heads. Models were obtained of old-time spears and other implements for fishing and hunting, no longer in use among the tribe, but the shapes of which still exist in the memory of the old.

Altogether, the field, although long closed to civilization, offered a rich and interesting opportunity for investigation. I believe that very little work of a scientific nature had hitherto been attempted. The complete results of my summer's researches will be submitted as soon as possible.

*(d)*

## ON MICMAC AND MALECITE WORK, 1911.

*(W. H. Mechling.)*

My field work for the summer of 1911 in New Brunswick and Quebec was among the Malecite and Micmac tribes. All the summer except one week was spent in New Brunswick, for there is only one Malecite village (Cacouna) in Quebec, and that an unimportant one. The following reservations were visited in the order named: Cacouna (Malecite), St. Anne de Restigouche (Micmac), St. Mary (Malecite), Oromocto (Malecite), Burnt Church, Big Cove, and Eel Ground (Micmac).

The greater part of the work was naturally spent on the Malecites, in order to complete the researches started in the summer of 1910. In the two seasons I have visited all the Malecite villages. The character of the work may be divided into the following heads: (1) collection of specimens and the making of phonograph records; (2) gathering of ethnological data; (3) linguistic work.

Seventy-five specimens were collected illustrating the life and culture of these people. Of these about twenty are Malecite and the rest Micmac. With those collected last summer and purchased by the Geological Survey, the Museum now possesses probably the largest collection from this area. The specimens of bark work are particularly good. During the summer about forty-five phonograph records were made, most of them Malecite. Many more Micmac records could have been made, but unfortunately the supply of blank records was exhausted and it was impossible to secure any more in time. However, the Malecite collection is a good one, as I was able to secure the services of the only three dance song leaders of the tribe. The best of these is in poor health and may die at any time. The younger generation are not able to sing the Indian songs, so that in all probability the music of the Malecite will die out with this generation.

Most stress was naturally laid on the collection of ethnological information. Part of the time was given to verification of the last summer's results, and further investigation was undertaken along lines suggested by last summer's work. All the more important ethnological topics received attention. It was found that the different aspects of their culture have been preserved with various degrees of tenacity. Mythology is preserved better than anything else except folk-lore and what is generally known as "superstitions." Aboriginal social organization and religion have long ago given place to white men's methods of government and to Catholicism: only suggestions of their former practices and beliefs could be obtained. Fortunately the social organization was simple and can probably all be reconstructed from the accounts of the early explorers, missionaries, and travellers. With their religion it is quite another story. The greater part of their material culture is still accurately preserved in the minds of the older people; in actual practice they differ at present little in this respect from their white neighbours. Much work can still be done on the folk-lore and mythology of the Micmacs.

My linguistic work consisted chiefly in recording texts of myths; some were secured in Micmac, but the greater part in Malecite. All myths recorded last summer were carefully gone over, both to ensure the accuracy of the texts and to get a better translation. Grammatical notes also received attention; furthermore the names of all objects and concepts of ethnological significance were recorded. I hope to receive during the winter of 1911-2 a great deal more linguistic material, as several Indians have been engaged to write down myths in Micmac and also make a translation of them.

(*e*)

## WORK AMONG THE ARCTIC ESKIMOS.

(*V. S. Stefánsson.*)

Letters addressed to the Director have been received from V. S. Stefánsson, who has been continuing his researches among the Eskimos of the Arctic region between Mackenzie river and Hudson bay. They are dated August 12, October 14 (joint letter to the American Museum of Natural History and the Geological Survey), November 4, and December 4, 7, and 11, of 1910; and January 20 and April 20 of 1911. Under date of November 4 Mr. Stefánsson writes from Dease river, a north-east inlet of Great Bear Lake:—

"It gives me pleasure to report to you that we have completed the work entrusted to us by the Geological Survey of Canada and the American Museum of Natural History of New York three years ago—completed it in so far as the itinerary is concerned. The completeness of the work otherwise cannot be judged till we have the pleasure of laying our results before you after our return.

". . . . On April 22 we left Langton bay to attempt reaching the Coronation Gulf district by sled and to search for hitherto undiscovered people that might inhabit Dolphin and Union straits. This was the last part of our itinerary as laid before you in Ottawa the winter 1907-8. April 27 we left Cape Lyon, the most easterly point at which Eskimo houses were seen by Dr. Richardson on his Franklin Search expedition and the most easterly point known to have been visited by the Western or Baillie Island Eskimos. Our outfit was three Eskimos and myself, one sled, six dogs, two week's provisions, and 960 rounds of ammunition for four rifles—besides some trade articles for the purchase of ethnological specimens from any people we might meet.

"We proceeded east slowly, as we were depending on seals for food, and although they were abundant on top the ice in Darnley bay April 25, they became rarer as we proceeded east—on account of the increasing severity of the weather. Our experience in winter quite agrees with Dr. Richardson's in summer as to the season's being a full month later at Cape Krusenstern than at Cape Parry. The first seals appeared on top the ice at Cape Bexley, May 17, 1910.

"May 13, we discovered the first people—the Akuliakattagmiut, whose winter home is in the middle of the straits north of Cape Bexley, but who hunt in summer south of Cape Bexley, inland on the lake A-ku-li-a-kat-tak, which is the source of the Rae river. This lake is said to be oval, roughly 20 miles north and south and 25 east and west, and is about due south of Bexley and due west of Back inlet. May 17 to 20 we visited the Haneragmiut, who live on the south shore of Victorialand and north of Cape Bexley, and then proceeded towards the Coppermine, making a portage south from a little unnamed bay southeast (true) from Liston island to the foot of Basil Hall bay. This route is partly over a chain of small lakes and is much used by the Eskimos. I made a rough sketch map of it. We entered the mouth of the Coppermine June 2, and June 6 were compelled by the thaw to end our sledding for the year some 8 miles south of Bloody fall and about equally far north of the northern limit of trees.

"Our summer has been spent on the Coppermine river, on Dismal lake, and Dease river with bands of Eskimos of various sizes. We have seen, all told, some 250 Eskimos, representing a population of 700 or 800 between the Kent peninsula and Cape Bexley—people from these extremes were met on Dease river in August. Our routine work of anthropometric measurement, notation of ethnological information and of such geological and zoological information as could be gained has been steadily carried on. . . . ."

Under date of April 20 word was received from Coronation gulf (latitude 67° 40' N., longitude 114° 35' W., about 18 miles east of Coppermine mouth):—

" . . . . The ethnological collection being sent to your Museum embraces, so far as I know, every article of common use or wear except dance caps (seldom used here), mosquito hoods for summer wear, kayak, and sled. Of several articles there are two or more duplicates. Our programme for the summer has been completely changed by finding here the *Teddy Bear* trading schooner, whose captain, Joseph F. Bernard, has generously offered assistance which much simplifies for us the transportation problem. . . . .

"I am sorely tempted to devote the spring to completing the survey of the coast of northeast Victorialand from the 'Farthest' of the Amundsen expedition. It would be easy to get a feather for one's cap that way, but I do not feel justified in risking your disapproval and that of the Museum, for after all this of ours is an ethnological expedition, and it may be said that we have no business running off into a probably uninhabited country just to complete an outline survey of an island. In February I commenced a 'report to print' on our ethnological work of the year, to send you by your request. It is not completed, by reason of many interruptions for hunting and other work. Now the unexpected meeting with a ship here and the offer of equipment for summer work has decided me to turn north at once to Victorialand. I am asking Dr. Anderson to send the report to you nevertheless, uncompleted as it is. . . ."

Three reports of an ethnological character have been received: one entitled, "Ethnological Report on the Eskimos of Coronation Gulf Region," dated Headwaters of Dease river, January 28, 1911; one containing map entitled, "Distribution and Seasonal Migrations of the Copper Eskimos," dated Langton bay, June 25, 1911; the third entitled, "Prehistoric and Present Commerce among the Arctic Coast Eskimo," dated the Parry peninsula, July 25, 1911. Two short Eskimo texts entitled, "The Girl Who Broke the Taboo" and "The Blind Boy and his Grandmother," with notes and English translation, have also been submitted, as well as a few negatives of ethnological interest.

## PART II.

### ARCHÆOLOGY.

*(Harlan I. Smith.)*

The archæological work of the Geological Survey from June 15, the date of my appointment, to the end of the calendar year has been divided into two main groups—the activities for diffusing archæological knowledge by such means as museum exhibits, guide books, and lectures, and those for increasing such knowledge, as by exploration, original research, and systematization.

All the archæological material of the Victoria Memorial Museum has been unpacked and sorted into groups corresponding to the divisions of the proposed museum exhibits equivalent to the five ethnological culture areas of Canada which have tentatively been adopted as archæological areas. The collection from the southern coast of British Columbia is found to be fairly representative, that from the southern interior of British Columbia is also representative; the collection from Ontario is large but lacks needed data. From Quebec and the Maritime Provinces there are hardly any archæological specimens possessed by the Museum, and the same is true of the Arctic, the Great Plains, and the northern part of the Plateau-Mackenzie region. Nine hundred and forty specimens from the southern interior of British Columbia, the entire collection from the region, have been numbered and catalogued.

A popular guide for the archæological collections from the interior of British Columbia has been prepared, another for the collections from the Pacific coast is nearly finished, and one for those from Ontario is well under way. General and typical labels have been prepared for the printer.

Casts of specimens to supplement the collections from the two western archæological areas have been secured by exchange with the American Museum of Natural History, New York. A small collection of archæological objects was obtained in field work with Mr. George E. Laidlaw and with Mr. W. J. Wintemberg in Ontario. Five specimens were received by gift, through Mr. Lawrence M. Lambe, from Sir James Grant, M.D., Ottawa. Stone beads collected at Yale, B.C., were presented by Mr. Charles Camsell, and a human skeleton, besides archæological objects, has been received among the results of field work by Mr. W. J. Wintemberg in Ontario.

A mould has been made of a large and interesting petroglyph from near Nanaimo, Vancouver island. From this a cast for exhibition purposes may be taken and duplicates may be made for loan to other museums throughout Canada. A selection has been made from our negatives. Lantern slides have been ordered from these selected negatives in order to develop a stock from which slides necessary for lectures on Canadian archæology may be chosen.

Turning to research work, attention has been given to the organization of an archæological survey of the Dominion. It has been found that we most sorely need archæological specimens and information from the northern part of the Plateau-Mackenzie area, the Great Plains, the Arctic, Quebec, and the Maritime Provinces.

A number of typical village sites in the vicinity of Washington, Ontario, were visited in company with Mr. W. J. Wintemberg, who was later employed to make an archæological survey of Blandford township, Oxford county, and to conduct other researches in Ontario. Village sites were also visited in company with Mr. George E. Laidlaw in the vicinity of Victoria Road, Ontario.

Photographs, for use chiefly in research work, were made of all the types of archæological objects from Ontario in the Provincial Museum at Toronto. All the collections available in Toronto, Montreal, and Quebec were inspected. Two collections which were offered for sale to the Geological Survey, one in Paris, the other at Waterdown, were visited. It is my opinion that the funds necessary for purchasing these might far better be spent in carrying on activities for the diffusion and increase of archæological knowledge and in securing material more sorely needed for these purposes.

Considerable attention has been given to systematizing and digesting scattered and incomplete archæological data. The co-operation of railway officials, members of the Northwest Mounted Police, and the explorers of the Geological Survey, has been enlisted to assist in the archæological survey.

## MAPPING AND ENGRAVING DIVISION.

*(C.-Omer Senécal.)*

The staff of the mapping and engraving division is at present composed of a chief officer, thirteen map compilers and draughtsmen, and one clerk-typist.

The work assigned to this division is of a varied nature and consists mainly in the construction and drawing of original maps and diagrams of all descriptions to be issued separately or to illustrate geological memoirs. Some members of the staff are trained for special map compilation and others for the preparation and finishing of drawings intended for reproduction by engraving or photolithographic processes. Considerable attention is also devoted to the elaboration of map specifications for the use of the engravers who are under the control of the Printing Bureau. A saving of time and expenditure in proofing is calculated to be thus effectuated.

Four hundred and eighteen letters, memoranda, specification sheets, reports, etc., relating to the work of this division, were sent out during the past year, while four hundred and eighty-six were received.

Attention was also given to the work of the Geographic Board of Canada, the meetings of which were regularly attended. A considerable number of lists of place-names covering maps prepared during the year were, as usual, edited, then submitted to the board for discussion and approval. Lists of approved names are published in the annual report of the board, under the authority of the Department of Marine and Fisheries, and from time to time, in the *Canada Gazette*.

The following twenty-five maps, plans, etc., are, at this date, in the hands of the King's Printer. Several editions are expected to be issued shortly.

MAPS in hands of King's Printer, December 31, 1911.

| Series A. | Publication Number. | Title. | Sent to King's Printer. |
|---|---|---|---|
| 17 | 1123 | Southeast Vancouver island, B.C ...... | Aug. 29, 1911 |
| 19 | 1147 | Lardeau Topographical map, B.C ...... | Sept. 5, 1911 |
| 26 | 1162 | Bathurst Topographical map, N.B ...... | June 1, 1911 |
| 27 | 1163 | Bathurst Geological map, N.B ...... | " 1, 1911 |
| 29 | 1167 | Mother Lode and Sunset mines, B.C., Topographical map...... | Mar. 24, 1911 |
| 30 | 1168 | " " " Geological map ...... | Nov. 17, 1911 |
| 31 | 1177 | Larder Lake district, Ont ...... | " 14, 1911 |
| 35 | 1181 | Parts of Albert and Westmorland counties, N.B...... | July 26, 1911 |
| 38 | 1184 | Danville Mining Area, Quebec ...... | Oct. 6, 1911 |
| 39 | 1185 | Geological Map of Nova Scotia...... | Aug. 31, 1911 |
| 40 | 1210 | Bighorn Coal Basin, Alta. ...... | Oct. 17, 1911 |
| 45 | 1195 | Tulameen Topographical map, B.C ...... | Aug. 29, 1911 |
| 46 | 1196 | " Geological map, B.C. ...... | " 29, 1911 |
| 47 | 1197 | Law's Mining camp, Tulameen, B.C...... | " 29, 1911 |
| 49 | 1199 | Orillia Topographical sheet, Ont ...... | Oct. 17, 1911 |
| 50 | 1200 | Portland Canal Mining area.. ...... | " 17, 1911 |
| 51 | 1201 | Geological map of Alberta, Saskatchewan, and Manitoba...... | Sept. 9, 1911 |
| 52 | 1202 | Northeast part of Serpentine Belt, Quebec.. ...... | Oct. 6, 1911 |
| 53 | 1208 | Southeast Nova Scotia ...... | Sept. 26, 1911 |
| ...... | 339 | Northwestern Manitoba, 2nd edition...... | Aug. 5, 1911 |
| ...... | 964 | Part of Algoma and Thunder Bay, Ont., 2nd edition...... | " 22, 1911 |
| ...... | ...... | Goldenville Gold district, N.S ; Libbey fissure vein ...... | Oct. 20, 1911 |
| ...... | ...... | " " " Plan and section...... | " 20, 1911 |
| ...... | ...... | Oldham Gold district, N.S.; Plan and section ...... | " 20, 1911 |
| ...... | ...... | Brookfield Gold district, N.S.; Plan ...... | " 19, 1911 |
| | | Also a large number of zinc-cut illustrations for reports ...... | |

A list of the maps, diagrams, etc., published during the past year, is appended herewith:—

List of Map Editions received from the King's Printer, during the year 1911.

| Series A. | Publication Number. | | Title. | Number of accompanying Memoir. | Remarks. |
|---|---|---|---|---|---|
| 28 | 1164 | British Columbia. | Portland Canal Mining district. Scale 2 miles to 1 inch. | Summary Report 1910. | Sketch geology. |
| 15 | 1135 | " | Phoenix map. Scale 400 feet to 1 inch. | 21 | Geology. |
| 16 | 1136 | " | Phoenix map. Scale 400 feet to 1 inch. | 21 | Topography. |
| 20 | 1148 | " | Victoria sheet, Vancouver island; Scale, $\frac{1}{62,500}$ | | " |
| 21 | 1149 | " | Saanich sheet, Vancouver island. Scale, $\frac{1}{62,500}$ | | " |
| | | " | Nanaimo sheet, Vancouver island. Scale, $\frac{1}{62,500}$ | | Topography, advance edition. |
| | | " | Duncan sheet, Vancouver island. Scale, $\frac{1}{125,000}$ | | " " |
| | | " | Sooke sheet, Vancouver island. Scale, $\frac{1}{125,000}$ | | |
| | | " | Tulameen map, Yale district. Scale, $\frac{1}{62,500}$ | | " " |
| 48 | 1198 | " | Tulameen coal area. Scale ½ mile to 1 inch. | 26 | Economic geology. |
| | 921 | " | Graham Island coal field. Scale 1 mile to 1 inch. | | " " 2nd edition. |
| | | " | Portland Canal coal mining area. Scale, $\frac{1}{125,000}$ | | Topography, advance edition. |
| | | " | Beaverdell map, Yale district. Scale, $\frac{1}{62,500}$ | | " " |
| | | Alberta. | Bighorn coal basin. Scale, $\frac{1}{125,000}$ | | " " |

| | | | | | |
|---|---|---|---|---|---|
| .... | ............ | " | **Jasper park** .......... Scale, $\frac{1}{62,500}$ | | " " |
| .... | ...... | Ontario. | Orillia sheet, Simcoe county .......... Scale, $\frac{1}{62,500}$ | | " " |
| .... | ....... | " | West Shiningtree area, Sudbury district .......... Scale, 1 mile to 1 inch. | | Economic geology, advance edition. |
| 18 | 1066 | Ontario and Quebec. | Lake Timiskaming Mining region .......... Scale 1 mile to 1 inch. | | Areal geology. |
| ...... | ... | " " | Larder lake and Opasatika lake .......... Scale 2 miles to 1 inch. | | Topography, advance edition. |
| 23 | 1154 | Quebec. | Thetford Black Lake Mining district .......... Scale 1 mile to 1 inch. | | Economic geology. |
| 34 | 1180 | " | Vicinity of National Transcontinental Ry. between Levis and Temiscouata .......... Scale 8 miles to 1 inch. | | Geological reconnaissance |
| | ......... | " | Danville Mining area .......... Scale 1 mile to 1 inch. | | Cadastral compilation, advance edition. |
| 21 | 1155 | New Brunswick. | Millstream iron ore deposit, Gloucester county .......... Scale 400 feet to 1 inch. | 18 | Economic geology. |
| 25 | 1156 | " | Nipisiguit iron ore deposit, Gloucester county .......... Scale 400 feet to 1 inch. | 18 | " " |
| 13 | 1133 | Nova Scotia. | Kingsport, Sheet No. 84, Hants and Kings county .......... Scale 1 mile to 1 inch. | | Areal geology. |
| ... | ... | " | Gaspereau, Sheet No. 85. .......... Scale 1 mile to 1 inch. | | Topography, advance edition. |
| ... | ... | " | New Ross, Sheet No. 86 .......... Scale 1 mile to 1 inch. | | " " |
| ... | .... | " | Lakeview, Sheet No. 97. .......... Scale 1 mile to 1 inch. | | " " |
| . | ... | " | Berwick, Sheet 98. .......... Scale 1 mile to 1 inch. | | " " |
| 22 | 1153 | " | Index map of the Province .......... Scale 12 miles to 1 inch. | 16 | " " |

Also 32 zinc cut sketch maps, diagrams, and illustrations for various reports.

## LIBRARY.

(*Jane Alexander, Acting Librarian.*)

During the calender year, 2,981 publications were received as gifts or exchanges, including—besides periodicals—maps, reports, and publications of foreign Geological Surveys, together with memoirs, transactions, and proceedings of the scientific societies of Canada and other countries.

306 volumes were added by purchase, costing $1,241.60.

242 volumes were bound during the year.

104 periodicals were subscribed for.

217 letters relating to the work of the library were sent out, with 597 acknowledgments of publications received as gifts.

Though the removal of the library to its new quarters in the Victoria Memorial Museum took place early in the year, it was not until the month of September that a systematic re-arrangement and classification of the books was begun. A modified form of the Cutter system is being used, and good progress has been made with the work. Many volumes—which for want of shelf room had been stored away—are now available.

## PUBLICATIONS.

**The following reports have been published since January 1, 1911:—**

No.

1006. Report on a Traverse through the Southern part of the North West Territories, from Lac Seul to Cat lake, 1902. By A. W. G. Wilson. Published January 10, 1911. } Bound together.

1080. Report on a Part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers. By W. McInnes. Published January 10, 1911. } Bound together.

1064. Report on the Geology of an Area adjoining the East Side of Lake Timiskaming. By Morley E. Wilson. Published May 1, 1911.

1110. Memoir No. 4: Geological Reconnaissance along the Line of the National Transcontinental Railway in Western Quebec. By W. J. Wilson. Published June 26, 1911.

1113. Memoir No. 16–E: The Clay and Shale Deposits of Nova Scotia and Portions of New Brunswick. By Dr. Heinrich Ries and J. Keele. Published July 18, 1911.

1115. Memoir No. 8: Preliminary Report on the Edmonton Coal Fields. By D. B. Dowling. Published February 13, 1911.

1130. Memoir No. 9: Bighorn Coal Basin. By G. S. Malloch. Published July 18, 1911.

1137. Memoir No. 10: An Instrumental Survey of the Shorelines of the Extinct Lakes Algonquin and Nipissing, in Southern Ontario. By J. W. Goldthwait. Published June 20, 1911.

1141. Memoir No. 12: On Tertiary Insects of British Columbia. By Anton Handlirsch. Published January 30, 1911.

1143. Memoir No. 14: Description of Shells collected by John Macoun at Barkley Sound, Vancouver Island, B.C. By Messrs. W. H. Dall and Paul Bartsch. Published January 16, 1911.

1150. Memoir No. 15: On a Trenton Echinoderm Fauna at Kirkfield, Ont. By Hon. Frank Springer. Published May 16, 1911.

1170. Summary Report of the Geological Survey for the Calendar Year ending December 31, 1910. Published June 20, 1911.

*Special Reprint.*

Note on the Parietal Crest of Centrosaurus Afertus, and on a Proposed New Generic name for Stereocephalus Tulus. By Lawrence M. Lambe. The Ottawa Naturalist, December, 1910. Published January 10, 1911.

No.

FRENCH TRANSLATIONS.

(*M. Sauvalle.*)

1035*a*. Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. By D. B. Dowling. Published March 17, 1911.

1072. Summary Report, 1908. Published January 17, 1911.

## ACCOUNTANT'S STATEMENT.

The funds available for the work and the expenditure of the Geological Survey for the fiscal year ending March 31, 1911, were:—

| Details. | Grant. | Expenditure. |
|---|---|---|
| Amounts voted by Parliament.. .. .. .. | $391,889 00 | |
| Civil list salaries.. .. .. .. .. .. .. .. | | $103,502 94 |
| Explorations in British Columbia.. .. .. | | 26,352 37 |
| Topographical surveys in British Columbia. | | 39,766 30 |
| Explorations in North West Territories.. | | 8,710 84 |
| Explorations in Ontario.. .. .. .. .. | | 6,708 78 |
| Topographical surveys in Ontario. .. .. | | 4,061 82 |
| Explorations in Quebec.. .. .. .. .. .. | | 4,904 39 |
| Topographical surveys in New Brunswick. | | 5,858 67 |
| Explorations in New Brunswick.. .. .. | | 344 78 |
| Explorations in Nova Scotia.. .. .. .. | | 4,549 49 |
| Explorations in general.. .. .. .. .. .. | | 2,931 49 |
| Publication of maps.. .. .. .. .. .. .. | | 13,993 93 |
| Publication of reports.. .. .. .. .. .. | | 9,787 55 |
| Instruments and repairs.. .. .. .. .. | | 9,841 80 |
| Specimens for Museum.. .. .. .. .. .. | | 9,066 35 |
| Miscellaneous.. .. .. .. .. .. .. .. .. | | 6,237 28 |
| Printing and stationery.. .. .. .. .. .. | | 5,209 35 |
| Wages of temporary employees.. .. .. .. | | 2,081 35 |
| Travelling expenses.. .. .. .. .. .. .. | | 1,752 67 |
| Library.. .. .. .. .. .. .. .. .. .. .. | | 1,598 76 |
| Photo supplies.. .. .. .. .. .. .. .. .. | | 1,298 14 |
| Removal to Victoria Memorial Museum. | | 1,171 94 |
| Legal fees.. .. .. .. .. .. .. .. .. .. | | 1,563 20 |
| Balance unexpended and lapsed.. .. .. | | 120,594 81 |
| | $391,889 00 | $391,889 00 |

JNO. MARSHALL.

All of which is respectively submitted.

I have the honour to be, Sir,

Your obedient servant,

(Signed) R. W. BROCK.

# INDEX

## S

# CANADA

# DEPARTMENT OF MINES

## GEOLOGICAL SURVEY BRANCH

HON. ROBERT ROGERS, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

# SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

## OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

## THE GEOLOGICAL SURVEY.

**Report of the Mines Section:—**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. 245. | Report of Mines Section, | | 1886. | No 662. | Report of Mines Section, | | 1897 |
| 272 | “ | “ | 1887. | 698 | “ | “ | 1898 |
| *300 | “ | “ | 1888. | 718 | “ | “ | 1899 |
| 301 | “ | “ | 1889. | 744 | “ | “ | 1900 |
| 334 | “ | “ | 1890. | 800 | “ | “ | 1901 |
| 335 | “ | “ | 1891. | 835 | “ | “ | 1902 |
| 360 | “ | “ | 1892. | 893 | “ | “ | 1903 |
| 572 | “ | “ | 1893-4 | *928 | “ | “ | 1904 |
| 602 | “ | “ | 1895. | 971 | “ | “ | 1905 |
| 625 | “ | “ | 1896. | | | | |

**Mineral Production of Canada:—**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. *414. | Year 1886. | No. *422. | Year 1893. | No. 719. | Year 1900. |
| *415 | “ 1887. | *555 | “ 1894. | 719a | “ 1901. |
| *416 | “ 1888. | *577 | “ 1895. | 813 | “ 1902. |
| *417 | “ 1889. | *612 | “ 1896. | 861 | “ 1903. |
| *418 | “ 1890. | *623 | “ 1886-96. | 896 | “ 1904. |
| *419 | “ 1891. | *640 | “ 1897. | 924 | “ 1905. |
| *420 | “ 1886-91. | *671 | “ 1898. | 981 | “ 1906. |
| *421 | “ 1892. | *686 | “ 1899. | | |

**Mineral Resources Bulletin:—**

| | | | | | |
|---|---|---|---|---|---|
| No. *818. | Platinum. | No. 860 | Zinc. | No. 881. | Phosphate. |
| 851. | Coal. | 869. | Mica. | 882 | Copper. |
| *854. | Asbestos. | 872. | Molybdenum and Tungsten. | 913. | Mineral Pigments. |
| 857. | Infusorial Earth. | *877. | Graphite. | 953. | Barytes. |
| 858. | Manganese. | 880. | Peat. | 984. | Mineral Pigments (French). |
| 859. | Salt. | | | | |

**Report of the Section of Chemistry and Mineralogy:—**

| | | | | | |
|---|---|---|---|---|---|
| No. *102. | Year 1874-5. | No. *169. | Year 1882-3-4. | No. 580. | Year 1894. |
| *110 | “ 1875-6. | 222 | “ 1885. | 616 | “ 1895. |
| *119 | “ 1876-7. | 246 | “ 1886. | 651 | “ 1896. |
| *126 | “ 1877-8. | 273 | “ 1887-8. | 695 | “ 1898. |
| *138 | “ 1878-9. | 289 | “ 1888-9. | 724 | “ 1899. |
| *148 | “ 1879-80. | 333 | “ 1890-1. | 821 | “ 1900. |
| *156 | “ 1880-1-2. | 353 | “ 1892-3. | *958 | “ 1906. |

* Publications marked thus are out of print.

## REPORTS.

### GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972 Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146 Notes on Canada, by R. W. Brock.

### YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m. = 1 in.; Nos. 275 and 277, scale 8 m. = 1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. = 1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. 688, scale 2 m. = 1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. = 1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. = 1 in. } Bound together.
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. = 1 in. } Bound together.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. = 1 in.
982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. = 1 in.
1016. Klondike Creek and Hill gravels, by R. G. McConnell. (French.) Map No. 1011, scale 40 ch. = 1 in.
1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.
1011. Memoir No. 5 (Preliminary): on the Lewes and Nordenskiöld Rivers coal-field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.

### BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30'), by G. M. Dawson. 1885. Map No. 223, scale 6 m. = 1 in. Map No. 224, scale 1½ m. = 1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
236. The Rocky mountains, geological structure, by R. G. McConnell. 1886. Map No. 248, scale 2 m. = 1 in.
263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281.
*271. Mineral wealth, by G. M. Dawson.

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* Publications marked thus are out of print.

*291. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. = 1 in.
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. = 1 in.
574. Finlay and Omineca rivers, by R. G. McConnell. 1894. Map No. 567, scale 8 m. = 1 in.
743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
939. Rossland district, by R. W. Brock. Map No. 941, scale 1,600 ft. = 1 in.
940. Graham island, by R. W. Ells. 1905. Maps No. 921, scale 4 m. = 1 in.; No. 922, scale 1 m. = 1 in. (Reprint).
986. Similkameen district, by Chas. Camsell. Map No. 987, scale 400 ch. = 1 in.
988. Telkwa river and vicinity, by W. W. Leach. Map No. 989, scale 2 m. = 1 in.
996. Nanaimo and New Westminster districts, by O. E. LeRoy. 1907. Map No. 997, scale 4 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.
1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.
1121. Memoir No. 13: Southern Vancouver island, by Charles H. Clapp. Map No. 1123—17 A, scale 4 m. = 1 in.
1175. Memoir No. 21: Geology and ore deposits of Phoenix, Boundary district, by O. E. LeRoy. Maps Nos. 1135 and 1136, scale 400 ft. = 1 in.
1204. Memoir No. 24–E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201–51 A, scale 35 m. = 1 in.

## ALBERTA.

*237. Central portion, by J. B. Tyrrell. 1886. Maps Nos. 249 and 250, scale 8 m. = 1 in.
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-1. Map No. 336, scale 48 m. = 1 in.
703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117-5 A and 1118-6 A, scale 2640 ft. = 1 in.
1130. Memoir No. 9-E: Bighorn coal basin, Alta., by G. S. Malloch. Map No. 1132, scale 2 m. = 1 in.
1204. Memoir No. 24–E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201—51 A, scale 35 m. = 1 in.

## SASKATCHEWAN.

213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.
601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map No. 957, scale 25 m. = 1 in.

* Publications marked thus are out of print.

868 Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204 Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201-51 A, scale 35 m. = 1 in.

## MANITOBA.

264 Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.
296 Glacial Lake Agassiz, by W. Upham. 1889 Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in.
} Bound together.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Josepb Keele. Map No. 1201-51 A, scale 35 m. = 1 in.

## NORTH WEST TERRITORIES.

217. Hudson bay and strait, by R. Bell. 1885. Map No. 229, scale 4 m. =1 in.
238. Hudson bay, south of, by A. P. Low. 1886.
239. Attawapiskat and Albany rivers, by R. Bell. 1886.
244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. = 1 in.
267. James bay and country east of Hudson bay, by A. P. Low.
578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. = 1 in.
•584 Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. = 1 in.
618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. = 1 in.
657 Northern portion of the Labrador peninsula, by A. P. Low.
680. South Shore Hudson strait and Ungava bay, by A. P. Low. Map No. 699, scale 25 m. = 1 in.
713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. = 1 in.
} Bound together.
725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.
778. East coast Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.
786-787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.
815 Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. = 1 in.
819 Nastapoka islands, Hudson bay, by A. P. Low. 1900.
905. The Cruise of the *Neptune*, by A. P. Low. 1905.
100 . Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson.
10-0. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in.
} Bound together.
1069 French translation: Report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.; No. 785, scale 50 m. = 1 in.

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• Publications marked thus are out of print.

1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.

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215. Lake of the Woods region, by A. C. Lawson. 1885. Map No. 227, scale 2 m. = 1 in.
*265. Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.
266. Lake Superior, mines and mining, by E. D. Ingall. 1888. Maps No. 285, scale 4 m. = 1 in.; No. 286, scale 20 ch. = 1 in.
326. Sudbury mining district, by R. Bell. 1890-1. Map No. 343, scale 4 m. = 1 in.
327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.
332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-1. Maps Nos. 344-349.
357. Victoria, Peterborough, and Hastings counties, by F. D. Adams. 1892-3.
627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. = 1 in.
678. Seine river and Lake Shebandowan map-sheets, by W. McInnes. 1897. Maps Nos. 589 and 560, scale 4 m. = 1 in.
723. Iron deposits along the Kingston and Pembroke railway, by E. D. Ingall. 1900. Map No. 626, scale 2 m. = 1 in.; and plans of 13 mines.
*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (*See* No. 739, Quebec.)
741. Ottawa and vicinity, by R. W. Ells. 1900.
790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. = 1 in.
961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint). Maps Nos. 775, 820, scale 1 m. = 1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.
962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
965. Sudbury Nickel and Copper deposits, by A. E. Barlow. (French).
970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No. 660, scale 4 m. = 1 in.
980. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1081. On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.

(980 and 1081: Bound together.)

992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
998. Report on Pembroke sheet, by R. W. Ells. (French). Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.

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* Publications marked thus are out of print.

1082. Memoir No. 6: Geology of the Haliburton and Bancroft areas, Ont., by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation: Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 961, scale 8 m. = 1 in. } Bound together.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 961, scale 8 m. = 1 in. } Bound together.

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216. Mistassini expedition, by A. P. Low. 1884-5. Map No. 228, scale 8 m. = 1 in.
240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m.= 1 in.
268. Megantic, Beauce, Dorchester, Lévis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
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579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams, 1894. Map No. 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m.=1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
923. Chibougamau region, by A. P. Low. 1905.
962. Timiskaming map-sheet, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m.=1 in.
974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m.=1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).
1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m.=1 in.
1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m.=1 in.
1052. French translation report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps No. 874, scale 4 m.=1 in.; No. 375, scale 3.000 ft.=1 in.; No. 876.
1064. Geology of an Area adjoining the East Side of Lake Timiskaming, Que., by Morley E. Wilson. Map No. 1066, scale 1 m.=1 in.
1110. Memoir No. 4: Geological Reconnaissance along the line of the National Transcontinental railway in Western Quebec, by W. J. Wilson. Map No. 1112, scale 4 m.=1 in.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.

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218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. Map No. 230, scale 4 m.=1 in.

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* Publications marked thus are out of print.

219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m.=1 in.
242. Victoria, Restigouche, and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-8. Map No. 290, scale 4 m.= 1 in.
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890-1. Map No. 350, scale 4 m.=1 in.
661. Mineral resources, by L. W. Bailey. 1897. Map No. 675, scale 10 m. = 1 in. New Brunswick geology, by R. W. Ells. 1887.
799. Carboniferous system, by L. W. Bailey. 1900. } Bound together.
803. Coal prospects in, by H. S. Poole. 1900. }
983. Mineral resources, by R. W. Ells. Map No. 969, scale 16 m.=1 in.
1034. Mineral resources, by R. W. Ells. (French). Map No. 969, scale 16 m.=1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m.=1 in.

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243. Guysborough, Antigonish, Pictou, Colchester, and Halifax counties, by Hugh Fletcher and E. R. Faribault. 1886.
331. Pictou and Colchester counties, by H. Fletcher. 1890-1.
358. Southwestern Nova Scotia (preliminary), by L. W. Bailey. 1892-3. Map No. 362, scale 8 m.=1 in.
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. Map No. 641, scale 8 m. = 1 in.
685. Sydney coal-field, by H. Fletcher. Maps Nos. 652, 653, 654, scale 1 m. = 1 in.
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900.
871. Pictou coal-field, by H. S. Poole. 1902. Map No. 833, scale 25 ch = 1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m. = 1 in.

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* Publications marked thus are out of print.

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278. Cariboo Mining district, scale 2 m. = 1 in.
604. Shuswap Geological sheet, scale 4 m. = 1 in.
*771. Preliminary Edition, East Kootenay, scale 4 m. = 1 in.
767. Geological Map of Crowsnest coal-fields, scale 2 m. = 1 in.
*791. West Kootenay Minerals and Striæ, scale 4 m. = 1 in.
*792. West Kootenay Geological sheet, scale 4 m. = 1 in.
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987. Princeton coal basin and Copper Mountain Mining camp, scale 40 ch. = 1 in.
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* Publications marked thus are out of print.

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*342. Hunter Island sheet, scale 4 m.=1 in.
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*373. Rainy River sheet, scale 2 m. = 1 in.
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*589. Lake Shebandowan sheet, scale 4 m. = 1 in.
599\. Timiskaming sheet, scale 4 m. = 1 in. (New Edition, 1907).
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606\. Nipissing sheet, scale 4 m. = 1 in. (New Edition, 1907).
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*571. Montreal sheet, Eastern Townships Map, scale 4 m. = 1 in.
*665. Three Rivers sheet, Eastern Townships Map, scale 4 m. = 1 in.
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*668. Graphite district in Labelle county, scale 40 ch. = 1 in.
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* Publications marked thus are out of print.

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1036. St. Margaret Bay Geological sheet. No. 71. Scale 1 m. = 1 in.
1037. Windsor Geological sheet. No. 73. Scale 1 m. = 1 in.
1043. Aspotogan Geological sheet. No. 70. Scale 1 m. = 1 in.
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* Publications marked thus are out of print.

NOTE.—Individual Maps or Reports will be furnished free to *bona fide* Canadian applicants.

Reports and Maps may be ordered by the numbers prefixed to titles.

Applications should be addressed to The Director, Geological Survey, Department of Mines, Ottawa.

New headquarters of the Mines Branch of the Department of Mines, corner of Sussex and George Streets, Ottawa.

# SUMMARY REPORT

OF THE

## MINES BRANCH

OF THE

# DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31

# 1911

*PRINTED BY ORDER OF PARLIAMENT*

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1912

*To His Royal Highness the Duke of Connaught and Strathearn, K.G., etc., Governor General of Canada.*

May it please Your Royal Highness:

The undersigned has the honour to lay before Your Royal Highness, in compliance with 6-7 Edward VII, Chapter 29, Section 18, the Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1911.

(Signed) ROBERT ROGERS,
*Minister of Mines.*

HON. ROBERT ROGERS,
Minister of Mines,
Ottawa.

SIR,—I have the honour to submit herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1911.

I am, sir, your obedient servant,

(Signed) A. P. LOW,
*Deputy Minister.*

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*Photographs.*



*Drawings.*



*Maps.*

# SUMMARY REPORT

OF THE

# MINES BRANCH OF THE DEPARTMENT OF MINES

## FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1911.

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A. P. Low, Esq., LL.D.,
Deputy Minister,
Department of Mines.

Sir,—I have the honour to submit, herewith, the Summary Report of the Mines Branch of the Department of Mines for the calendar year ending December 31, 1911.

## ADDITIONS TO STAFF.

The following additions to the Mines Branch staff were made during the year:—

H. E. Baine, appointed June 6, 1911, as chief draughtsman.

A. H. A. Robinson, B.Ap.Sc., appointed May 11, 1911, as assistant mining engineer.

John Blizard, B.Sc., appointed August 1, 1911, as technical engineer.

Frederick Ransom, B.Sc., appointed May 11, 1911, as assistant mining engineer.

Walter M. Vincent, appointed April 1, 1911, as filing clerk.

Gordon H. Simpson, appointed August 9, 1911, as distribution clerk.

Miss B. W. Russell, appointed April 1, 1911, as typewriter of technical reports.

## ORGANIZATION: CLASSIFIED LIST OF STAFF.

The following is a complete list of technical officers and other employes at present on the staff of the Mines Branch:—

### INSIDE SERVICE.

*Administration staff:—*

Miss J. Orme, secretary.
W. Vincent, filing clerk.
G. Simpson, mailing and distribution clerk.
Miss B. Russell, technical typewriter.
Miss I. McLeish, typewriter.
Miss W. Westman, typewriter.
A. F. Purcell, messenger.
A. A. Ellement, messenger.

*Division of Mineral Resources and Statistics:—*

J. McLeish, B.A., chief of division.
C. T. Cartwright, B.Sc., assistant engineer.
J. Casey, assistant.
Mrs. W. Sparks, assistant.
Miss G. C. MacGregor, B.A., assistant.
Miss B. Davidson, typewriter.

*Division of Fuels and Fuel Testing:—*

B. F. Haanel, B.Sc., chief of division.
J. Blizard, B.Sc., technical engineer.
E. Stansfield, M.Sc., chemist.
A. H. A. Robinson, B.Ap.Sc., assistant engineer.

*Division of Chemistry:—*

F. G. Wait, M.A., chemist, chief of division.
M. F. Connor, B.A.Sc., assistant chemist.
H. A. Leverin, Ch.E., assistant chemist.

*Ore Dressing and Metallurgical Division:—*

G. C. Mackenzie, B.Sc., chief of division.
F. Ransom, B.Sc., assistant engineer.

*Division of Metalliferous Deposits:—*

A. W. G. Wilson, B.Sc., Ph.D., chief of division.
E. Lindeman, M.E., assistant engineer.

*Division of Non-metalliferous Deposits:—*

H. Fréchette, M.Sc., chief of division.
L. H. Cole, B.Sc., assistant engineer.
H. S. de Schmid, M.E., assistant engineer.

*Explosives Division:—*

J. G. S. Hudson.
NOTE.—*This division will be fully organized on the passage of the proposed Explosives Bill.*

*Draughting Division:—*

H. E. Baine, chief draughtsman.
L. H. S. Pereira, assistant draughtsman.
A. Pereira, assistant draughtsman.

OUTSIDE SERVICE.

*Dominion of Canada Assay Office, Vancouver, B.C.:—*

G. Middleton, manager.
J. B. Farquhar, chief assayer.
D. Robinson, chief melter.
A. Kaye, assistant assayer.
G. N. Ford, computer.
G. B. Palmer, assistant melter and janitor.

## INTRODUCTORY.

One of the signs of the times is the increasing demand by the commercial and industrial world that the investigations of our mineral and metal resources shall be of a more practical and economic character. This demand was the primary cause of the establishment of the Mines Branch. And the fact that the general staff has increased from two in 1902, to the comparatively large and complex organization indicated in the foregoing classified list for 1911; the fact that the entire three floors of the commodious departmental building on Sussex street—when ready—will be filled; and the fact that 35,156 publications of a strictly technical and economic character were distributed during 1911, is cumulative evidence that the inauguration of the Mines Branch for the purpose of technologically investigating the metallic and non-metallic mineral resources of the country, was a wise departure, and has met a pressing public demand.

The programme of work mapped out each year is largely made in compliance wth urgent public requests and petitions for special investigations of ore deposits, etc., of promise, or to supply technical information of commercial value, bearing on industrial development. The Mines Branch is endeavouring to do the work the people are asking for, based upon numerous requests for information. This popular line of policy is dominant in Mines Branch procedure; because it is realized that the main objective should be the rendering of practical public service in the interests of the country.

For these reasons it is manifest that the work planned yearly must become increasingly comprehensive in scope: including as it does, the gathering of industrial statistics; investigation of ore dressing methods for preparing lean ores for the market, or smelter; laboratory research and analyses; magnetometric surveys of iron ore deposits; and general work in the field.

In accordance with the usual custom, this summary report is intended to furnish what is, of necessity, only a brief synopsis of the year's work. In addition to an account of the work carried on by the technical officers, reference is made to what may be considered as executive work, and office routine. Among the various synopses of work herewith submitted, it is difficult to single out any one particular paper as being of greater ultimate value than others. In some cases, however, more detail has been given regarding certain results, since the prompt publication of this technical data has been considered of more immediate value to the public.

The official programme of the Mines Branch for the past year was, to a considerable extent, a continuation of work previously begun. Such a condition is only natural, when the wide extent of the field covered by the Mines Branch is taken into consideration. For example, investigations dealing with wide-spread branches of the mining industry, such as the winning of building and ornamental stones, and the development of the iron, copper, and gypsum deposits of the Dominion: all of which are matters of very considerable magnitude. At the same time, the work of the past year has also been marked by the inception of certain new investigations.

It is, however, a matter of profound regret that, among the latter, it has not been found possible to include the establishment of a national explosives testing station. Attention has in the past been directed repeatedly to the imperative need for such a station, the undeniable value of which is now generally recognized by the mining and contracting public, and indeed by all those interested in the manufacture or use of explosives. In anticipation of definite action by the Government, and aided by the best expert advice, the necessary legislation—as embodied in the Explosives Act—was drawn up, and all necessary data secured. Owing, however, to an early dissolution of Parliament, action regarding this important matter was necessarily deferred.

It is earnestly hoped that the establishment of an explosives station, along the lines already suggested, will constitute a part of the legislation of the present session.

The investigation, having for its aim the establishment of a Canadian peat-fuel industry, and which has for some time been conducted by the Mines Branch, has now been practically completed. This investigation has demonstrated a process which is well adapted to the commercial manufacture of the peat fuel in Canada, and has resulted, moreover, in the creation of a market for such fuel. A practical recognition of the results of this work is already apparent, as evidenced by the active preparations at present being made by Mr. J. M. Shuttleworth and associates, for the manufacture of cheap peat fuel on a commercial scale, and on lines similar to those demonstrated at the Government peat plant, Alfred, Ont.

On pages 27-30 of this report, reference will be found to the establishment of a metallurgical research laboratory. As constituting one of the most practical forms in which departmental activity can find expression, the establishment of such a laboratory will undoubtedly commend itself to a large section of the mining public of Canada. Its possible value, direct as well as indirect, as applied to the metallurgical industry of this country, should amply justify any outlay that such work may involve.

Reference will also be found, elsewhere, to the important extensions which have been projected in connexion with our ore-dressing laboratory. Although little more than one year has elapsed since the work of this division was first inaugurated, the scope of its operations has already increased to such an extent as to demand the extensions referred to above.

Finally, it is a matter of very great satisfaction to be able to state that definite steps have now been taken to remedy the present inadequate office accommodation, which has in the past handicapped the efficient administration of the work of the Mines Branch. Owing to the impossibility of securing a building sufficiently commodious for the general work of the Mines Branch, the various divisions are at present quartered in five separate buildings, in various parts of Ottawa. With the constantly broadening scope of the economic work, the practical enterprises initiated, and the corresponding numerical increase in the technical staff, the inconvenience resulting from such decentralization may be readily conceived. Plans recently prepared, however, provide for the complete renovation, and fitting up for offices, of the building owned by the Dominion Government at the corner of George and Sussex Streets; which was formerly occupied by the Geological Survey Branch of the Department of Mines. It is expected that this building will be ready for occupancy sometime during 1912, and that ample accommodation will then be available, under one roof, for the entire staff of the Mines Branch.

The present year, as usual, has witnessed a large demand for the various technical publications of the Mines Branch, the total number of monographs, reports, bulletins, etc., distributed through the Post Office during the year being 35,156. Owing to this demand for copies of the various publications, editions are frequently exhausted in a very short time, thus requiring the printing of a second, and at times even a third, edition.

The total value of the mineral production for the year 1911 was $102,291,686; a decrease of $4,531,937 as compared with the preceding year. This decrease must be largely attributed to the long continued strike among the coal miners of Alberta, and the Crowsnest district in British Columbia. This strike not only seriously reduced the coal output, but, through the closing down of the Granby Smelter—on account of a shortage of coke—indirectly caused a smaller production of copper, silver, and gold.

The correspondence of the statistical division amounted to 7,727 communications received and sent; while the direct correspondence of my own office amounted to 6,307 letters received, and 4,696 letters sent.

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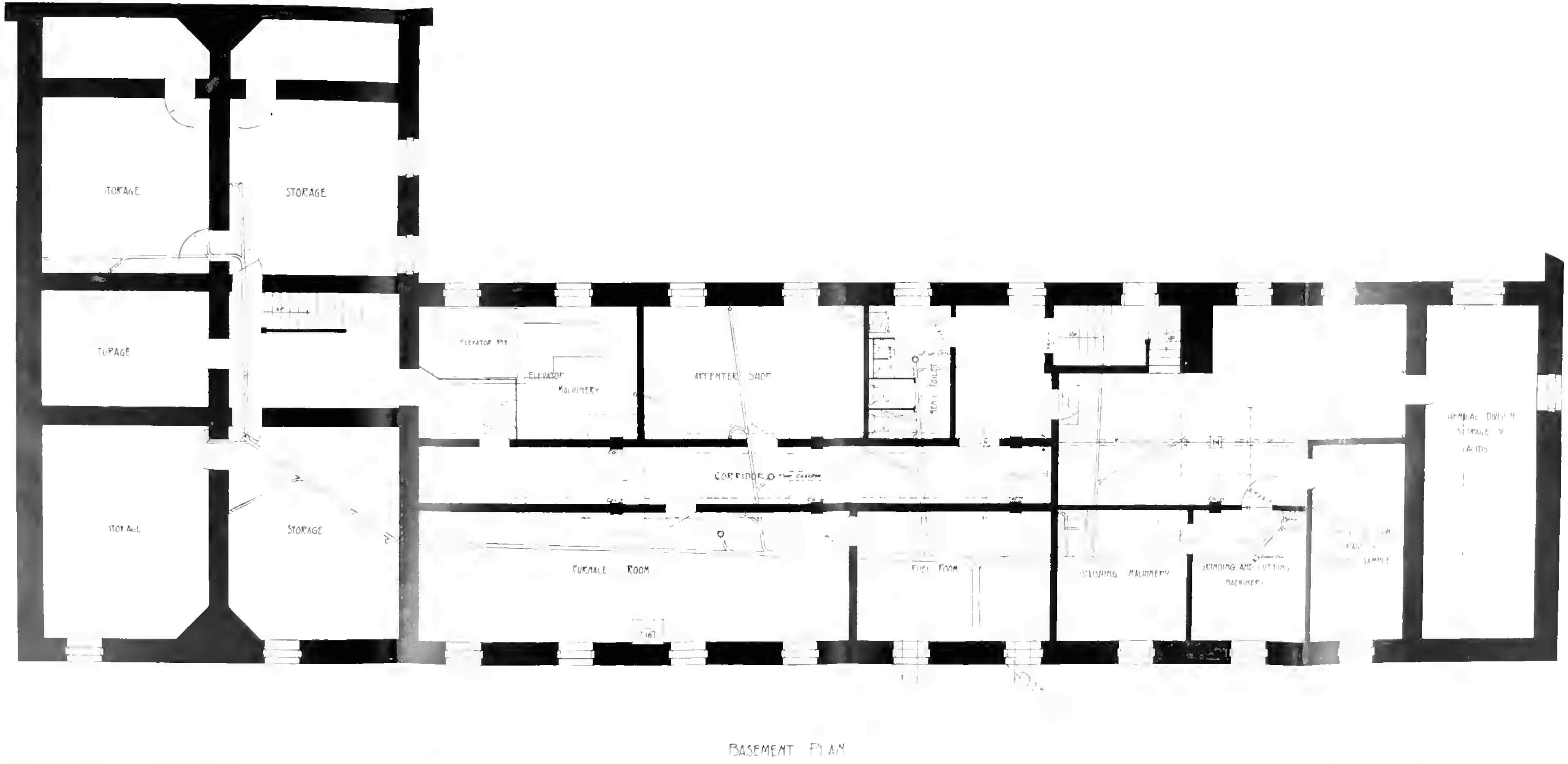


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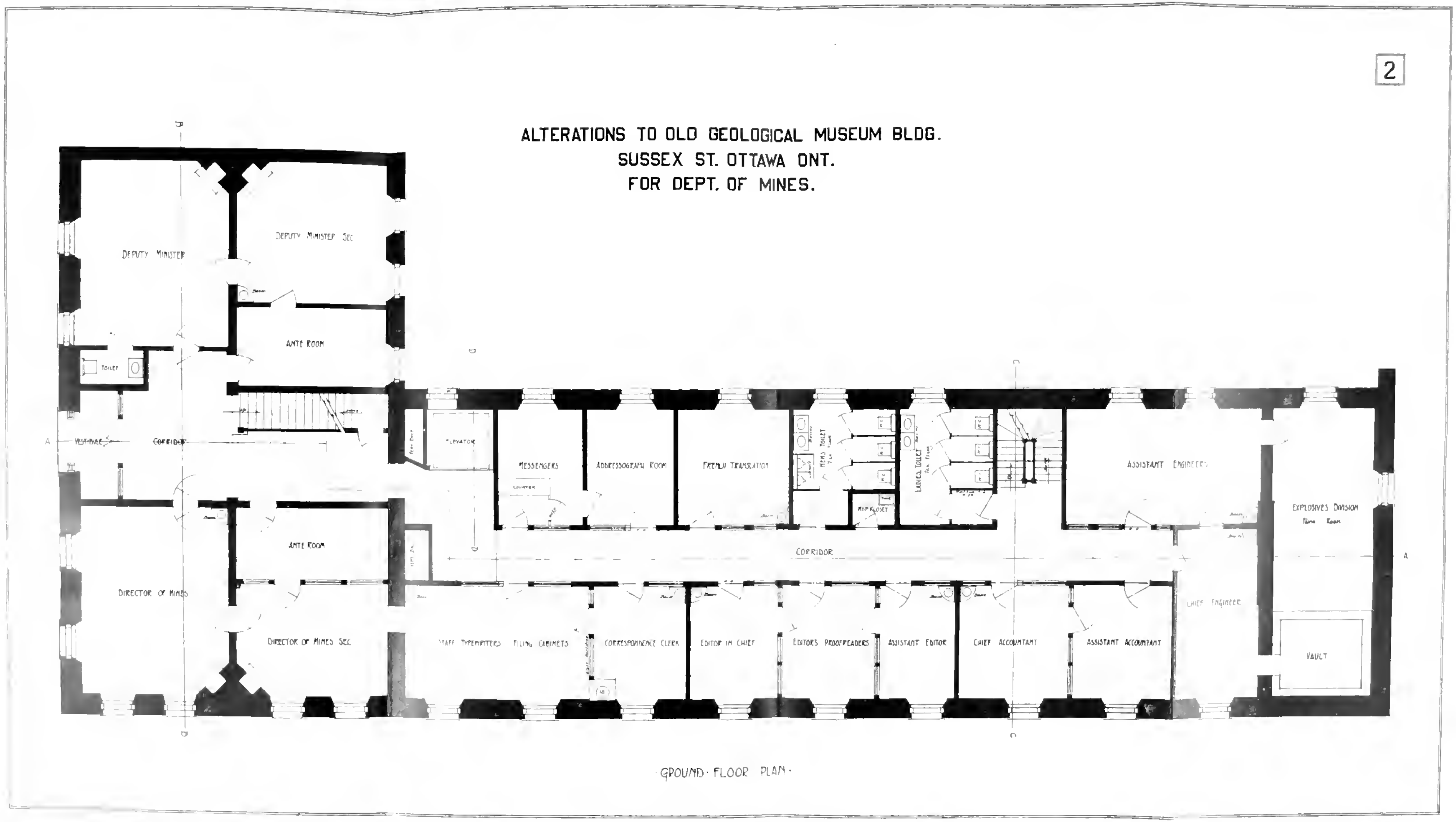


Fig. 2.—New Headquarters of the Mines Branch

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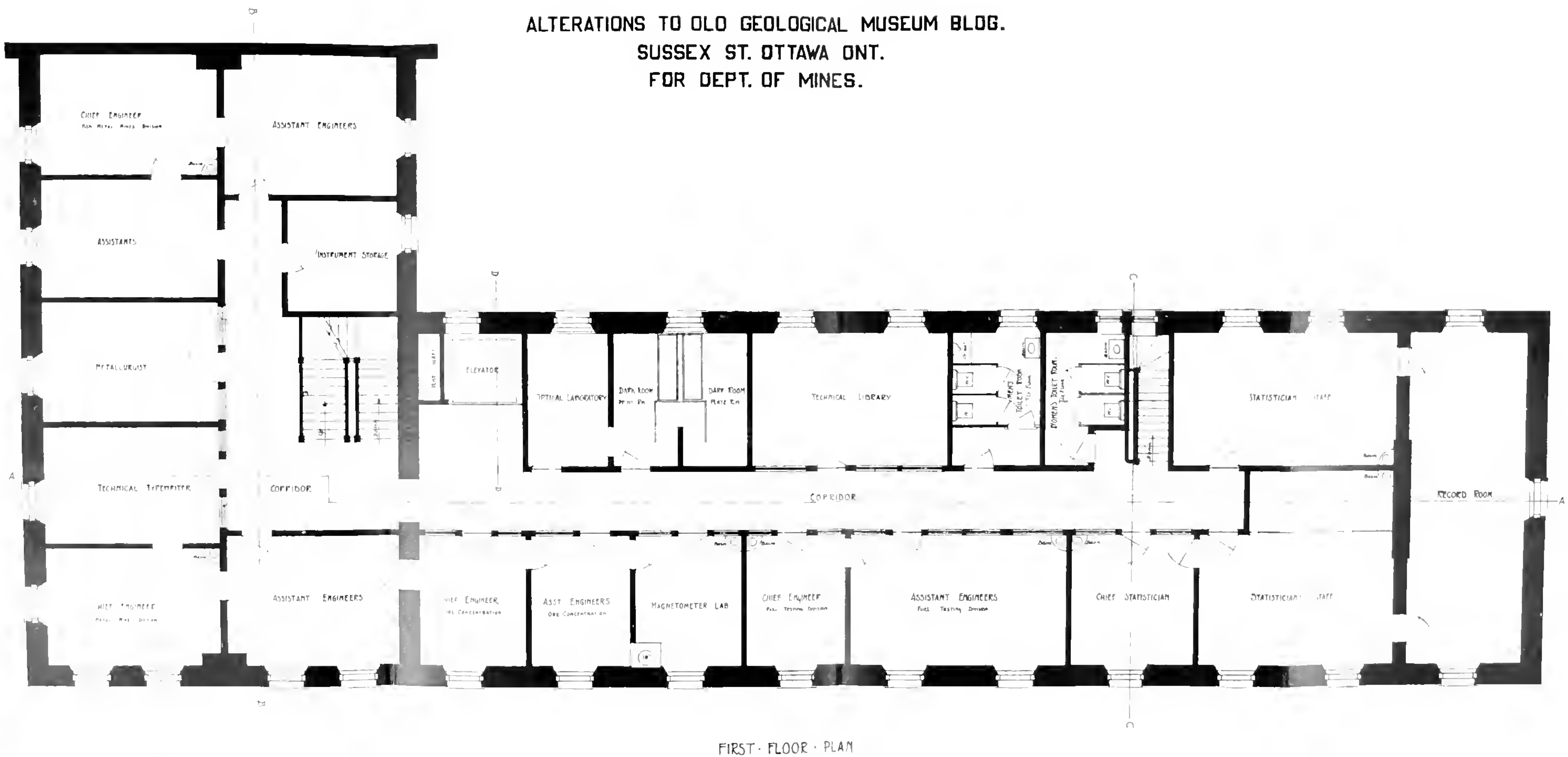


Fig. 3. New Headquarters of the Mines Branch.

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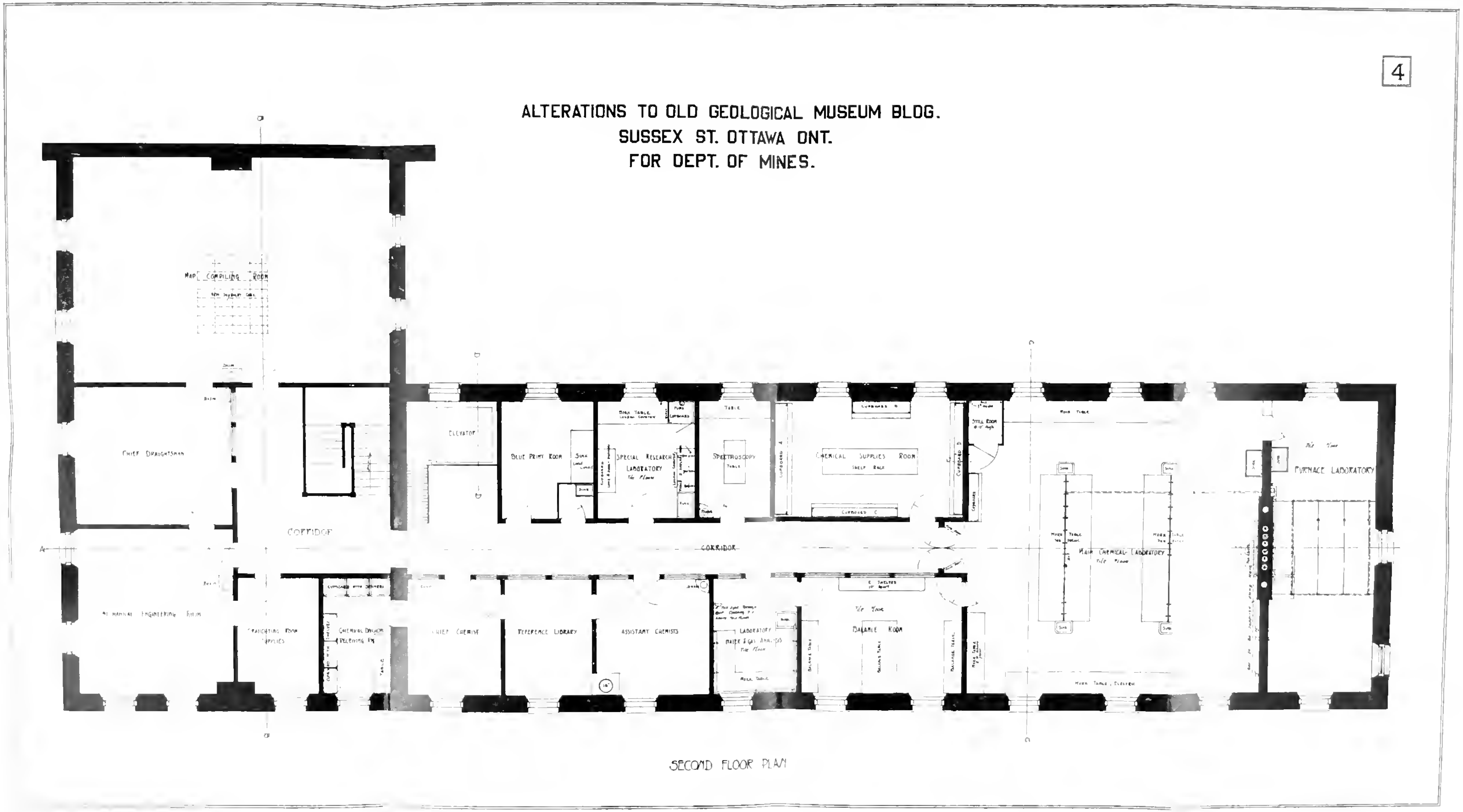



Fig. 4.—New Headquarters of the Mines Branch

## RECENT DEVELOPMENT OF ELECTRO-METALLURGY.

The present year has, in Canada, witnessed little progress in the development and application of the principles of electro-metallurgy as applied to the iron and steel industry. Indeed, at times it would seem that Canadian business men are inclined to be over-careful in accepting new methods of metallurgical treatment. They appear to be unwilling to try new methods of which the success has not been completely proven, and to lack that spirit of inquiry which, in European and American practice, is continually extending the limits of successful ore reduction.

In considering the development of the electric furnace, it should be remembered that such progress as has been made is of comparatively recent date. Thirty years ago the original Siemen's furnace was regarded almost as a scientific toy, and as being of little or no practical value. This was doubtless due, in part, to the wide difference which then existed between the cost of an electrical horse-power year, and its equivalent in coal. Conditions, such as the recent cheapening of electric energy on the one hand, and the steady advance in the price of solid fuel on the other, have, however, more nearly established the balance between these two factors.

In many of its applications the electric furnace has already safely passed the experimental stage; and although of comparatively recent date, its progress has been rapid and sure. In the production, for example, of high speed steel, the melting down of scrap metal, the production of certain ferro-alloys, and in its many other applications, it is no longer a question of demonstrating the reliability of the electric furnace, but a matter of engineering and finance. In 1905, there were very few electric furnaces, and these were of small capacity; while in 1910, sixty furnaces were either in use or under construction, some having a capacity of 15 tons. At the beginning of this period the value of the electric furnace rested more or less on such claims as were advanced by optimistic inventors. It is, however, to the engineer and designer, rather than to the inventor, that we must now look for the final adaptation of the electric furnace to commercial requirements. The following extract on the application of electro-metallurgy to commercial uses, is taken from "The Norse Power and Smelting Syndicate, Limited":—

"Though heat has played so great a role in human affairs, the problems of economy in the use of its available sources have been amongst the most difficult which have been presented for solution to engineers. Electrically generated heat appears at first sight to be the most extravagant conceivable, and this view is under many conditions correct. Electrical energy may, however, be converted into heat practically without loss, and hence, if the electrical energy is cheap enough, and if economy in its use can be effected, as is frequently the case, with greater ease than in the direct fuel furnace, it is capable of taking its place in the arts in competition with fuel as a source of heat. Moreover, the cost of electric heat is practically independent of temperature whereas the cost of heat from burning fuel increases as the temperature increases. The unit of work commonly used in connection with water power is the electrical horse-power year, which may mean either one horse-power operating for a year, 365 horse-power operating for a day, or any other power operating for a corresponding period.

The heat obtainable from this is equivalent to that got by burning about 14 cwts. of high class British coal. A direct comparison of the costs of one horse-power year and of 14 cwts. of coal is, however, unfair to the former, as the conditions under which the heat is produced are so unlike; electric heat is under better control than fuel generated heat, and the losses in its application are smaller and of a different character.

An example of the economy to be effected electrically is that of the production of crucible steel. A Sheffield crucible steel furnace does not utilize more than 2 per cent of the heat in the coal with which it is fed, and the heat necessary to be applied to an electric steel refining furnace doing exactly the same work is about one twenty-eighth part of that supplied to the crucible furnace. No laboured argument in favour of the electric furnace in such a case is necessary, and slow as the steel trade is to adopt new methods and processes, the electric steel furnace has now become recognized as a practical and economical apparatus in Europe and America.

A second application of electric heat in the iron industry is the production of iron and steel direct from ore. Experiments have been going on for some years in Sweden, Canada, and California, and recently the results have been so favourable that the Swedish Jarnkontoret, probably the best informed institution in the world on the subject of the production of high class iron and steel, has given financial support to a works in course of erection for the industrial exploitation of the process."

In the conditions affecting the production of iron and steel in certain parts of Canada, there is a resemblance to those of Norway and Sweden. In each case there is a scarcity of coal and coke, but an abundance of cheap water-power. In Norway and Sweden the development of the electric furnace promises to re-establish the iron industry—which a scarcity of fuel had almost destroyed. During the past two years, considerable work of an experimental nature has been carried on in Sweden under the auspices and direction of the Jarnkontoret. This association voted $90,000 toward the building of a 2,500 H.P. electric furnace for iron smelting at Trollhättan; and to further assist the undertaking, power was furnished by the Swedish Government at very low rates. A description dealing with the construction and operation of this furnace, as well as with the results obtained, has recently been written by Mr. T. D. Robertson. After describing the general design and arrangement, the writer considers the actual operation of the furnace as follows:—

"The furnace was thoroughly dried out with wood and charcoal fires, and heated up electrically by filling the hearth with coke and turning on the current. Charging was commenced on November 15, 1910. The furnace began to produce iron regularly and without difficulty, the first few tappings being rather high in sulphur from the large quantity of coke in the hearth.

The various iron works of Sweden sent their ores to be electrically smelted. In order to gain as much information as possible, the burden of the furnace was constantly altered to vary the grade of iron produced. Such treatment involving the frequent alternation of acid and basic slags was not good for the furnace hearth, and it must be admitted that it was something of an achievement for this to stand six months of this treatment without needing any serious repairs.

OPERATING RESULTS OF ELECTRIC IRON SMELTING FURNACE.

| Periods of Operation. | 2 | 3. | 4. | 5. |
|---|---|---|---|---|
| Per cent iron in ore | 65·57 | 65·06 | 49·50 | 57·92 |
| Per cent iron in charge | 62·1 | 62·56 | 42·42 | 53·06 |
| Slag per ton (2,000 lb.) of iron, lb. | 410·00 | 448·00 | 1,560·00 | 916·00 |
| Material charged per hectolitre of charcoal, lb. | 146·3 | 156·5 | 198·7 | 153·7 |
| Time consumed in working, hr | 2,010·00 | 184·5 | 639·3 | 506·5 |
| Time consumed in interruptions, hr. | 105·6 | 5·00 | 21·00 | 22·2 |
| Average load, kw. | 1,319·00 | 1,694·00 | 1,017·00 | 1,733·00 |
| Kw.-hr. per ton of iron | 2,087·00 | 1,953·00 | 2,384·00 | 2,403·00 |
| Iron per kw.-yr., tons | 4·2 | 4·49 | 3·67 | 3·64 |
| Electrode consumption, per ton of iron, lb | 22·48 | 21·68 | 18·38 | 14·9 |

Period No. 1 covers the firing up of furnace on November 15, 1910; per cent of iron in ore, 64·92; per cent of iron in charge, 59·8; slag per ton of iron, 780 lb.; time consumed, 7 hr. 50 min.; average load, 1,121 kw.; kw.-hr. per ton of iron, 3,454; iron per kw.-yr., 2·54 tons.

The conditions governing the grade of iron produced are similar to those in the ordinary blast furnace, except that the irregular influence of the air blast is absent. The furnace gives the maximum output when making white iron, as the making of grey iron requires a rather higher temperature and consequently a greater power consumption. By increasing the amount of ore in the charge when the furnace is making white iron, a low carbon iron with very little silicon is produced, a typical analysis of which is as follows:—

| | C. | Si. | Mn. | S. | P. |
|---|---|---|---|---|---|
| Percentages | 2·60 | 0·10 | 0·11 | 0·02 | 0·01 |

This iron naturally is full of holes, but instead of these having coloured oxidized surfaces, they are silvery white; the absence of oxygen from the furnace atmosphere accounting for the production of this grade of iron free from oxides. The results of making steel from this iron are given later.

A point of interest is the success met with in smelting magnetic concentrates at Trollhättan. The design of shaft in this particular case is not considered suitable for the purpose, being too narrow, but in spite of this, 65 per cent of finely divided concentrates caused no inconvenience in working. The inventors of the furnace are of the opinion that, with a specially designed shaft, charges of all fine concentrates could be smelted. Canada is rich in deposits of iron sands and lean magnetites, which are easily concentrated, but which are expensive to nodulize or briquette into a form suitable for blast-furnace smelting, so that where these are within easy reach of water powers, there seems to be a good field open for electric smelting.

Dr. Haanel, in his report on the experiments made at Sault Ste. Marie, mentions that no difficulty was experienced in smelting titaniferous ores electrically, and it is interesting that the Swedish experience bears out this point, although no ores were used with more than ·08 per cent $TiO_2$. The electric smelting of ores with high sulphur content is another interesting problem. Dr. Haanel was successful in producing low sulphur iron from sulphurous ores, but in Sweden there are practically none of these ores mined, so that this point was not confirmed on a large scale at Trollhättan; however, there can be little doubt that the electric furnace, with its reducing atmosphere and basic lining of the hearth, permitting as it does of the use of slag very rich in lime, offers the best method of producing sulphur-free pig iron from ores containing that unwelcome element.

The pig iron produced by the furnace was sent to various Swedish iron works for conversion into steel in open-hearth furnaces. The characteristic feature of electric pig iron is its freedom from oxides; and in consequence electric pig of normal silicon content (say, 1 per cent and over) takes a longer time and more ore to convert into steel than ordinary blast-furnace grey iron. Low-carbon electric pig iron, however, is found to give surprising results, charges made up of 50 per cent of this iron and 50 per cent of scrap producing hot fluid steel with considerable saving of time over ordinary practice. As was to be expected, the open-hearth furnace managers looked somewhat askance at this iron at first, as they knew the disastrous effect of using low-carbon iron full of holes from the blast furnace; however, after giving it a trial the workmen asked for more, as they said that the furnace worked better and more rapidly with the new pig iron. Fortunately for the electric furnace in Sweden, it is more economical to make the white iron that the steelmakers prefer than to make high-silicon grey iron. Thus it may be maintained, on the strength of the experience gained, that for the open-hearth process, high-silicon contents are detrimental rather than advantageous, while in the blast furnace pig iron a certain quantity is necessary to neutralize the defects of a reduction process less perfect and ideal than that employed in the electric furnace."

These results appear to indicate that the electro-thermic process for smelting purposes, has now passed beyond the experimental stage, and that the use of the electric furnace, in the production of pig iron, will, in the near future, supersede the present charcoal furnaces in Sweden. It may be further added, that at the present time there are eight Grönwall reduction furnaces, having an aggregate of 25,000 H.P., in operation, or in course of construction. In addition, the construction of other furnaces having an aggregate of 36,000 H.P., has been projected.

## PROGRESS OF PEAT FUEL INDUSTRY.

The possible future of peat, as an asset of economic value to the Dominion, has, for several years, in the laboratory as well as in the field, been the subject of systematic investigation by the Mines Branch of the Department of Mines. That the tests which have been carried out have met with public approval, is evidenced by the wide-spread interest with which the investigation has been followed. The recent successful termination of this work has already been recognized by active preparations for the development of our peat resources by private enterprise along purely commercial lines. Commenting on this fact, the *Ottawa Citizen*, in its issue of November 15, 1911, remarks:—

"The Alfred Peat Plant is not only at the present time furnishing Ottawa with fuel, but has met with recognition by those best qualified to judge. It is already bearing practical fruits in the establishment of commercial plants, which was, after all, the primary object of the Department."

The fact that the central provinces of Canada possess no deposits of coal, added to the rapidly decreasing supply of wood, renders the use of these fuels prohibitive in many localities, and constitutes a condition that might, under certain circumstances, lead to alarming results. At present, Ontario and Quebec rely largely for their coal supply—not only for domestic but for steam purposes also—on importations from the United States. This coal is obtained from year to year, but no provision is made for such contingencies as would be presented through a stoppage of the supply.

It was in large measure through the consideration of conditions such as these, that attention was first directed to the potential importance of the abundant supplies of peat known to exist in various parts of the central provinces.

Prior to 1906, many attempts had been made, not only by private individuals, but also by incorporated companies, to place on a commercial basis the manufacture of raw peat into marketable fuel. These attempts were prosecuted persistently by some, and in a desultory manner by others; but, owing to various causes, all resulted in absolute failure, and in financial losses which were said to aggregate over $1,000,000. It may be added that, in each case, this want of success must be largely attributed to failure to adopt economic methods in reducing the very large percentage of water contained in the crude peat. Some experimenters resorted to artificial means of drying; while others endeavoured to remove the excess water by means of powerful presses. As already stated, neither of these methods proved successful; and it is now recognized that, in actual practice at the present time, both are absolutely impracticable and uncommercial.

In 1907, the men who had until then endeavoured unsuccessfully to solve the problem of commercially manufacturing peat fuel, appealed to the Government for assistance, and as a result of this appeal the attention of the Mines Branch was directed to a systematic study of the question. The aims of the investigation were, in brief:—

(1) To investigate the peat resources of Canada as to the depth, quality, and suitability of the individual peat bogs for fuel and other purposes.

(2) To actually demonstrate a process that is in successful operation in Europe.

(3) To demonstrate the economy effected in the production of power by gas producers adapted to the use of peat as fuel.

(4) To interest capital in the further development of the peat industry, and to create a market for peat.

In initiating this investigation, and in order to prevent the expenditure of money on processes which had long ago proved to be failures, advantage was taken of those results which present European practice had evolved, after half a century of experiment and research. A member of the Mines Branch staff was, therefore, commissioned to make a careful examination of the various processes and types of plants in use in the various northern European countries. Conditions governing the production of peat in these countries were compared with the conditions existing in Canada; and, based on the conclusions deduced from these observations—taking warning from the failures, and benefitting by the successes of European manufacturers—the experiments by the Mines Branch were begun.

For purposes of practical demonstration, a portion of a peat bog was purchased near Alfred, Ont., and on this bog a small peat manufacturing plant was installed. This plant represents the most economic and progressive European process—the wet process for manufacturing air-dried machine peat—and 1,300 plants of this type have up to the present been installed in Sweden and Russia. Subsequently, as the final step in the investigation, a 60 H.P. peat gas producer and gas engine were installed to demonstrate the economic production of power by this means.

Relative to the peat manufacturing investigation into the possible future of the peat industry in Canada, the references and data contained in this annual report will probably constitute the final chapter as far as the Mines Branch is concerned. The work which this Department has conducted during the past four years, has afforded a practical demonstration of the detailed working out of the method best adapted for use under Canadian conditions, and has shown:—

(1) That the production of air-dried machine peat is the cheapest and most practical method of manufacture;

(2) That by utilizing mechanical excavators, and manufacturing on a commercial scale, peat fuel for local use, or for use within reasonable distance of a bog, can successfully compete with anthracite coal.

(3) That for power purposes it has been demonstrated that peat is a most admirable fuel, and, as compared with bituminous coal, can be used with greater economy in the gas producer. The above statement is based on peat at approximately $2 per ton, and bituminous coal at $4 per ton.

In recognition of what has been accomplished toward the development of a peat fuel industry, the Conservation Commission of Canada, at its third annual meeting, held in Ottawa, passed the following resolution: "That the Commission of Conservation approves of the investigation that has been carried on by the Mines Branch of the Department of Mines in connexion with the commercial use of peat, and suggests that further investigations and experiments be made with a view to making the proposition still more attractive to the people."

It now, therefore, remains for private enterprise to place the production of peat on a purely commercial basis; for in interpreting such results and cost data as have from time to time been published by the Mines Branch, due consideration must be given to the fact that, the work has been partly demonstrative and partly experimental, and has, moreover, been carried out under Government auspices, and by trained technical officers. Under such circumstances, primary importance cannot always be given to commercial considerations. Hence, we must look to private enterprise, operating on a commercial scale, and along strictly commercial lines, to further supplement and confirm what has already been demonstrated. In the following letter, recently received from Mr. J. M. Shuttleworth, of Brantford, Ont., this fact has been recognized:—

"Dr. Eugene Haanel,
Director of Mines,
Mines Branch, Department of Mines,
Ottawa.

Dear Sir,—

Speaking for myself, and I feel that I am voicing the sentiment of many people, your department and yourself personally, deserve great credit for having shown that the manufacture of peat fuel is practicable in Canada. You have blazed the way, and it is now up to us to show its commercial possibilities."

Mr. Shuttleworth has already formed a company who have carefully examined, through their own engineers, the process employed at the Government plant at Alfred. These experts have measured the excavations, assured themselves of the output, questioned the workmen, and have come to the conclusion that this process is the most practical one in use to-day. In consequence of this examination by Mr. Shuttleworth and his engineers, the Department has been petitioned to permit the Company to install on the Alfred peat bog next spring (1912), and at their own cost, a plant in which the partial hand labour of our appliances will be replaced by machinery and power. This request has been granted by the Department, and the order for the machinery to be employed has been given. It is fully expected, therefore, that in June, 1912, a plant of 10,000 or 15,000 tons capacity will be in operation.

During the past season, operations were continued at the Alfred bog, resulting in the production of 2,100 short tons gross of peat, during a period of 93 days. Making allowance for waste and for fuel used in the plant, the net amount available for other uses was 1,800 short tons. Of this amount about 1,200 tons were sold, a large portion being shipped to various points by rail. The remainder has been stored in stacks at the bog for use at the Government Fuel Testing Station, Ottawa.

In addition to this practical demonstration work, the examination of peat bogs, in various parts of Canada, was continued. In all, some 20 bogs were visited; 17

being situated in the Province of Manitoba, and the remainder in the Province of Ontario. Descriptions of these bogs, with illustrative maps, will be found in the detailed report dealing with this subject.

## FUEL TESTING STATION, OTTAWA.

Reference was made in the Summary Report of 1910, to the installation of testing appliances and machinery at the Fuel Testing Station recently established at Ottawa, by the Mines Branch. The idea embodied in a plant of this kind is not a new one; for its economic value has long been fully acknowledged by the Mining Bureaus of other progressive Governments. Fuel testing stations or laboratories in England, Germany, France, and the United States, are, to-day, recognized assets of national importance.

The aim of such fuel testing plants is, to demonstrate in a thoroughly practical way, and by actual tests, the manner in which the various fuels, such as coals, lignites, and peats, may be most efficiently and economically applied to the development of power. To appreciate this fact, one has only to consider the wide variation in the physical properties, and chemical composition of any series of coals, even when mined in the same locality. Failure to recognize this principle can only result in low efficiency in the generation of power, and in a waste of fuel which, in the aggregate consumption of a manufacturing community, becomes a matter for serious consideration.

Generally speaking, the work of a fuel testing station is to determine the commercial possibilities of fuels, by classifying them according to their chemical analyses and heating capacity; to ascertain their amenability to mechanical purification, *i.e.*, washing; their suitability for the manufacture of coke, and finally, their adaptability for steaming purposes. The investigations to be carried on by the technical staff in the immediate future will include:—

(1) An examination of samples of shipping coals, anthracite and bituminous, from operating mines, and from newly opened deposits. Similarly, the lignites found in the Provinces of Alberta, Saskatchewan, and Manitoba, will be investigated, as to their suitability and value for the generation of steam, and for the production of power by means of the gas producer and gas engine, and

(2) Investigation of the coals imported from the United States: as regards their suitability and value for steaming and producer gas purposes.

Since by far the greater part of the coal used in the Province of Ontario is imported from the United States, any economy which may be effected through more economical methods of utilization will mean a large reduction in the amount of foreign coal imported, and, consequently, a large saving in the amount of money leaving Canada.

The method commonly employed for converting the potential energy of coal into useful work is, by burning the coal under a steam boiler, and then expanding the steam generated thereby, in a steam engine or steam turbine. This method, except in the operation of the largest and most elaborately constructed plants, is exceedingly wasteful when compared with the economy which may be attained by the use of a producer gas plant. It is, therefore, hoped that the present investigation into the behaviour of the different coals in gas producer plants, will result in a marked economy in the development of power.

The results of investigations, made along the above lines by the Fuel Testing Division of the Bureau of Mines of the United States, have proven to be of specific importance to those States, which, like Ontario, are comparatively remote from coal supplies; or which have only low grade coal, lignite, or peat. In the New England States, for example, the rapid industrial development has made the coal problem an important one, since the question of a fuel supply in that section of the United States is similar to that of the middle provinces of Canada: their coal supply being obtained from Pennsylvania, and the Virginias, while a small amount is imported from Canada. Consequently, the manufacturers of New England have to pay for transporting their fuel from distant coal-fields, and still compete with manufacturers who have coal at their doors. This condition has led to a general discussion of the coal problem in the New England States, and even to the appointment of committees of manufacturers to consider means of relief.

The following quotation from Bulletin 13 of the United States Bureau of Mines: "Resumé of Producer-Gas Investigations" will show the great value of such investigations to large users of coal for industrial purposes:—

"The investigations made by the United States Geological Survey and the Bureau of Mines, indicate that marked economies can be gained by a general use of the gas producer in New England, and moreover, that these economies will be sufficient to overcome the handicap placed on the industries there by coal transportation charges. In 1902, the coal consumed to produce steam power for manufacturing purposes in the New England States cost approximately $50,000,000, and the annual fuel bill of these states now approximates $100,000,000. The development of this power through the more efficient method suggested by these investigations would mean a yearly saving of many millions of dollars."

In order to carry out the proposed research work, it is purposed to install a commercial steam boiler equipped for experimental work in that part of the fuel testing station, at present occupied by the ore concentrating laboratory. Provision is made in the plans which have been prepared for this extension of the fuel testing plant, for a chemical laboratory sufficiently large to accommodate a staff of chemists. The duties of this staff will be to make chemical analyses and to determine the heating value of the various samples of coal, lignite, and peat collected from the various operating mines of Canada, and also of the coals imported from the United States. Large samples of these coals, lignites, and peats will be tested:—

(1) For their value for steaming purposes when burned under a steam boiler.

(2) As to their value for the production of power when used in a gas producer.

The results of these investigations will be published in bulletin form, as soon as convenient after the completion of the tests, and distributed to those interested.

In view of the fact that the Dominion Government is yearly increasing its purchase of coal for supplying the various departments, government railways, and ships of the newly created navy, it is of great importance that the Government be placed in a position to purchase this coal on an economic basis. With a view to assisting the Government in this matter, *i.e.*, in the drawing up of technical specifications which will ensure the delivery of the particular kind and quality of fuel contracted for, it is further proposed to extend the scope of the work outlined above by including the sampling, chemical analyses, determination of heating value; and, whenever desired, the testing for steam purposes, of all the coals purchased by the Government. This will necessitate a considerable increase in the technical staff at present employed, in order to include technical officers qualified to collect representative samples at the mines of the fuel purchased, and at the same time, necessitate additional assistance in the chemical laboratory for making chemical analyses.

The work of the Fuel Testing Division for the current year has, for the most part, been carried out along lines of investigation very similar to those followed during the previous year. Numerous tests were made in the Körting gas producer plant, for the purpose of determining the economic value, and commercial adaptability of peat procured from bogs in Ontario and Quebec. In the operation of the Körting gas producer, considerable difficulty was at first experienced owing to defective design. As a result, much of the tarry distillate was carried past the gas cleaning system, and, being redeposited in the engine, interfered with the operation of the plant. On this matter being referred to the manufacturers, the producer was at once overhauled, and the defect partially remedied under the direction and at the expense of the Körting Brothers. These alterations in the producer, together with modifications of the gas cleaning system subsequently devised by Mr. B. F. Haanel, have resulted in the plant giving entire satisfaction. Moreover, using the Körting producer, it has been demonstrated by means of a series of exhaustive tests, that on the bog, peat fuel at $2 per ton can successfully compete with bituminous coal at $4 per ton. An illustrated report, giving complete results and all necessary data relative to the above investigation, is now in the press, and will be issued shortly.

A recent addition to the Fuel Testing Station, consists in the installation of a Westinghouse double zone bituminous suction gas producer of 125 H.P. capacity. This producer is adapted for the use of all kinds of bituminous coals and lignites. The fuel testing plant of the Mines Branch is now, therefore, in a position to determine on a commercial scale, the relative value of all varieties of peat, lignites, and bituminous coals, when used in gas producers for power development purposes.

Gas analyses, and other determinations involved in the above tests, have been made in the chemical laboratory connected with the fuel testing station, by Mr. Edgar Stansfield.

During the field season of the present year, a careful study of a large number of peat bogs situated in the Provinces of Ontario and Manitoba, was made by Mr. A. Anrep, Jr. The manufacture of peat at the Government bog at Alfred was also resumed, under the supervision of Mr. Bengtsson. The season's operations at this bog resulted in the production of 2,100 short, gross tons, during a period of 93 days; or an equivalent of 1,800 short tons of peat containing 25 per cent moisture. A portion of this output was disposed of in Ottawa, Montreal, and in the vicinity of Alfred. The remainder was reserved for use at the Fuel Testing Station, Ottawa. Cost data relative to the above operations will be given in a bulletin to be issued during 1912.

Interim reports by Mr. Anrep, and by Mr. Stansfield, will be found in connexion with the report of the Chief of the Fuel Testing Division.

## ORE DRESSING AND METALLURGICAL LABORATORY.

During the current year, general approval of the purpose and work of the ore dressing and concentrating laboratory operated under the direction of the Mines Branch, has been expressed by the mining public. The conditions which appeared to require the establishment of such a laboratory, as well as the results which it was hoped would be attained, were referred to in the Summary Report for 1910.

A scarcity in the domestic supply of high grade iron ore on the one hand, and extensive, but as yet undeveloped deposits of low grade iron ore on the other, may, in a word, be considered as among the chief conditions which, to-day, confront the Canadian iron masters, and which determine the output of Canadian furnaces. By concentration of our low grade ores, and by the elimination of such impurities as sulphur, phosphorus, and titanium, when present in excess, it is hoped that large iron deposits, which up to the present time have been considered as of little or no value, may become profitable sources of supply for our own blast furnaces.

During the year just closed, trial shipments of low grade iron ores were received from Robertsville, Goulais river, and Culhane, in the Province of Ontario; from the Natashkwan river in the Province of Quebec; from the Gloucester iron deposits in the Province of New Brunswick, and from the Nictaux-Torbrook deposits in Nova Scotia. By means of the Gröndal magnetic separation system, tests of these ores, relative to their adaptability to concentration and purification, were carried out under conditions which approximated, as nearly as possible, those required by commercial practice. A sample of nickeliferous pyrrhotite from a deposit near Nairn, Ont., was also tested, with a view to determining the treatment best adapted for extracting the nickel and copper content.

The above work was carried out in the ore dressing laboratory of the Mines Branch under the direction of Mr. G. C. Mackenzie; and detailed results, as well as an outline of methods employed, will be found in his report. In addition to this work Mr. Mackenzie also spent a part of the field season in a systematic examination of the deposit of iron-bearing sands lying along the north shore of the St. Lawrence, near the mouth of the Natashkwan river. Previous investigations, carried on at various times by different people, resulted in a considerable divergence of opinion regarding the possible economic value of these sands. The enormous deposits which are known to exist, not only on the Natashkwan, but along the lower St. Lawrence, also, render the accurate determination of their probable value a matter of considerable importance. Consequently, a report of Mr. Mackenzie's investigations in the field, and of the subsequent concentration work in the laboratory—of a shipment of the iron-bearing sands—will be read with interest. It appears, however, that further investigation will be required to finally determine the commercial value of these deposits.

The work of the ore dressing laboratory has, during the past year, been considerably handicapped owing to insufficient accommodation; but contemplated alterations in the plant will, it is expected, greatly improve conditions in this respect.

## INVESTIGATION OF PROCESSES FOR THE REDUCTION OF REFRACTORY ZINC ORES.

In the Summary Report for 1910, the attention of the Government was called to the desirability of instituting an inquiry into modern processes for the extraction of zinc from refractory ores. At that time ample evidence was presented establishing the undoubted benefit that such an investigation, if successful, would bring to the zinc mining industry of Canada, particularly in the Province of British Columbia. In the report of the Zinc Commission, page 47, Mr. W. R. Ingalls said: "All things considered, it is probable that 15,000 tons of zinc ore of 50 per cent grade would be a liberal estimate for the productive capacity of the Slocan." Mr. Philip Argall considered that the mines of Ainsworth camp could produce from 16,000 to 30,000 tons of zinc ore per annum, which estimate, in the opinion of Mr. Ingalls, was "extremely liberal." Taking the lower figure for Ainsworth camp, there was thus indicated a possible production of about 30,000 tons of zinc ore per annum in British Columbia. However, its mines have never yet attained any such figure, their actual output in 1908 having been only 7,000 tons, Ainsworth camp not yet having become a producer at all.

This unsatisfactory condition of the industry is largely due to adverse operative and transportation conditions. Costs of production are relatively high, and the product must be shipped to smelters in the United States and Europe, in the former case being obliged to meet a hostile tariff duty and stand a long haul; and in the latter case being obliged to stand a still longer haul. These conditions have particularly delayed the beginning of zinc ore production in the Ainsworth district, where it has been found impossible to raise the grade of the zinc concentrate sufficiently high to withstand the charges.

The zinciferous ores of British Columbia are in no wise different, broadly speaking, from ores existing elsewhere, but their exploitation is rendered difficult by their remoteness from the Eastern and European markets and by various economic conditions that exist in the Rocky Mountain regions as above remarked. The problem that confronts the zinc industry of British Columba is consequently the discovery or development of some metallurgical improvement of an extent sufficient to offset these adverse conditions. Several local undertakings, conducted privately at the expense of large sums of money, having failed, the zinc producers of East and West Kootenay appealed for assistance to the Department of Mines.

In answer to this appeal, the sum of $50,000 was, in 1910, voted by the Dominion Government "for investigating processes used in the production of zinc; for making experiments and for any other purpose that may be deemed advisable for the promotion and manufacture in Canada of zinc and zinc products from Canadian ores." Thereupon, instructions were issued to Mr. W. R. Ingalls of New York, authorizing him "to inaugurate and carry through an investigation for the discovery or development of some method for the economical treatment of the mixed zinc sulphide ores of Canada, in the production of metallic zinc or a marketable zinc product." The following report, recently received from Mr. Ingalls, summarizes the results of his investigation up to the present time:—

COPY.

Walter Renton Ingalls, 505 Pearl Street,

New York, August 23, 1911.

Dr. Eugene Haanel,
Director of Mines,
Ottawa.

Dear Sir,—In compliance with your request for a report upon the progress of the zinc investigation now being conducted by the Department of Mines, I beg to present the following:—

The general plan of the investigation was fully outlined in my report to you under date of January 28, 1911, to which I beg to refer you. Since that time work has been prosecuted, especially in the field of electric smelting, this being done in the metallurgical laboratory at McGill University, Montreal, under the immediate direction of Dr. Alfred Stansfield. A large number of experiments have been made with several forms of furnaces, certain of which have been of rather elaborate construction, and with a variety of raw material.

Our early experiments were directed chiefly toward a discovery of the metallurgical conditions that have heretofore prevented a satisfactory condensation of zinc as molten spelter. While I cannot say that these experiments have afforded us a complete explanation of those conditions, they have taught us a good deal, but in spite of the knowledge acquired, we have been so far unable to master the difficulties.

We have indeed produced some small quantities of spelter, and in certain experiments have condensed a fairly large proportion as molten metal, but we have not yet been able to do that at will.

Our experiments have thrown light upon the principles of furnace design and have led us to condemn several types that we have tried. Our work has indicated that in order to achieve any material improvement over the ordinary practice of zinc smelting, it is necessary to abandon certain features of the latter and contemplate continuous charging of the ore and reduction material and discharging of the residuum without interfering with the process of distillation. These conditions introduce a multitude of perplexing difficulties that can be worked out only by tedious experimentation.

At the request of the Secretary of the Canadian Mining Institute, and with your permission, I presented at the meeting of the institute in Quebec, in March, 1911, a paper on 'The Problem of Mixed Sulphide Ores,' a copy of which I attach to this report, that concisely summarizes the state of the art in the treatment of such ores, and the natural obstacles that block procedure in certain directions.

A careful scrutiny of the work on the treatment of such ores that is being done by other metallurgists and investigators has been maintained, and I have examined numerous proposals that have been presented with more or less detail, both through your office and to me directly; but I have not discovered anything save one that in my opinion holds out any promise of successful adaptation to the conditions existing in British Columbia. I am conducting correspondence respecting this, but as to inaugurating experiments upon it, I am disposed to hold them in abeyance pending further progress in our electric work.

I regard the electric work as being of particular interest as an exploration in a virgin field of unknown possibilities. Doubtless with the same idea a great deal of work in this field is being done by numerous investigators in both Europe and America. I have been informed within a few weeks, that there are now two electro-thermic zinc smelters in operation in Scandinavia, viz., one in Trollhättan, Sweden, using about 7,000 horse-power, and one in Sarpsborg, Norway, using about 4,000 horse-power. Operations at these works were inaugurated five or six years ago, but, according to my information, the results were for several years commercially unsatisfactory, and it is only recently that it has been claimed to have become possible to make spelter from ore upon an industrial scale. The companies operating these works maintain absolute secrecy respecting them, and I have not been able to learn any details as to their operations.

Apart from the work in Scandinavia, as to the commercial success of which no information is available, the electric smelting of zinc ore is, in spite of all claims to the contrary, not only still in the experimental stage, but is in the infancy of the experimental stage. Even if the metallurgical difficulties can be overcome, which is possible, I am of the opinion that no one, except perhaps the Scandinavians, is yet in a position to make any reliable estimate of commercial advantage or commercial results in any way. It is, however, well worth while to determine the possibilities and publish the results for the general benefit, unveiling so far as possible the secrecy that is likely to be maintained as to investigations in this field by private interests, having always in mind, of course, the hope that our work may develop a process that will be commercially applicable to the treatment of the zinc ores of Canada.

Respectfully submitted,

(Signed) **W. R. Ingalls.**

## EXPLOSIVES DIVISION.

The need of a bill, authorizing the regulation—under Federal authority—of the manufacture, testing, importation, transportation, and storage of explosives in Canada, was more evident than ever during 1911.

The frequency of disasters—many of them of a preventable nature—which accompany the use of explosives in Canada to-day, cannot but impress the most casual observer of current events. The reports of the deplorable accidents that appear from time to time in the daily press, are sufficient to demand serious consideration; but the evidence annually presented in the statistical returns compiled by the Mines Branch, and the Provincial Bureaus, demands aggressive action. Therefore, realizing this to be the case, a representative of the Mines Branch was, early in 1909, commissioned to investigate existing conditions in Canada.

In 1910, the conclusions set forth in this thoroughly technical inquiry and investigation, assumed tangible form in the drafting of a Bill for regulating the manufacture, testing, importation, and storage of explosives in Canada. The aim of this proposed legislation was, to provide:—

(1) That as a result of placing all inspection and testing under Federal authority, explosives manufactured in Canada shall reach the standardization and consistency specified in the proposed Explosives Act.

(2) That after the passing of the Explosives Bill, all explosives imported into Canada shall comply with the specifications and tests indicated in the same.

The official testing of explosives at the Government Station at Ottawa, would thus raise the standard of manufacture: while the publication of the results of the regulation tests to which explosives must be submitted, would enable miners, contractors, and others, to intelligently determine the adaptability of certain explosives to specific uses under definite conditions.

The proposed Bill for regulating the manufacture, testing, importation, and storage of explosives in Canada, was formulated by the Mines Branch: acting in conjunction with the Department of Justice. This Bill went into Committee of the House of Commons on the 4th of May, 1911. It was discussed, clause by clause, and passed up to, and including, section 11: these being the most important of the twenty-five clauses contained in the Bill. Owing, however, to the dissolution of Parliament, early in July, the Explosives Bill was allowed to stand over, and has not, as yet, been taken up during the present year.

The necessity for an Explosives Act in the Dominion is manifest, and needs little comment. In adopting such a measure, Canada is following the example already set by practically every other progressive Government. In 1875, Great Britain passed an Act (38 Victoria, C. 17) to regulate the manufacture, importation, transportation, storage, and testing of explosives. While this Bill was originally concerned chiefly with the manufacture and handling of gunpowder, it has from time to time been so amended, as to include the wide range of high explosives which have subsequently been invented. Incidentally, it may be regarded as a significant fact, that the

Explosives Act of Great Britain has, during the past twenty-five years, formed the basis of similar legislation by all the European countries, as well as by South Africa, India, New Zealand, Egypt, and the Commonwealth of Australia.

Regarding the extent to which explosives are manufactured in Canada, we have no definite knowledge. Manufacturers are, at present, under no obligation to furnish statistics as to their output, the number of their employes, or the number of accidents, that occur. It may be added that, in no other country where mining and construction work is carried on to the extent that it is in Canada, does such a state of affairs exist to-day.

Canadian Customs returns indicate that, during the fiscal year ending March 31, 1911, 913,498 pounds of explosives of all classifications were imported into this country. At the present time, all these explosives—with the exception of those on the authorized and permitted lists of Great Britain—are allowed to enter Canada, and are placed in the hands of the users without having been previously submitted to any Government test as to their adaptability, chemical composition, and standardization of stability. This absence of Government supervision is, in the case of Canada, still further emphasized, when we consider the important factor of extreme climatic conditions of heat and cold, and its well-known effect on nearly all classes of explosives.

There is little doubt but that such a state of affairs is, in no small degree, directly responsible for many of the disasters resulting from the use of explosives. To more fully realize the truth of this, one has only to read paragraphs such as the following quotations taken from the Annual Report of the Ontario Bureau of Mines for 1910 and 1911. The author of these extracts is Mr. E. T. Corkill, Chief Inspector of Mines for Ontario:—

"There were last year in all twenty-four fatalities caused by explosion or from gases, or 49 per cent of the total fatalities. There is no country that publishes accurate statistics where the accidents from explosives constitute so large a percentage of the total number."—Ont. Bureau of Mines, 1910, p. 59.

"The necessity for an inspection of explosives, which can only be instituted by the Dominion government, is clearly proved by the death rate due to their use, not only in Ontario but throughout Canada."—Ont. Bureau of Mines, 1910, p. 58.

" There were sixteen fatalities resulting from the use of explosives underground and two on the surface, a total of eighteen men killed There were thirty-six men in all killed at the mines, so that explosives were responsible for 50 per cent of the fatalities. In 1910, there were ten men killed by explosives at the mines, or 27 per cent of the total number killed. It is, therefore, evident that there has been an increase of nearly 100 per cent in the fatalities from this cause.

"This condition is a matter for regret and also for censure when, on an analysis of the fatalities, we find that at least half of the accidents was the result of carelessness. In the greater number of accidents from explosives there are generally only two factors. The first is the condition of the explosive, and the second the care with which it is handled. The first cause is one over which the Inspector of Mines has but little control, and has no facilities for acquiring such control. There has never been in Canada any legislation dealing with the inspection of explosives, which is a matter coming within the jurisdiction of the Federal government. At present any one who has a substance that will explode may sell it, if he can get a buyer. Before the quality of the explosive is proven accidents may result. It is not only the small dealer who needs inspection, but also the large producers. In the competition for making sales and the desire for large profits, the grade of the explosive may not be kept up to the standard. Improper mixing, improper proportion of ingredients, improper packing, all tend to render the explosive unsafe and to increase the accident rate. Old explosives that have been in storage for more than a year are sometimes shipped into the less accessible camps in the winter time, and have to be used by the mining companies during the summer, as no others can be obtained. When an accident occurs now from an explosive, there is no way by which this explosive may be thoroughly tested, to ascertain wherein the fault lies."—Report on Mining Accidents in Ontario, 1911, p. 8.

As a result of the above consideration of the imperative need for adequate Government supervision, plans have recently been prepared for a Chemical Explosives Laboratory, which, when erected, will constitute the main building in connexion with the Explosives Testing Station of the Explosives Division of the Mines Branch. These plans, designed by Messrs. A. Dupré and Sons, chemical advisers to the Explosives Department of the Home Office, Great Britain, provide for a main laboratory 75 feet long × 35 feet wide. In this building, provision has been made for a heat test room, balance room, gas analysis room, furnace room, extraction room, nitrometer room, physical test and research room, and spectroscope room; where complete chemical, as well as certain physical tests will be applied to explosives. In design, in equipment, and in the apparatus provided, it is confidently anticipated that this laboratory will, when established, rank as one of the most complete of its kind in America. In connexion with this Explosives Laboratory, plans have also been prepared for the erection of two climatic huts. These huts will be of great importance in determining to what extent explosives may be affected by storage. Moreover, having in view the chemical reactions due to the crystallization and exudation that take place in many classes of explosives, it will be possible to demonstrate to what extent deterioration takes place in explosives stored in magazines, when affected by our varied high temperatures in summer, and extremes of cold in winter.

Correspondence, having in view the duplication at Ottawa of the Explosives Testing Station in Great Britain, has for some time been carried on with the Explosives Department of the Home Office. From this it appears that a new Testing Station has recently been erected by the British Government at Rotherham in Yorkshire. Major Cooper-Key, His Majesty's Chief Inspector of Explosives—and to whom the Mines Branch is indebted for many courtesies in connexion with the establishment of the Explosives Division—has undertaken to furnish complete detailed plans of their own Explosives Testing Station. Major Cooper-Key has, however, advised waiting until their new testing plant has been fully tried out, in order that we may have the full benefit of their experience before erecting the necessary apparatus for carrying on the work in Canada. Official information has subsequently been received from Lord Strathcona, Canadian High Commissioner in London, to the effect that details have now been sufficiently worked out by actual tests to warrant the Home Office in forwarding plans and specifications in the near future.

One of the problems in connexion with the establishment of the Explosives Division of the Mines Branch is the appointment of men specially fitted for the work. Applicants for the position of explosives chemist would, of necessity, have to be duly qualified for the chemical and physical examination of explosives, and would be required to possess a wide knowledge of the intricate details of manufacture of same, amplified by a personal knowledge of conditions as they exist in Canada to-day. It is doubtful whether, at the present time, any of our own educational institutions are in a position to furnish the training which the requirements of such a position demand. In his recent report on the explosives industry in Canada, Captain Desborough, H. M. Inspector of Explosives, remarks:—

> "The responsibility of the chemical adviser to the department will be considerable, as in his hands will rest the recommendation for acceptance or rejection of explosives. When it is remembered that the authorization of an explosive or otherwise, or the condemnation of a batch of explosives which has been issued from a factory may involve large financial interests, it is hardly necessary for me to point out that this gentleman should be possessed of the highest technical qualifications and integrity. The salary of the chemical advisers of the Home Office is entirely dependent on fees; but it would be far preferable if the chemist of the new department were paid an adequate salary so that his whole time should be at the disposal of the government."

In order, therefore, to accelerate the consideration of this question, I have consulted with Sir Francis Nathan, late Superintendant of the Woolwich Arsenal, with the result that he has kindly submitted the names of several experts whom he considers qualified to fill this position.

It is of supreme importance that special care and discrimination be taken in the selection and appointment of a Chief Inspector; for it is better to have no law at all, than one poorly administered. The duties attached to such a position demand not only a thorough and intimate acquaintance with the technology of explosives, but a conspicuous administrative and executive ability as well; for the Explosives Act, as drafted, gives only general powers, and contains scarcely any detail. Indeed it has been considered advisable to avoid as far as possible, any hard and fast regulations, since in this way scope is allowed for differences of conditions and material, and, within reasonable limits, for the interpretation of each case on its own particular merits. Under such circumstances, therefore, it is obvious that the successful administration of the Act will depend almost altogether on the ability of the Chief Inspector. Commenting on this appointment, Captain Desborough remarks:—

"I cannot state too emphatically that the chief inspector should have sufficient technical knowledge, not only to enable him to administer what must of necessity be a very technical Act, but also to deserve the confidence of the explosives manufacturers. As men possessing such qualifications are rare, I would venture to suggest that it would be very unwise to attempt to economize by offering an inadequate salary."

In conclusion, it may be mentioned that during the year 1911, four explosions in explosives factories—accompanied in each case by fatal results—have come to the attention of the Mines Branch as follows:—

(1) An explosion on April 27, in the drying house of the Dominion Explosives Company at Sand Point, in the Province of Ontario, whereby, four men lost their lives.

(2) An explosion on September 24, 1911, in a dynamite packing house of the Canadian Explosives Company at Belœil in the Province of Quebec, whereby, one man was killed. We have been informed that, of four others who were at the same time seriously injured, three have subsequently succumbed to their injuries.

(3) An explosion on October 19, 1911, in the mixing house of the Curtis and Harvey Company, of Canada, at Rigaud, in the Province of Quebec, whereby, four men lost their lives.

(4) An explosion on December 19, 1911, in the gelignite mixing house of the Canadian Explosives Company, Limited, at Northfield near Nanaimo, British Columbia; whereby, three men were killed, and three injured.

In the Summary Report of the Explosives Division by Mr. J. G. S. Hudson, will be found detailed reports of the various explosions noted above. These reports—which are based on official personal investigation by Mr. Hudson—substantiate the plea that has already been advanced, as to the necessity for immediate legislation for regulating the manufacture, testing, importation, and storage of explosives in Canada.

## DIVISION OF MINERAL RESOURCES AND STATISTICS.

The work of the Division of Mineral Resources and Statistics consists in the collection and compilation, in a form readily available for reference, of statistics of the mining and metallurgical production throughout Canada. This Division also keeps a record of all information directly affecting the country's mineral resources in general. The following statistical returns, bulletins, and reports, have been issued by the Division during 1911:—

No. 102.—Preliminary Report of the Mineral Production of Canada during the calendar year 1910.

No. 88.—Annual Report of the Mineral Production of Canada during the calendar year 1909.

No. 114.—The Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada during the calendar year 1910.

No. 115.—Production of Iron and Steel in Canada during the calendar year 1910.

No. 116.—Production of Coal and Coke in Canada during the calendar year 1910.

No. 117.—General Summary of the Mineral Production in Canada during the calendar year 1910.

During the latter part of the field season, Mr. C. T. Cartwright spent some months in British Columbia, gathering data for the proposed revision of the Report on the Mining and Metallurgical Industries of Canada (1907-8). Mr. Cartwright also secured much valuable information in connexion with the work of the Statistics Division.

The usual annual report of the mineral production during 1910 will be issued as soon as possible: but the preliminary report already published—which is included as an appendix of this report—constitutes a complete synopsis of the mineral production of Canada during 1911.

The total mineral production during 1910 is valued at $102,291,686—as compared with $106,823,623 for the preceding year. The causes which resulted in this decrease are referred to in detail elsewhere in this report.

In his report for 1910, the officer in charge of this Division referred to the desirability of a special investigation concerning the markets in Canada—among manufacturers and others—with particular reference to the numerous mineral products in various stages of refinement. It was then pointed out that, whereas considerable quantities of mineral products which have undergone some process of treatment are being imported, the crude mineral ores themselves are exported. It thus appears that a knowledge of the requirements of the Canadian consumer in this respect might be of great assistance in the development of numerous branches of our mineral industries. Recognizing the value of such an investigation, an officer of the Mines Branch spent several months during the past season in collecting data regarding actual conditions. The results of this work are discussed elsewhere in this report.

## THE VALUE OF MAGNETOMETRIC SURVEYING IN EXPLORING FOR NICKELIFEROUS PYRRHOTITE.

During the field season of 1911, a magnetometric survey was made of a small mineralized area situated in the Sudbury nickel field. This work was of a purely experimental character, and was undertaken with a view to determining the value of the magnetometer when applied to the exploration of nickeliferous pyrrhotite deposits.

The area selected for investigation was one regarding which more or less complete data had already been secured by means of diamond drilling. It was thus possible to compare the evidences of mineralization, as indicated by the magnetometer, with the actual conditions as previously determined.

The results of this work indicate that, when the ore bodies are fairly uniform in character and composition, the magnetometer will be of assistance, both in extending the known boundaries of deposits already recognized, and also in determining the existence and general extent of new deposits.

It would thus appear that exploration by means of magnetometric surveys may also be extended to any other ore deposits in which magnetite or pyrrhotite is known to be an accompanying accessory mineral. As an example of this may be cited the copper deposits of Texada island, B.C., where the copper pyrites occurs associated with magnetite.

## CHEMICAL LABORATORY.

The summary report of Mr. F. G. Wait, indicates that the work of the Chemical Laboratories has, as heretofore, been confined very largely to the examination and analyses of such minerals, ores, etc., as are deemed likely to prove of economic value and importance. A considerable number of rock analyses have, however, been also made.

Inability to secure adequate accommodation under one roof has, in the past, more or less handicapped the work of this Division. On the completion, however, of the permanent quarters now in course of preparation for the Mines Branch, the present decentralization—which until now, has resulted in the work being carried on in separate buildings in different parts of the city—will be obviated.

It may be added that the work of the Chemistry Division has grown to such an extent as to necessitate the engaging of an additional assistant chemist. Hence, not only will the new laboratory afford improved facilities in the matter of modern equipment, but it will also allow sufficient space for needed additions to the present staff of chemists.

## DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.

In another section of this report, will be found the complete financial statement dealing with the operations of the Dominion of Canada Assay Office for the year ending December 31, 1911. This statement accurately reflects conditions at present affecting our Vancouver office. It will be remembered that this assay office was established during the month of July, 1901. Owing, however, to various causes, its operations have never met with that degree of success which had been confidently anticipated. Certain regulations affecting the rates charged, and which have resulted in discrimination in favour of the United States Mint at San Francisco, must be held largely responsible for the present unfortunate state of affairs.

In the official report for 1910, issued by this Department, attention was directed to the manifest and unfair handicap under which the assay office at Vancouver has been, and still continues to be operated. The following memorandum received from Mr. G. Middleton, Manager of the Vancouver office, conveys a very accurate idea of the general conditions affecting the movement of gold bullion on the Pacific Coast:—

DOMINION OF CANADA ASSAY OFFICE,
VANCOUVER, B.C., November 25, 1911.

SIR,—I beg respectfully to submit the following particulars relative to the utility of the Assay Office, and the desirability of shipping the gold purchased at same to the Mint at Ottawa, instead of selling it to the Assay Office at Seattle or to the Mint at San Francisco.

The Vancouver Assay Office was established during the month of July, 1901, but its operations have been more or less hampered and handicapped during the greater part of its history, the charges imposed during a period dating from July 1, 1902, to June 30, 1906, being nearly double those imposed at Seattle.

The charges were adjusted on July 1, 1906, to meet those imposed at Seattle. But in the meantime it was found that gold bullion could be shipped by registered mail from Dawson to the Mint at San Francisco, where the charges were one-eighth of one per cent less on the gross value of the bullion deposited, than at this office or at Seattle, and the bullion from the Yukon was thereafter largely marketed at San Francisco instead of at Seattle.

The commercial men of Vancouver, realize and freely express the opinion that the Assay Office should be one of this city's most valuable assets, but they have also time and again expressed the opinion to me that it has been discriminated against. These opinions have sometimes been expressed in a very antagonistic mood, emphasizing the fact that such discrimination has been the means of diverting millions of dollars' worth of trade to a foreign country. The supplies required in connexion with the operation of the mines in the Yukon and British Columbia are, of course, purchased at some point on this coast, and if the output of the mines is marketed in the United States the supplies are naturally purchased there, since hams, bacon, eggs, stoves, shelf hardware, boilers, mining machinery, miners' clothing, such as overalls, boots, etc., fruits, vegetables, canned goods, etc., etc., can be imported at about the same prices (including customs duty) as they can be bought in Vancouver. There is, moreover, a certain amount of sentiment in the matter. A great many of the mine operators, both in the Yukon and British Columbia, are Americans, and unless the conditions for the marketing of their gold in Canada compare favourably with those obtaining in their native country, they naturally prefer to sell their gold and divert their trade to the country from which they hail.

I have observed that in a region where wheat is produced, the citizens establish a central wheat market or exchange at the most convenient point in that region, and that the same remark applies to cotton or wool, or any of these great staple products. But when gold happens to be the commodity, it falls to the Government to establish this market or exchange. If, however, the Government should establish that market at a point several thousand miles from the region where the gold is obtained, or discriminates against the market or exchange which they have established in that region, it would become apparent that neither course would be of much value or benefit to those immediately interested.

The United States Government has recognized the above-mentioned principle, and has established assay offices and mints in the gold producing states, so that the gold can be marketed in the region where it is obtained; and unless the same course is followed in Canada, the greater part of the output of our gold mines will continue to be marketed in a foreign country. The State of Washington is not a gold-producing state, but when gold was discovered in the Yukon Territory the United States Government, recognizing what it meant in trade, established an assay office at Seattle for the purchase of the gold. That city consequently secured the trade that accompanied the marketing of the gold: it being a recognized fact that it was the trade accompanying the marketing of the output of the Yukon gold mines, that built up Seattle. The charges imposed at our Vancouver office are now the same as those in force at the Seattle Assay Office, but the charges at the Ottawa and San Francisco Mints are one-eighth of one per cent less on the gross value of the bullion deposited than at this office. The result is that the Yukon gold output is marketed at the two latter mentioned institutions, the transportation charges on gold bullion from Dawson to Ottawa and San Francisco by registered mail being the same as to Vancouver.

There is still a large amount of bullion from Alaska deposited at the Seattle Assay Office, the Nome and Fairbanks trade being mostly in the hands of large trading and banking concerns which have their headquarters in Seattle. These companies consequently market the gold, which they have gathered in trade, at the Seattle Assay Office, and the small mining operators in the region where these big concerns operate naturally follow the lead of the big commercial concerns. This makes the volume of business transacted by the Seattle office, including the bullion received from this office, sufficient to warrant their operations being published regularly.

By adjusting the charges so that they would be the same as those imposed at the Ottawa and San Francisco Mints, this office, in my opinion, could be made a most valuable asset and an institution of which the citizens would be justly proud. Moreover, the benefit accruing in the way of trade and financial prestige, would far outweigh any expense incurred. This office brings considerable trade to Vancouver with its present limited operations, but gold shipped direct to the Mint at Ottawa from the Yukon or British Columbia might as well be shipped to Philadelphia or to the Royal Mint in London, as the trade and financial prestige that should accompany the primary marketing of the gold, would be scattered instead of being centred in the region where the gold is obtained. All gold, however, purchased by this office should, in my opinion, be shipped to the Mint at Ottawa, as it might be considered as an evidence of weakness to be marketing the output of our gold mines in a foreign country, instead of refining and minting it in Canada and thereby realizing a handsome profit in seigniorage on the silver contained in the bullion. This office has been paying 47 cents per standard ounce for silver during the whole of this season, and if we purchased bullion in the course of a season to the value of $5,000,000, there would be a gross profit of $45,385 in seigniorage on the silver contained in same, that is, provided the Government refined and coined the bullion.

Five million dollars value of bullion, at $16 per ounce, would represent 312,500 ounces of bullion; and 18 per cent of the bullion being silver (that being a fair average) would give 62,500 standard ounces of silver. This amount, at 47 cents per standard ounce, would be equivalent to $29,375. Therefore, since a silver dollar piece (United States) contains 0·836 standard ounce silver, it follows that 62,500 standard ounces, which cost $29,375, would make $74,760, leaving a gross profit on the transaction of $45,385. From this sum there would only be the expense of insurance on the bullion in transit, refining, and minting to deduct. In selling the bullion purchased by this office to any of the different institutions in the United States, we merely get what we pay for it, the United States Government making the seigniorage profit on the silver contained in the bullion.

Considering that the banks, or in fact anyone, can ship gold bullion by registered mail from the Yukon Territory and British Columbia to the Ottawa Mint, I presume the same privilege would be extended to this office, the only difference being that it would not be necessary for this office to put postage stamps on the parcels of bullion. Instead, such parcels would be mailed "O.H.M.S.," insured, the rate of insurance being 35 cents per thousand dollars value on gold bullion by registered mail Vancouver to Ottawa.

Looking at the whole matter from a constructive and a progressive standpoint, and with the view of strengthening our institutions, there would appear to be only one course to pursue, viz., that the primary market for the gold obtained in the Yukon Territory and British Columbia, should be at the most convenient point in the region where the gold is obtained. As it was decided many years ago that Vancouver should be that point, and an Assay Office established there accordingly, it only remains to adjust the charges imposed at that office, so that it will serve the purpose for which it was established.

I am, Sir,

Your obedient servant,

(Signed) **G. Middleton,**

*Manager.*

As intimated by Mr. Middleton, the commercial men of Vancouver have time and again protested on the ground that this discrimination in assay rates has, by favouring a United States institution, been the means of diverting a very large trade with northern ports to a foreign country. Official utterance is given this sentiment in a recent communication from the Board of Trade of the city of Vancouver:—

VANCOUVER BOARD OF TRADE,

VANCOUVER, B.C., November 17, 1911.

The Honourable the Minister of Mines,

Ottawa.

SIR,—By instruction of the President, I have the honour to advise you that the Board is informed that the charges on gold assayed at our local Assay Office being one-eight of one per cent higher than the charges made in San Francisco and also in Ottawa, the result is, that less than one-fourth of the gold produced in the Canadian Yukon comes to Vancouver and by much the heaviest consignments from Dawson go to San Francisco.

This cannot but be detrimental to our local business interests as the rule always has proved itself true, that trade follows the gold.

In the interests of our city, this Board would, therefore, respectfully request that you may be pleased to look into the matter and, if our information be correct, may so direct that the Vancouver Assay Office be placed on an equality with the other offices named.

I have the honour to be, Sir,
Your obedient servant.
(Signed) **W. Skene.**
*Secretary.*

In conclusion, I would again call attention to my own memorandum of December 5, 1911, dealing with the above question:—

*Memorandum:*

OTTAWA, December 5, 1911.

Honourable W. B. NANTEL, M.P.,
Minister of Mines.

In further reference to the letter from the Secretary of the Vancouver Board of Trade relating to the charges made on deposits at the Dominion of Canada Assay Office, Vancouver, B.C., I have the honour to enclose a copy of a memorandum on this subject, submitted to me at my request, by the Manager of the Assay Office. This memorandum deals also with the utility of the Assay Office and the desirability of shipping the gold purchased at same to the Mint at Ottawa instead of selling it, as has been our practice, to the Assay Office at Seattle, or to the United States Mint at San Francisco.

In view of the facts presented by the Manager, and those ascertained by myself and reported upon in my Summary Report for 1910, page 20, I strongly recommend that, as regards charges, the Assay Office at Vancouver be placed in the same position for the purchase of gold as the United States Mints and the Mint at Ottawa, by abolishing the charge of one-eighth of one per cent on the gross value of the deposit. This charge was adopted to defray, in part, the expenses and maintenance of the Assay Office.

I further recommend that gold hereafter purchased at our Assay Office, Vancouver, B.C., be sent to our own Mint at Ottawa, and that advantage be taken of the present system of shipping the gold from Vancouver to Ottawa by registered mail.

The charges at present exacted were authorized by Order-in-Council, dated May 10, 1906, and are as follows:—

"The charges to be made on each deposit after assays to be as follows:—

On gold on which royalty has been paid:—

1st charge: Assaying and stamping charge: $\frac{1}{8}$ of 1 per cent on the gross value of the gold and silver contained in the deposit.

2nd charge: Parting and refining charge: 4 cents per ounce of the weight after melt.

3rd charge: Toughening and alloy charge: 2 cents per ounce on $\frac{1}{11}$ of the standard weight of gold contained in the deposit.

*a*. In paying for silver,* $\frac{1}{99}$ of the standard weight of the gold to be deducted from the gross standard weight of the silver contained in the deposit. (This deduction is to cover loss in converting silver from solution.)

b. On gold on which no royalty has been paid an additional charge of one dollar on each melt is to be exacted."

The recommendation of discontinuing one of the charges, relates to the first charge. The other charges are Mint charges to defray expenses incurred at the Mint in preparing the crude gold for coinage and alloying with copper.

In provision "b", a concession is made to depositors who have paid a royalty on their gold to the Department of the Interior on Yukon gold, by omitting the charge of one dollar on each melt.

Respectfully submitted.

(Signed) **Eugene Haanel**,
*Director of Mines.*

## INVESTIGATION OF THE CANADIAN MARKET FOR VARIOUS MINERAL PRODUCTS IN A CRUDE OR PARTIALLY-PREPARED STATE.

Mr. Fréchette was engaged during the field season, in collecting data from manufacturers in the Provinces of Ontario and Quebec, concerning the minerals used by them with special regard to the quantity, quality, and present source of supply. The ultimate object of this investigation is, to still further encourage the use of Canadian minerals; to point out to the producers the requirements of the domestic market; and to indicate the form in which the minerals should be prepared for use in the various industries in which they are to be employed.

In the course of this inquiry, Mr. H. Bradley acted as assistant to Mr. Fréchette. During the season, sixty-nine towns and cities were visited in the Province of Ontario, and twenty-five in the Province of Quebec.

## BITUMINOUS SHALES OF NEW BRUNSWICK.

It is to be regretted that, as yet, active development of the bituminous shales of the Province of New Brunswick, has not been commenced. Although the existence, and to a certain extent, the value of these deposits, have been recognized for many years, all attempts to establish a mineral oil industry have, in the past, ended in failure. This failure may be considered as having been due, in part, to an imperfect knowledge of the chemistry of the shales themselves, and partly to an attempt to utilize machinery which was quite unsuited for the purpose to which it was applied. Finally, the discovery of the Pennsylvania oil wells, in the early sixties, ended what had always been a struggling industry.

In 1908, therefore, a thorough and systematic investigation into the economic possibilities of these shales was initiated by the Mines Branch. As a result, not only were the shale deposits in New Brunswick carefully examined, but a Commission was dispatched to Scotland—the recognized home of the oil-shale industry. This Commission made a comprehensive study of the Scotch deposits, correlating them with the Canadian shales, and reported fully on the economic aspect, and technology of the oil-shale industry.[1] On practically every point this report was favourable to Canadian shales. Particularly favourable conditions appeared to control the manufacture and marketing of the products of such an industry. The conclusions, based on the investigation of this Commission, were eminently satisfactory.

This report has now been in the hands of the mining public for upwards of two years; but unfortunately up to the present time, conditions quite apart from economic considerations—and not related in any way to the real value of the shales themselves—have retarded actual development in the New Brunswick areas. It is

* Bituminous or oil-shales of New Brunswick and Nova Scotia, by R. W. Ells, LL.D., F.R.S.C., Mines Branch, Department of Mines, Ottawa, 1910. (No. 55).

reported, however, that the control of the greater part of these shale deposits has recently passed into the hands of strong and responsible financial interests, and it is confidently anticipated that the work of development will shortly be commenced on an extensive scale.

As the source of an ideal producer of heat, light, and power, the value of these deposits of oil-shale is very great. This is especially true when we consider the rapidly growing demands for liquid fuel as applied to marine transportation. Moreover, in its chief by-product, sulphate of ammonia, it has an even more important and a wider application among the agricultural interests of this country and, recently, attention has been directed to the economic utilization of the "spent shale" from the retorts, *i.e.*, the shale from which the valuable volatile constituents have been already distilled.

Situated more or less conveniently with regard to the beds of oil-shale, are deposits of gypsum, limestone, and clays of various kinds. Thus the possibility of utilizing the "spent shale" in combination with the gypsum and lime for the manufacture of Portland cement, at once suggested itself. Consequently, samples of these various materials were submitted by the Mines Branch to a cement expert, Mr. Richard K. Meade, of Pittsburgh, Penn. Results of Mr. Meade's analyses and determinations are given herewith. It is to be regretted that localities from which certain of the samples were taken are not more specifically indicated.

"The materials investigated consisted of the following samples:—

*Limestone*—Marked "No. 2 joining Albert Mines on the south side."
*Limestone*—Marked "No. 3 N.E. of Albert Mines prop."
*Limestone*—Marked "McHenrys."
*Limestone*—Unmarked.
*Oil-bearing shale*—Albert Mines property.
*Clay*— " "
*Gypsum*—Quarries of Albert Mfg. Co., Hillsborough.

*Analyses.*

All of the above materials were first subjected to a careful chemical analysis the results of which follow:—

| | Per Cent. |
|---|---|
| (1) *Limestone*—No. 2, joining Albert Mines on south side. | |
| Silica | 12·08 |
| Iron oxide and alumina | 3·52 |
| Carbonate of lime | 81·60 |
| Carbonate of magnesia | 2·29 |
| (2) *Limestone*—N.E. of Albert Mines prop. No. 3. | |
| Silica | 7·42 |
| Iron oxide and alumina | 2·82 |
| Carbonate of lime | 88·15 |
| Carbonate of magnesia | 1·36 |
| (3) *Limestone*—McHenry. | |
| Silica | 1·04 |
| Iron oxide and alumina | 0·64 |
| Carbonate of lime | 98·43 |
| Carbonate of magnesia | 0·26 |
| (4) *Limestone*—Unmarked sample. | |
| Silica | 18·82 |
| Iron oxide and alumina | 6·42 |
| Carbonate of lime | 71·07 |
| Carbonate of magnesia | 2·53 |
| (5) *Oil-bearing shale.* | |
| Silica | 30·31 |
| Iron oxide | 4·46 |
| Alumina | 11·52 |
| Lime | 6·06 |
| Magnesia | 3·48 |
| Volatile matter (oil, etc.) | 38·38 |

(6) *Clay.*

| | Per Cent. |
|---|---|
| Silica | 75·44 |
| Iron oxide | 3·45 |
| Alumina | 11·41 |
| Lime | 0·89 |
| Magnesia | 1·05 |

(7) *Gypsum.*

| | |
|---|---|
| Silica | 0·34 |
| Iron oxide and alumina | 0·18 |
| Lime | 32·27 |
| Magnesia | 0·07 |
| Sulphur trioxide | 46·69 |
| Loss on ignition | 20·80 |

"These analyses indicate that satisfactory Portland cement can be made from a combination of any one of the first three limestones, and the residue from the oil-bearing shale. The fourth sample of limestone does not contain enough carbonate of lime to be used with the residue from the oil-bearing shale; but it could be employed with either of the first three limestones to make Portland cement. For instance, a mixture of 100 parts of this limestone, and 17 parts of the No. 3 (McHenry's) limestone, would make excellent Portland cement. The clay is too high in silica and too low in alumina to be employed satisfactorily for the manufacture of Portland cement. The gypsum is very pure, and is very suitable for use as a retarder of the setting time of Portland cement.

"As I understand that the purpose of this investigation is to determine the suitability of the residue from the oil-bearing shale for Portland cement manufacture, and as the quantity of limestone No. 2 was greater than that of any of the other limestone samples, I made a trial lot of cement from these two materials and applied the usual tests to this cement. Details of this experiment follow.

### *Experimental Manufacture of Cement.*

"The shale was first crushed roughly and ignited at a red heat until all the oil was expelled. It would be chemically possible to make cement from the oil-shale as it is mixed, but it would be very hard to grind the shale and limestone mixture if the former contained the oil. It would, of course, also be more advantageous from economic reasons also to first distill off the oil owing to the value of the latter. The residue from the oil-shale had the following composition:—

*Analysis of the Oil Shale Residue.*

| | Per Cent. |
|---|---|
| Silica | 49·58 |
| Iron oxide | 7·30 |
| Alumina | 18·84 |
| Lime | 9·91 |
| Magnesia | 5·69 |

"The shale oil residue and the No. 2 limestone were mixed in the following proportions:—

Limestone, 100 parts by weight.
Shale oil residue, 16½ parts by weight.

"The mixture of the two was next ground until 95 per cent of it passed through a test sieve having 100 openings to the linear inch (a No. 100 cement test sieve). The chemical composition of the pulverized mixture was then checked and found to agree with the following calculated figures:—

*Analysis of the Pulverized Mixture.*

| | |
|---|---|
| Silica | 13·38 |
| Iron oxide | 1·82 |
| Alumina | 4·29 |
| Lime | 43·80 |
| Magnesia | 1·38 |

"The chemical composition of the mix having been proved to be satisfactory the mixture was burned in a small experimental kiln, which was kept at the same temperature as is employed in industrial rotary kilns of 2500° to 2700° F. After cooling, the resulting clinker was mixed with 2 per cent of the gypsum, and ground to the same degree of fineness as is employed in commercial work. The analysis and tests of the resulting experimental cement follow:—

*Analysis and Tests of Experimental Cement.*

ANALYSIS.

| | |
|---|---|
| Silica | 21·36 |
| Iron oxide | 3·05 |
| Alumina | 7·01 |
| Lime | 63·56 |
| Magnesia | 2·05 |
| Sulphur trioxide | 1·12 |
| Loss on ignition | 1·18 |

TESTS.

*Fineness* (Standard cement test sieves)—
Passing No. 100 test sieve .......... 95·1
" " 200 " .......... 81·6

*Setting time* (Gilmore's needles)—
Initial set, 2 hours and 15 minutes.
Final set, 5 hours and 45 minutes.

*Soundness* (Thin edge pats)—
Boiling test, 5 hours, perfect.
Steam test, 5 hours, perfect.
Air pat, 28 days, perfect.
Cold water pat, 28 days, perfect.
Specific gravity—3·21.
Tensile strength.

| | | | | | |
|---|---|---|---|---|---|
| Time in air | 1 day | 1 day | 1 day | 1 day | 1 day |
| Time in water | O | 6 days | 6 days | 27 days | 27 days |
| Total age | 1 day | 7 days | 7 days | 28 days | 28 days |
| Composition | neat | neat | 1 : 3 sand | neat | 1 : 3 sand |
| Pounds per | 330 | 650 | 245 | 815 | 315 |
| square inch | 315 | 670 | 260 | 825 | 335 |
| Average | 313 | 660 | 253 | 820 | 325 |

CONCLUSIONS.

"The above tests show that a high grade Portland cement can be made from the oil-shale by mixing with the same, limestone of the character of the samples which I received marked (1) 'No. 2 Joining Albert Mines on south side.' (2) N.E. of Albert Mines property No. 3, and (3) 'McHenrys.'"

## INVESTIGATION OF METALLURGICAL PROBLEMS OF ECONOMIC IMPORTANCE.

It is generally conceded that the phase of Mines Branch operations which may be described as *original research work*, constitutes one of the most important features of departmental activity. As a recent illustration of the great practical value of such research work, in general, may be cited the success that has recently attended the electro-thermic production of pig iron in Sweden. As a result of this success—which is only one of the many instances which might be mentioned—it is confidently believed that electric furnaces will entirely supersede the charcoal furnaces of Sweden. To pioneer investigation by the chemist, the metallurgist, and the physicist, may be attributed the very great progress which is, to-day, synonymous with modern industrial development. Thus, such questions as the application of new methods of metallurgical treatment, and the discovery of new uses for our minerals themselves, are clearly of very real importance to the mining industry of the Dominion

An example of the practical results that may be anticipated from such research work, is presented in connexion with the conditions which at present govern the marketing of Cobalt ores. Canada is now, practically, the sole producer of cobalt ore; the cobalt content of the ores mined in the Timiskaming district exceed 2,000,000 pounds per year. The market for this, at present, depends altogether on its limited use as a blue colouring substance. Hence there is a large accumulation of cobalt oxide at the smelters and at the Cobalt camp. Under present industrial conditions, the smelters refuse to pay for the cobalt and nickel content; consequently, the miner receives nothing for this valuable constituent of the ore. Yet the metal cobalt resembles nickel in almost all its properties. Its density, malleability, ductility, hardness, tensile strength, and electrical properties are, so far as they are known, very similar to those of nickel.

These properties of nickel make it of remarkable industrial value in the composition of a great variety of alloys. Of these may be mentioned the high grade steels, where toughness and hardness are desired: for automobile parts, steel tubes, gun steel, cranks and crank-shafts, boiler plates, tires, connecting rods and axles; the nickel-iron wires such as "Invar" and "Platinite," with low temperature coefficients of electrical resistance and of expansion respectively; and the variety of important nickel alloys with non-corrosive properties, for coins, boat propellers, etc.

It would be surprising if cobalt could not be advantageously substituted for nickel to produce a better grade of some of the above products. As these are high grade products, where superior qualities are desired, a high cost, within certain limits, would not be prohibitive. Hence, if research leads to the substitution of cobalt for nickel, even in the case of one of these products, a market for the metal cobalt at a reasonable price would be assured, and large sums of money would be annually added to the returns from Canadian natural resources. With a fair market for cobalt, certain silver-cobalt ores, too lean in silver to be worked at present, might be profitably smelted. The indirect value of an increased market for cobalt is incalculable.

Again, there are, of course, an endless number of possibilities of discovering cobalt-containing alloys, not analogous to nickel-containing alloys, but with valuable commercial properties.

As already noted, cobalt is essentially a Canadian product, hence it is not surprising that foreign investigators have not interested themselves particularly in this field. Up to the present time, very little original work for the purpose of discovering new industrial applications for such ore, has been done. And, realizing that anything which adds to our knowledge of the properties of cobalt and its alloys will be of ultimate value in the development of the industrial resources of the Dominion, and concentrating special attention on alloys which have the promise of immediate commercial use, the value of a comprehensive experimental investigation of the kind indicated, becomes obvious.

Having in view, therefore, practical considerations of far reaching importance such as the above, the Mines Branch recently took steps to further extend the scope of its technical activity. The present crowded condition of our existing laboratories, however, and the impossibility of arranging for suitable accommodation for carrying on research work at Ottawa led the Department to look elsewhere for temporary quarters. Consequently, early in 1910, an arrangement was entered into with the Board of Governors of the School of Mining at Kingston, the general terms of which were as follows:—

(1) That the School of Mining undertake to carry on for the Mines Branch, metallurgical investigations of a directly economic character, and such as may commend themselves to the Director of Mines and the Minister.

(2) That the School of Mining undertake to secure for such work a competent man having as high qualifications as the salary offered will command, and that this officer shall devote his time exclusively to the work of investigation, and shall not be called on to do any teaching in the School of Mining.

(3) That all expenses of the investigations, including salaries, materials, a fair allowance for use of laboratories, and cost of special apparatus required, are to be paid for by the Department of Mines.

(4) That the results of such investigations are to be promptly reported to the Mines Branch, and are not to be used or published otherwise without the permission of the Director of Mines. The consideration of mutual advantage implies that, in the publication of such reports, the fact is made plain that the work was done at the School of Mining, and that it was done for the Mines Branch.

(5) That the metallurgist appointed, report on the metallurgical processes practiced in Canada; render himself conversant with all new developments in metallurgical methods on this continent and abroad; report upon the same; and recommend for special investigation such of these processes as would tend to a more economical treatment of our ores. For this purpose it will be necessary that part of the appropriation for this Research Laboratory be expended in subscribing for all important metallurgical journals; that an annual résumé of all new developments in metallurgy be prepared by the metallurgist, with his criticism and recommendations, for publication in the Summary Report of the Mines Branch.

Various delays have, up to the present, intervened, and have prevented the actual commencement of the above work for upwards of two years. Arrangements recently completed, however, have proved entirely satisfactory, and experimental work is to commence in April, 1912.

Dr. Herbert T. Kalmus, formerly Professor and Research Associate at the Massachusetts Institute of Technology, Boston, and recently Professor at the School of Mining, Kingston, has been appointed to engage in these investigations, and to be Director of the Research Laboratories at the School of Mining for the Mines Branch.

The following programme has been drawn up, and includes investigations which should prove of value to the mining industries of Canada. Dr. Kalmus and his assistants have commenced work on the investigations under captions I, II, and IV, while it is expected to start the investigation under caption III as soon as I is well in hand.

CHARACTER OF INVESTIGATIONS SPECIFIED.

I. An Experimental Investigation of the Metal Cobalt and its Alloys.

II. A Study and Report on the Present Status of the Cobalt Industry.

III. An Investigation of Nickel-Copper-Iron Alloys.

This experimental investigation is to be conducted along similar lines, and with much the same equipment, as the investigation on cobalt alloys. Certain American investigators have claimed that nickel and copper together, in the proportion in which these elements are found in the Sudbury ores, give valuable properties to steel. This subject should be investigated; for if this affirmation be found correct, it might lead to the production of high grade steel, cheaply and directly from Canadian ores, thus using the iron content as well as the nickel and copper.

IV. A Report on the More Recent Advances in the Application of Electro-thermic Processes to the Smelting of Iron Ores and the Making of Steel.

The last named investigation (IV) is educational, economic, and statistical, rather than experimental; and is for the purpose of bringing the various reports of the Mines Branch—which have treated of this subject exhaustively in the past—up-to-date. The pioneer work done by the Mines Branch in connexion with the application of the electro-thermic process to iron and steel manufacture, and the commercial applicability of this method to Canadian conditions, have already been carefully set forth in the publications of the Mines Branch.

During the past two years—as pointed out elsewhere in the present report—electric furnaces have been in active operation at numerous iron and steel plants on the continent, and in the United States, of which much added information and new data have been obtained. Almost every number of the leading electro-chemical or metallurgical journals contains contributions bearing on this work. The results point uniformly to the probability of a remarkable increase in the use of electro-thermic methods in the iron and steel industries in the near future. The purpose of the proposed investigation is, to review these reports, articles, and papers; to summarize and deduce from them such conclusions as may be of educational, industrial, statistical, and economic value, to those who are already engaged, or about to be engaged, in the iron and steel, or allied industries, in Canada.

## IRON.

*Mr. E. Lindeman* continued his investigation of the iron ore deposits occurring in territory tributary to the Central Ontario railway, in the counties of Hastings and Peterborough. During the field season, some seventeen more or less developed mines and prospects were visited, and magnetometric and topographic surveys made of such properties as appeared to warrant detailed examination.

Mining activity in connexion with the development of these deposits, has been carried on intermittently since 1820. Results in the past have, however, with few exceptions, been rather disappointing. This may be attributed in part to the high sulphur content of the ore, and also to the irregular mode of occurrence, typical of the ore bodies themselves. But, while many of the iron deposits in this district are undoubtedly of little or no value, results of the past season's investigation, carried on by means of magnetometric surveys, have shown that there are at least five properties which appear sufficiently promising to warrant further exploration. These properties represent a probable ore-bearing area aggregating approximately seventeen acres.

It is evident, however, that all these ore-bodies distinctly constitute a concentrating proposition. Failure in the past to recognize this feature must, to a considerable extent, be held responsible for previous lack of success.

In addition to the work in Hastings and Peterborough counties, an examination was also made by Mr. Lindeman of certain occurrences of iron ore situated in Renfrew county near Calabogie. Mining operations in this district were begun in 1881, and have subsequently, at irregular intervals, been continued on the various properties. During this period, upwards of 35,000 tons of good quality, non-bessemer ore have been shipped.

For the most part these ores carry over 50 per cent metallic iron, are low in sulphur, and are conveniently situated as regards shipping facilities. On the other hand, however, the ore bodies are extremely irregular in character, and of such limited extent as to preclude all likelihood of their ever becoming iron producers of importance.

## COPPER AND PYRITES.

*Dr. Alfred W. G. Wilson*, during the early part of 1911, was occupied in gathering material for a special report on pyrites and its uses. During the month of January, a number of the larger chemical works in Canada and the United States were visited, for the purpose of studying the various types of roasting furnaces in operation. Inquiries instituted regarding the market requirements of the various chemical industries, together with such trade returns as are embodied in Dr. Wilson's report, indicate in general the commercial and mining conditions under which the pyrites industry is at present conducted in Canada. A review of the production of pyrites during the past five years, establishes the fact that Canadian operators have more than held their market. Compared, however, with many other branches of mining activity in Canada, the rate of increase as indicated by greater tonnage of shipments, has been comparatively small. A consideration of Dr. Wilson's report appears to indicate that, with a more careful study of existing market conditions in the United States, there still remains room for a very considerable expansion in the export of Canadian pyrites. Exigencies beyond the control of the Department have somewhat delayed the publication of this report, but it is hoped that it will be available for distribution early in 1912.

During July, Dr. Wilson paid a short visit to the works of the General Chemical Company, at Sulphide, Ontario, and to the pyrites mines in that vicinity.

On July 19, Dr. Wilson left for British Columbia in the continuation of his investigation of the copper industry of Canada. The wide scope and many phases of an investigation dealing with questions of the magnitude of those presented by the copper industry, require no comment. The publication of Dr. Wilson's work will render available to the mining profession and to the general public, the latest and most complete information available with respect to the Canadian production of copper.

## NICKEL.

*Dr. A. P. Coleman* was occupied during a greater part of the field season of 1911, in revising the existing geological map of the Sudbury district, and in gathering material for the preparation of a complete monograph on the nickel industry, with special reference to the Sudbury region. Having been engaged during the two previous summers on behalf of the Canadian Copper Company in a geological study of several of their most important working mines, Dr. Coleman had already had ample opportunity to familiarize himself not only with the geology of the district, but also with the various aspects of mining methods and of metallurgical treatment. Moreover, through the courtesy of the Canada Copper Company, Dr. Coleman has been enabled to make use of much of the material obtained while in their employ. Without these additional data, the results of a single season's work must necessarily have been much less complete.

It is now anticipated that the above monograph will be ready for publication early in 1912. The following are the more important topics which will be discussed:—

(1) General account of the topography, means of communication, etc., with a historical sketch of earlier development.

(2) General description of the ores and their relationship to the enclosing rocks, including surface features and methods of prospecting.

(3) Account of the distribution, size, and importance of the various ore-bodies, both marginal and those belonging to offsets.

(4) Description of all mines which have been worked, with reference to methods of mining employed.

(5) Reference to economic minerals of the interior basin.

(6) Other Canadian nickel deposits; reference to nickel ores of the United States, Europe, and New Caledonia.

(7) Mechanical treatment of Sudbury ores, including magnetic separation and hand-picking; also metallurgical treatment of ore in the reduction of matte, including roasting and smelting as well as a description of the recent improvements at Copper Cliff.

(8) Accounts of methods of refining based on study of working plants; also text of various patents relating to the separation of nickel and copper and the refining of nickel.

(9) Statistics of nickel and copper production.

(10) Account of uses of nickel, of monel metal, of German silver, and of nickel in steel.

(11) Account of precious metals, gold, silver, platinum, palladium, etc., associated with nickel ores.

In connexion with the above work, the first part of the summer of 1911 was occupied in visiting the various nickel-producing centres of the old world, with the object of making a comparative study of conditions affecting mining and metallurgical operations. Dr. Coleman, however, reached Sudbury early in July, and completed his work in that district about the first of October.

Considering the great extent of these nickel-copper deposits, together with the high values carried by the ore itself, Dr. Coleman's report, apart from its undoubted value as a work of reference, appears to furnish ample evidence of large and long continued production from the mines of the Sudbury district.

## PHOSPHATE AND FELDSPAR.

*Mr. Hugh S. de Schmid,* during the greater part of the summer of 1911, was engaged in gathering and in compiling data for a monograph on mica. This monograph—which is expected from the press shortly[1]—supersedes and revises to date, the information contained in the bulletin previously issued by the Mines Branch in 1905.

On the completion of the above work, Mr. de Schmid devoted the remainder of the season to a preliminary study of conditions governing the production of phosphate and feldspar in the Provinces of Ontario and Quebec. Regarding the production of phosphate, the conclusions arrived at by the writer establish beyond doubt the fact that, in competition with foreign production, the phosphate properties of Ontario and Quebec cannot, for the present at least, hope to successfully compete. This conclusion is based not only on a consideration of the general mode of occurrence, but on the general mining conditions governing the working and development of Canadian deposits.

Regarding the production of feldspar, it is shown that practically the whole output—which represents not only the production of Ontario and Quebec, but that of the whole Dominion—is at present derived from the Province of Ontario. This production, while not large, about holds its own from year to year in competition with the larger deposits of the lower grade spar of the United States.

With the above report also appear tabulated statements indicating the relative importance of the phosphate and feldspar industries in Canada and in the United States.

## BUILDING STONES.

*Professor W. A. Parks,* of the University of Toronto, has, during the season of 1911, continued his examination of the building and ornamental stones of Canada. During the summer of 1910, Dr. Parks confined his attention to stones of the Province of Ontario, and the published report of this work is expected from the press shortly. During the present field season this detailed examination was extended to the Maritime Provinces, and to a part of the Province of Quebec. The results of this work will furnish not only descriptions of the different varieties of stone produced in the various localities, but also references to transportation facilities and other conditions affecting production. There is, in the Provinces of New Brunswick and Nova Scotia, a very considerable number of quarries, which were at one time large shippers, but which, owing to various causes, are at present lying idle. Professor Parks has, therefore, given special attention to a study of those circumstances which have adversely affected the stone-working industry.

After completing the work in Nova Scotia, New Brunswick, and Prince Edward Island, Dr. Parks' investigation was further extended to that part of the Province of Quebec lying to the north of the St. Lawrence river.

During the progress of the field work, numerous samples of stone, typifying the production of each locality, were collected. These samples are now being subjected

[1] Published July 10, 1912.

to the various tests for determining the physical and chemical properties, in order to accurately ascertain the particular uses to which each variety of stone may be most economically applied.

It is the intention of this Department to include in the present investigation all the provinces of the Dominion, the data so gathered to constitute a monograph on the building and ornamental stones of Canada. It is, moreover, anticipated that this work will prove of special value to builders, contractors, and others by indicating those localities in which each particular variety of stone may be most readily obtained.

## GYPSUM AND SALT.

*Mr. L. H. Cole* spent the field season in a study of the principal deposits of gypsum and salt in Ontario and in western Canada. Apart from a careful investigation of the mode of occurrence and probable extent of the gypsum beds, Mr. Cole also gathered information concerning mining and milling operations at present being carried on in connexion with the gypsum industry.

The production of gypsum in Ontario is, at the present time, derived chiefly from the well-known deposits occurring along the Grand river, between Cayuga and Paris; while the extensive beds situated near Lake St. Martin constitute the main source of supply in the Province of Manitoba. During the present year, British Columbia appeared for the first time as a producer of gypsum, deposits in that Province occurring at Spatsum, at Merritt, near Grande Prairie, and also on Granite creek near Tulameen. Little actual development has, up to the present, been done on any of these gypsum properties. Considering, however, the satisfactory quality of much of the gypsum, the apparently large tonnage available, and the large and increasing demand for this mineral and its derivatives, there is reason to anticipate in the near future, a considerable development in connexion with the gypsum deposits of British Columbia.

The salt beds occurring in the counties of Essex, Lambton, Huron, and Bruce, at present constitute the salt-producing area in Canada. Besides references to the various localities which were visited in this area, the writer also briefly describes the chief evaporating processes adopted by the different companies operating in this field.

The above report, which includes numerous analyses of samples from different localities, furnishes a general review of the gypsum and salt industries of middle and western Canada.

In conclusion, trade statistics are cited to establish the fact that an excellent opportunity exists for the development of a soda industry in connexion with the evaporation of brine from the wells.

## OIL AND GAS DEVELOPMENT IN ALBERT AND WESTMORLAND COUNTIES, NEW BRUNSWICK.

During the year 1908, Maritime Oilfields, Limited, of London, England, acquired control of certain oil and gas leases formerly held by the New Brunswick Petroleum Company, Limited. Under this new control a comprehensive programme was at once inaugurated, and the work of boring for gas and oil in Albert and Westmorland counties energetically prosecuted. The gratifying results which, up to the present time have attended drilling operations, especially in Albert county, should prove an important factor in the industrial development of those parts of Nova Scotia and New Brunswick within reach of the producing wells. The following information relative to the operations of the Maritime Oilfields, Limited, has been furnished this Department by Mr. O. P. Boggs, General Manager of the operating company.

## Summary of the producing wells[1] drilled by Maritime Oilfields, Limited, in Albert and Westmorland Counties, New Brunswick.

| Well No. | Elevation above sea. | Thickness, oil sands. | Thickness, gas sands. | Total depth. | Yield of Oil and Gas. |
|---|---|---|---|---|---|
| | ft. | ft. | ft. | ft. | |
| 3 | 275 | 91 | 33 | 1,728 | Oil about 2 bls. per day. Gas 1,657,338 cub. ft. per day at rock pressure of 95 98 lbs. |
| 5 | 265 | 38 | 83 | 1,414 | Oil about 2 bls. per day. Gas 1,657,593 cub. ft. per day. Rock pressure 110-135 lbs. |
| 7 | 463 | 232 | 12 | 1,990 | Oil about 8 bls. per day. Gas 852,411 cub. ft. per day. Pressure 110 150 lbs. |
| 8 | 453 | 83 | 68 | 1,680 | Oil—variable. Gas 1,738,583 cub. ft. per day. Rock pressure 200-245 lbs. |
| 9 | 310 | 63 | 38 | 2,060 | Oil about 8 bls. per day. Gas 20,000 cub. ft. per day. Rock pressure 30 lbs. |
| 10 | 456 | 138 | 46 | 1,885 | Oil about 5 bls. per day. Gas 907,073 cub. ft. per day. Pressure, 150 lbs. |
| 12 | 464 | 43 | 52 | 1,955 | Oil sands not torpedoed. Gas 3,695,074 cub. ft. of gas per day. Rock pressure 505 lbs. |
| 13 | 446 | 116 | 19 | 1,628 | Oil sands not torpedoed. Gas 1,376,698 cub. ft. of gas per day. Rock pressure 172-200 lbs. |
| 14 | 424 | 5 | 86 | 1,480 | Oil sands not torpedoed. Gas 12,088,848 cub. ft. per day. Pressure 365-379 lbs. |
| 15 | 395 | ........ | 214 | 1,440 | Gas 6,531,840 cub. ft. per day. Pressure 225-230 lbs. |
| 16 | 405 | 72 | 29 | 1,475 | Oil sands not torpedoed. Gas 9,490,049 cub ft. per day. Rock pressure 375 lbs. |
| 17 | 360 | 42 | 28 | 1,940 | Oil sands not torpedoed. Gas 80,000 cub. ft. per day. |
| 18 | 375 | 96 | 1,290 show of gas. | 2,175 | Only one group of sands could be torpedoed. Yield of oil about 2 bls. per day. |
| 19 | 290 | 15 | 83 | 1,315 | Gas 4,550,764 cub. ft. per day. Rock pressure 370-373 lbs. |
| 20 | 450 | 65 | 133 | 1,795 | Oil sands not torpedoed. Gas 10,295,599 cub. ft. Rock pressure 405-430 lbs. |
| 21 | 420 | 147 | 1,325 show of gas. | 1,977 | Oil sands not yet torpedoed. Test of natural yield gave 8 bls. per day. |
| 22 | 325 | ........ | 59 | 1,510 | Gas 6,417,488 cub. ft. per day. Rock pressure 500 lbs. |

The yield of natural gas from the wells as indicated in the above statement, is the capacity as tested immediately after the gas was struck and the well shut in. A certain allowance must, therefore, be made when calculating, from these figures, the actual capacity of the wells when the gas is being steadily drawn from them. A thorough test, recently made by experts from the United States, indicates that nearly 35,000,000 cubic feet of gas per day may be confidently assumed when the wells are being constantly drawn upon.

Gas mains are already laid to the town of Moncton, and the work of installing the necessary connexions in private houses, stores, and industrial plants is now under way. Moreover, and depending on, the further development of gas which is believed to be certain, it is anticipated that gas will be piped to Hillsborough, Sussex, St. John, Dorchester, Sackville, and Amherst.

The control of the Moncton Tramways, Electricity and Gas Company, Limited, which acts as the distributing company for the gas, has been acquired by Mr. T. N. Barnsdall, of Pittsburgh, Pa. Mr. Barnsdall also controls the Dominion Gas Company, operating in Ontario, and is the largest independent gas producer and distributer in the United States. The following is the tariff of charges which the distributing company proposes to adopt:—

[1] Indicated yield of natural gas is the capacity as tested immediately after the gas was struck and the well shut in.

Domestic consumption—40 cts. per 1,000 cub. feet, with a discount of 2 cts. per 1,000 cub. feet.

Gas engines—27 cts. per 1,000 cub. feet, with a discount of 2 cts. per 1,000 cub. feet. If consumption reaches 75,000 cub. feet per day or over, the rate is 20 cts. per 1,000 cub. feet.

Boiler gas—17 cts. per 1,000 cub. feet, with a discount of 2 cts. per 1,000 cub. feet.

During the season of 1912, the Maritime Oilfields, Limited, in further extending their operations, propose to operate four strings of drilling tools in their Albert County areas.

I have the honour to be, Sir,

Your obedient servant,

(Signed) **Eugene Haanel.**

# REPORTS

ON

# CHEMICAL LABORATORIES, STATISTICAL DIVISION, ASSAY OFFICE, FUEL TESTING STATION, METALLURGICAL LABORATORY, ETC.

## CHEMICAL LABORATORIES.

*F. G. Wait, M.A.*

Chief Chemist.

During the twelve months ending December 31, 1911, 550 specimens have been reported upon.

Both branches of the laboratory have been in operation during the year until late in December, when the Sussex Street section was closed and its fittings removed on account of extensive changes being made in the interior arrangements of the building. When the operations now being carried on are completed, a new and fully equipped laboratory will be provided in which the two sections hitherto separated will be united.

Mr. M. F. Connor, B.Sc., and Mr. H. A. Leverin, Ch.E., assistant chemists, have worked earnestly and steadily throughout the year, and it is mainly to their efforts that the results here tabulated are due.

Continuing the practice of former years, no more than an outline of the work done is given in this summary, the details being reserved for publication at a later period.

For convenience, the materials here dealt with may be classified as follows:—

FUELS—76 samples, comprising peat, lignite, lignitic-coal, coal, anthracitic coal, and semi-anthracite, as follows:—

I. *Peat*—11 samples from the Holland peat bog, situated in the counties of York and Simcoe, Province of Ontario.

II. *Lignite*—15 samples from the undermentioned localities in—

(*a*) Alberta—

i. Section 32, township 6, R. 12, west of 2nd meridian.

ii. Section 22, township 28, R. 20, west of 3rd meridian, sample from the middle and lower parts of an 8′-10″ seam, at the bottom of a 130 ft. shaft.

iii. Section 16, township 51, R. 9, west of 4th meridian—at or near Mannville. Sample from a 5 ft. seam taken at a depth of 17 feet.

iv. From the Castor Coal Co.'s property at Castor, being the S.W. ¼ of section 3, township 38, R. 14, west of 4th.
(*a*) Sample from the "old mine".
(*b*) Sample from face of entry 1—51 feet from outcrop.
(*c*) Sample from outcrop of entry No. 6—seam 6'-1".

v. Section 28, township 41, R. 17, west of 4th meridian, at or near Meeting creek.

vi. Section (?), township 53, R. 6, west of 5th meridian.

vii. Section 5, township 49, R. 27, west of 5th meridian, Jasper park.
(*a*) Moose creek—seams undefined—4 samples.

viii. Tofield—from a boring (well No. 1) taken from a depth of 200 feet.

(*b*) Saskatchewan—
ix. Section 21, township 7, R. 21, west of 3rd meridian.

III. *Lignitic coal*—5 samples from—
(*a*) Alberta—
i. Section (?), townships 46 and 47, R. 17, west of 5th meridian, taken from a point south of Edson, on the Grand Trunk Pacific railway.
ii. Section 5, township 49, R. 27, west of 5th meridian, Jasper park, Alberta.
(*a*) Moose creek—seams undefined—3 samples.

(*b*) British Columbia—
iii. Davis creek—north fork, in the Groundhog coal basin, Omineca Mining Division. Sample from the upper seam—4·3 feet.

IV. *Coal*—38 samples from—
(*a*) Alberta (30)—from—
i. Just inside "The Gap" in the Livingston range of mountains.
(*a*) North Race Horse hill—seams 1, 2, 3, and 4—4 samples.
(*b*) South Race Horse hill—seams 1, 2, and 3—1 sample.
(*c*) South Race Horse hill—seam 4—1 sample.
(*d*) South Race Horse hill—an undefined seam—1 sample.
(*e*) Dutch creek—an undefined seam—1 sample.
(*f*) Dutch creek—No. 3 seam—1 sample.
(*g*) Livingston river—1 sample.

ii. Jasper park—section 5, township 49, R. 27, west of 5th meridian.
(*h*) Main tunnel of Jasper collieries, taken across a 9 ft. seam—1 sample.
(*i*) Upper seam—21 feet thick at outcrop—1 sample.
(*j*) Drinnan's claim, taken across a 12 ft. seam—1 sample.
(*k*) Moose creek—from undefined seams—8 samples.
(*l*) Moose creek—from McVicar creek—3 samples.
(*m*) Moose creek—taken at a point one-half mile above 6th meridian crossing—1 sample.
(*n*) Moose creek—from 40 feet below conglomerate—1 sample.
(*o*) Brulé lake, Scovill creek, from Bartholemew's claim, taken from the upper seam—1 sample.

iii. From E. Loder's claim, at the head of Kananaskis river—seam 10 feet—1 sample.

iv. Section 13, township 45, R. 21, west of 5th meridian.
Sample No. 1, from a 9 ft. seam.
Sample No. 2, from a 15 ft. seam.

(*b*) British Columbia (8) from—
1. Nanaimo coal-fields—Vancouver island—
(*a*) East Wellington, No. 1 mine—"run of mine"—ultimate analysis.
(*b*) Extension mine—run of Nos. 1, 2, and 3 mines—ultimate analysis.
(*c*) South Wellington mine—"run of mine"—ultimate analysis.
(*d*) Suquash mine—Pacific Coal Company—ultimate analysis.
(*e*) Extension mine, No. 2—sample of "rash" or dirty coal.

2. Vicinity of Hazelton—Omineca Mining Division—
(*f*) Skeena river—at the "big slide"—9 miles above Kispiox mission—from upper seam—1·9 feet thick.
(*g*) Skeena river—1½ miles above Kispiox mission.

3. Groundhog coal basin. Omineca Mining Division—
(*h*) Specimen taken from the top seam of the section.

V. *Anthracitic coal*—7 samples—all from British Columbia—
(*a*) Omineca Mining Division—
1. Groundhog coal basin—
i. Biernes creek, "Pelletier" seam—5·2 feet thick.
ii. Davis creek near its mouth—4·4 ft. seam.
iii. Discovery creek, upper tunnel—6·0 ft. seam. 0·6 ft. "bone" omitted in sampling.
iv. Trail creek—sample taken across a 6·5 ft. seam.

2. Vicinity of Hazelton—
From the "big slide" on Skeena river, some 17 miles north of Hazelton, or 9 miles north of Kispiox mission.
v. Sample across "middle" seam—2·8 feet coal and 0·9 feet of "bone"—the latter omitted in sampling.
vi. Sample across "lower" seam—6·5 feet coal and 3·0 feet bone—the latter omitted.

(*b*) Skeena Mining Division—
vii. Panorama creek—10 miles west of Groundhog coal basin—selected sample.

VI. *Semi-Anthracite*—3 samples, all from Groundhog coal basin, Omineca Mining Division, British Columbia—
i. Abraham creek, sample across seam, coal 5·05 feet—5 feet "bone" omitted.
ii. Biernes creek—"Scott" seam, 5·3 feet—0·2 foot "bone" omitted.
iii. Discovery creek—lower tunnel, sample across seam. Coal, 5·4 feet—0·4 foot "bone" omitted.

IRON ORES—87 samples from:—
(*a*) Nova Scotia—
1. Annapolis county—
Torbrook—hematite—15 samples examined after treatment at ore concentration plant.
2. Antigonish county—
Siderite, from Copper Lake mine, Polson lake.

(b) New Brunswick—

Gloucester county—so called "Bathurst" ore—from Nipisiguit, 21 miles from Bathurst—three analyses—one on "crude" ore, one on product of concentration, one on "tailings."

(c) Quebec—

Magnetite from "Eardley" farm, on the north shore of the Ottawa river, near Aylmer East, in Wright county.

(d) Ontario—

Algoma district—Goulais river—14 samples, after concentration.

Hastings county—

| | | | |
|---|---|---|---|
| Carlow | township, lot 17, con. | VI. | |
| Dungannon | " " 30, " | XIII. | |
| Faraday | " " 21, " | XI. | |
| Lake | " " 17, " | XI.—2 samples. | |
| Mayo | " " 11, " | IX.—Child's mine. | |
| " | " " 14, " | IX. | |
| " | " " 13, " | IX. | |
| " | " " 10, " | IX.—Rankin mine. | |
| " | " " 4, " | VI.—Bessemer ore, 3 samples. | |
| Tudor | " " 57, Hastings road, Horton mine. | | |
| " | " " 19, con. | XII.—St. Charles mine. | |
| " | " " 18, " | XVIII.—Baker mine. | |
| Wollaston | " " 17, " | II.—2 samples. | |
| " | " lots 15 and 16, con. | VIII.—Coe Hill mine. | |
| " | " lot 17, con. | VIII.—Jenkins' mine, 2 samples. | |

Renfrew county—

| | | | |
|---|---|---|---|
| Bagot | township, lot 16, con. | IX.—"Tommy R." pit. | |
| " | " " 16, " | IX.—"I. B." pit. | |
| " | " " 16, " | IX.—Holden pit. | |
| " | " " 16, " | VIII. | |
| " | " S.W. ½ lot 16, con. | IX. | |
| " | " S.W. ½ " 13, " | X.—Martell mine. | |
| " | " N. ½ " 21, " | VII.—Culhane ore. | |
| Lavant | " lots 3 and 4, con. | XII.—Wilbur mine. | |
| " | " Calabogie. | | |

(e) Saskatchewan—

26 miles N.E. of Herb lake (Wekusko lake), N. lat. 54° 45', W. long. 99° 45'—magnetite.

50 miles N. of Moosejaw, 6 miles N. of Canadian Pacific railway—clay ironstone.

(f) Alberta—

Near Burmis—2 samples of magnetite.

(g) British Columbia—

Bog iron ore from Demaniel river, Sooke district, southern Vancouver island, collected by Mr. Charles Clapp, of the Geological Survey.

(h) 27 samples without locality being given.

BLACK (IRON) SANDS:—

Collection of samples from the extensive deposits of iron sands lying along the north shore of the lower St. Lawrence, made by Mr. G. C. Mackenzie ,and submitted by him to treatment at the ore concentrating plant. Analyses were made not only upon the original "sand" as collected, but also upon material after treatment, in its different degrees of fineness. Some 70 determinations were made upon 27 distinct samples, or separations, from "sand" taken at the mouth of **Natashkwan river,** Saguenay county, Quebec. The work is being continued during the early part of 1912.

COPPER ORES—8 samples from:—

(*a*) Nova Scotia—
 i. Swan creek, Cumberland county.

(*b*) Ontario—
 i. Frontenac county.
 ii. Sudbury district from near Webbwood—2 samples.

(*c*) British Columbia.
 Sandon, Slocan district—4 samples.

LEAD-ZINC ORES—5 samples:—

The lead and zinc content of five ores was ascertained. Their localities of occurrence were:—

(1) Calumet island, Pontiac county, Quebec—one sample of ore and one of concentrates.

(2) Monarch mine, Mount Stephen, B.C.

(3) Black Prince mineral claim, Mount Field, B.C.

(4) An undefined locality in Frontenac county, Ontario.

LIMESTONES AND DOLOMITES—24 samples from:—

(*a*) Ontario—

| | | |
|---|---|---|
| i. Bruce | county | —Cook's quarry, Wiarton. |
| | | Lot 39, con. II, of township of Eastnor. |
| ii. Carleton | " | —Old marble quarry, Fitzroy Harbour. |
| iii. Frontenac | " | —Sanford's marble quarry, Barrie township. |
| | | Wallace quarry, Kingston. |
| iv. Grey | " | —Perkins' quarry, Owen Sound. |
| v. Hastings | " | —Black marble from Madoc. |
| | | Ontario Marble Co.'s quarry at Bancroft. |
| vi. Lanark | " | —McEwan's quarry, Carleton Place. |
| | | Coughlin's quarry, Smiths Falls. |
| | | North Lanark Marble and Granite. |
| | | Company's quarry, Clyde Forks. |
| vii. Lincoln | " | —Gibson's quarry—Beamsville. |
| | | Queenston Quarry Company's property, Queenston. |
| viii. Prescott | " | —Ross quarry, Hawkesbury. |
| ix. Renfrew | " | —McGinnis' quarry, Haley station. |
| | | Legris' quarry, Calabogie. |
| | | Old quarry, Arnprior. |
| x. Stormont | " | —Marcotte's quarry, Mille Roches. |
| xi. Victoria | " | —Britnell's quarry, Burnt River. |
| xii. Wellington | " | —Central Prison quarry, Guelph. |
| xiii. Wentworth | " | —Marshall's quarry, Hamilton. |

(*b*) Alberta—
 From near milepost 88 on the Grand Trunk Pacific railway.

(*c*) British Columbia—
i. Nootka marble quarry.
ii. Departure bay, Nanaimo.

GYPSUM—22 samples from:—

(*a*) Nova Scotia—
"Blue gypsum" from near Windsor, Hants county.

(*b*) Ontario—
i. Haldimand county—
(*a*) From the Crown Gypsum Company's property, 1 mile southeast of York—6 samples.
(*b*) From a shaft on the Hudspeth property, on the south side of the Grand river, one-half mile west of Caledonia.

(*c*) Manitoba—
i. From a point some 17 miles east of Dominion City, Provencher county.
ii. From the Manitoba Gypsum Company's quarry at Gypsumville—2 samples.

(*d*) British Columbia—
i. From a point 10 miles east of Princeton in Yale-Cariboo.
ii. From a band, 5 feet wide, at Spatsum.
iii. From "Bauxite" claim, one-half mile east of Merritt—2 samples.
iv. From different points on claims situated 10 miles east of Grand Prairie —5 samples.
v. From Warren claims, 1½ miles northwest of the preceding—2 samples.

BRICK AND POTTERY CLAYS:—

Thirteen samples were submitted to complete or to partial analysis to ascertain their fitness for the purpose of manufacture of the several clay products. Of these four were from Manitoba and nine from British Columbia. In no case was the precise locality of their occurrence made known.

OIL-SHALES:—

Determinations of the oil content and ammonium sulphate yield were made upon 10 "oil-shales" from Albert county, New Brunswick.

ROCKS AND MINERAL:—

During the year six analyses were reported, as follows:—
i. From the Tulameen district, B.C.—
(*a*) Granite—Collins gulch.
(*b*) Granite—east side of the northeast end of Otter lake.
(*c*) Granodiorite—Siwash creek.
ii. From Ice river, B.C.—
(*d*) Nepheline-syenite.
(*e*) A rock of the essexetic type.
iii. A sample of scapolite from the Craigmont corundum mine—Raglan township, Renfrew county.

The analytical work upon 9 other samples was carried on, but not completed on the date of closing this summary report.

NATURAL WATERS AND BRINES:—

Two natural spring waters and eight samples of brines have been analysed during the year.

Their several sources are given below—

i. Spring on the banks of Cain river, 10 miles from its junction with the Miramichi in Northumberland county, New Brunswick—a qualitative examination only.

ii. Spring on lot 205, Range of Ste. Antoine, Parish of Ste. Elizabeth, Joliette county, Quebec—a quantitative analysis was made of this sample.

iii. Brines from—

(*a*) Western Canada Flour Mills' well, Goderich, Ont.
(*b*) American Chemical Company's well, Goderich, Ont.
(*c*) Stapleton Salt Works, Clinton, Ont.
(*d*) Ontario People's Salt and Soda Company's well, Kincardine, Ont.
(*e*) Sparling Company's property, Wingham, Ont.
(*f*) Western Salt Company's well, Mooretown, Ont.
(*g*) Dominion Salt Company, Sarnia, Ont.—old well.
(*h*) Dominion Salt Company, Sarnia, Ont—new well.

Assays for Platinum, Gold, and Silver:—

One hundred and eighty seven furnace assays have been made upon material taken in different parts of the whole Dominion.

Under the heading of provinces, their distribution is as follows:—

| | | |
|---|---|---|
| From New Brunswick | 2 | samples. |
| " Quebec | 5 | " |
| " Ontario | 19 | " |
| " Saskatchewan | 2 | " |
| " Alberta | 3 | " |
| " British Columbia | 97 | " |
| " Yukon district | 6 | " |

In addition to the foregoing, there were 53 samples submitted to assay, of which no particulars of locality of occurrence were furnished.

Miscellaneous Examinations:—

Under this caption are placed such analyses—mostly partial—or descriptions of samples as do not properly come under any of the preceding divisions, or concerning which little or no information was given. Here are included upwards of fifty rocks and minerals requiring description or determination of species only—eight supposed tin ore samples from Galetta, Ontario; apatite, gypsum, manganiferous bog iron ore, one sample of each; pyrrhotite for determination of the content of nickel or copper, or both—six samples; pig iron and calcareous marl, of each one sample, two furnace slags; a supposed nickeliferous quartzite from Siwash, B.C.; a supposed tin and tungsten-bearing pegmatite from Dalhousie East, Lunenburg county, N.S.; two samples of material which it was thought might be used as glass sand—one from near Dauphin, Man., and the other from the vicinity of Medicine Hat, Alta.; three samples of well-borings from Ouaitchouan Falls, Chicoutimi county, Que., to determine their mineralogical character; nine sandstones which were to be utilized for building purposes for determination of the quantity of sulphur and iron which they contained; and one sample of tar sand from near Calgary, Alta.

# REPORT OF THE DIVISION OF MINERAL RESOURCES AND STATISTICS.

*John McLeish, Chief of Division.*

The work of this Division, comprising the collection of information respecting the mining industry, the preparation of annual reports on mineral production, etc., and defined more specifically under section 6 (*a*) of the "Geology and Mines Act, 1907," has already been described in some detail in previous summary reports.

During the year 1911 the chief work of the staff was, naturally, devoted to the collection of statistics and the preparation of reports on mineral production for the year 1910. These statistics were collected entirely by correspondence, the returns received directly by this Division being supplemented by information furnished by other government departments and by provincial mining bureaus. Mr. C. T. Cartwright spent several months, from September to November, gathering information relative to the mining industry in British Columbia.

An annual record of the mineral production in Canada has been collected since 1886, and the growth of the industry is significantly shown by the statistics published. In 1886, the total value of the production was $10,221,255, or an average of $2.23 per capita, whereas in 1911, the total value of the production was $102,291,686, or an average of $14.20 per capita.

The annual reports published contain as complete information as was available respecting production as well as a record of exports and imports, together with information respecting the occurrence, development, uses of, and markets for mineral products.

The completion of these reports, which require considerable time both in the compilation and in the printing, is usually so long delayed that a practice has been made of issuing short preliminary reports on mineral production, with statistics subject to revision, and these have almost invariably been completed and distributed during the first week in March in each year. Thus the manuscript for the Preliminary Report on the Mineral Production of Canada during the Calendar Year 1910 was sent to press on February 23, and the printed report of 21 pages was received February 27, 1911. Copies were first distributed at the annual convention of the Canadian Mining Institute held at Quebec, March 1, 2, and 3, 1911, at which meeting a short paper on the mineral production of Canada during the year was read, thus placing before the mining fraternity and the public—at the earliest opportunity—information concerning the extent of Canada's mining output. This report was also published as an appendix to the Summary Report of the Mines Branch for 1910.

The completed report for the year 1909 was received from the printers July 19, 1911.

The separate publication of selected parts of the final reports in the form of advance chapters was continued, and in pursuance of this plan the following reports were prepared and sent to press on the dates indicated:—

The Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, during the calendar year 1910—August 12.

The Production of Iron and Steel in Canada, during the calendar year 1910—August 11.

The Production of Coal and Coke in Canada, during the calendar year 1910—August 21.

A General Summary of the Mineral Production of Canada, during the calendar year 1910—August 24.

These were issued as advance chapters of the complete Report on the Mineral Production of Canada, during the calendar year 1910, and were all received and distributed before tho close of the year. The complete report was transmitted to the printers on October 25, 1911.

Much of the time of the staff is taken up in the furnishing of information to correspondents and others respecting the mining industries and mineral resources of the country.

The routine correspondence of the Division during the year comprised about 1,347 letters sent out and received, in addition to which about 4,308 circular communications were sent out and 2,323 received. Six statistical reports prepared by the Division were distributed during the year, comprising about 11,500 copies. In addition to these reports, lists of operators were also printed as follows: (1) List of Manufacturers of Clay Products in Canada; (2) List of Lime Burners in Canada; (3) List of Stone Quarry Operators in Canada. Copies of these lists were sent to each firm or individual interested for purposes of confirmation and correction.

Mr. Cartwright devoted the first part of the year to office work, and contributed largely to the preparation of the annual report, with special reference to the chapters on metalliferous production. From September to November he was engaged in field work in British Columbia collecting information with respect to the metal mining industry in that Province. Mr. Cartwright furnishes the following summary report with respect to his field work:—

"In accordance with instructions received, the writer spent September, October, and most of November, 1911, in British Columbia with a view to obtaining the necessary data for a revision of the Report on the Mining and Metallurgical Industries of Canada, and information for the work of the Statistics Division.

"Southern British Columbia was covered as thoroughly as time permitted, special attention being paid to the silver-lead and the gold ores, any duplication of work with other officers of the Branch being avoided. Practically all the railway and steamer routes of the south were traversed, with, in addition, trips by stage or saddle horse.

"Copies of the schedules of information desired are appended. At the time of the visit the Kootenay and Boundary districts were feeling the effects of the coal strike, on the Crowsnest, yet there was a most noticeable activity in West Kootenay.

"In the Nelson division considerable interest was shown in the reported discovery of metals of the platinum group; in the new locations in the Sheep Creek lead belt; and in the experiments with the "French" zinc process.

"Ainsworth and Silverton camps of the Slocan were active, several properties re-opening under new owners or reaching a shipping stage, whilst Sandon, Bear Lake, and McGuigan would seem to promise a good tonnage in 1912 with the resumption of work on many well-known properties and the completion of the Bear Lake branch of the Canadian Pacific railway.

"As ever, the economical treatment of zinc ores and zinc-lead concentrates was the question of importance to the Kootenays. At present, in addition to the expensive long freight haul, the ores have to stand the United States import duty of one cent per pound on zinc content, the duty of one and a half cents per pound on all lead content, although for this no payment is made by the smelters, and a deduction of more than twenty-five per cent of the silver value.

"The larger smelting companies of the interior showed considerable activity in the acquirement of new properties, the British Columbia Copper Company, and the Consolidated Mining and Smelting Company extending their operations in West Kootenay, the Boundary, and Similkameen, while the Granby Consolidated Mining and Smelting Company took up their bond on the Hidden Creek mine on the coast.

"The Nickel Plate gold mine at Hedley showed the beneficial results of the improvements to its mill, and near Princeton work was progressing on the coal and other properties.

"On the coast the chief features were the large increase in production from the Britannia mines, and, as mentioned, the development of the Hidden Creek mine.

"The writer was fortunately able to attend the meeting at New Denver, B.C., September 13-14, of the Western Branch of the Canadian Mining Institute, and found his work thereby greatly facilitated, not only from information contained in the papers read, but far more from personal contact with so many of the leading mining men of the Province.

"The chief limitations placed on the work were due to the lateness of the season, the small amount of time at the writer's disposal, and to the fact that an unusually large number of mines were changing hands, or the operating companies re-organizing, making much data for the time unobtainable. Everywhere, however, those interviewed showed the greatest courtesy, so much so that it is impossible properly to acknowledge here the kindness shown and aid given by the officials of the Provincial Department of Mines, of the Western Branch of the Canadian Mining Institute, and by so many others."

## SCHEDULE OF INFORMATION SOUGHT.

### OPERATING COMPANY.

Company's name.
Head office address.
Capital authorized. in shares of. Issued.
Incorporation. Date. Place.
President. Address.
Vice President, 1st. "
" 2nd. "
Treasurer.
Secretary.
General manager.
Fiscal year ends.
Reports published.
Properties owned or leased.

### MINE.

Name. Location.
Operator. Head office address.
Owner (if not operator). Head office address.
Mine office. Local manager.
Property: Area. No. of claims.
How held: Crown granted or leasehold.
Type of ore: Metals contained.
Typical or average analysis.
Type of deposit.
Method of working: Tunnel or shaft.
Extent of workings.
Shaft depth. Stoping methods.
Timbering. Filling.
Power equipment: Horse-power used.
Pumping, hoisting, heating.
Electricity, steam or water power.
Labour: Day or contract work: Average number employed on surface and underground. Rate and wages paid.
Drilling: Hand, stope drills, machine drills.
Number and kind.
Diamond drilling.
Shipping: Altitude above shipping point.
Distance to and nearest shipping point.
Means: rawhide, wagon, rail, tramway.
Destination of shipments.
Transportation and treatment charges.
Products shipped—bullion, ore or concentrates.
Methods employed in handling ore, such as handpicking, crushing, etc., previous to milling or shipping.
Total value of product to date, if known.
Mill. Stamps, and number, if any. Concentration.
Cyanide or other process.
Capacity. Average number of men employed
General equipment.
Remarks. Any additional cost data, reference to good description in technical journals of property and special mining methods in vogue, etc., which will add to the value of this report will be appreciated.

A Preliminary Report on the Mineral Production during 1911 has already been prepared and published, as usual, as a separate bulletin. While this statistical record shows a slight falling off in the total value of the production as compared with the year 1910, the decrease is to be largely ascribed to special conditions, among which the labour troubles affecting the coal mining industries of the western provinces are most prominent, and the general prospects in the mining industry would appear to be particularly bright for a largely increased production during the next few years. A great deal of prospecting and development work has been undertaken in many camps, and in many cases with promising results. The building of the Grand Trunk Pacific railway and other lines through central British Columbia and northern Ontario, is opening up rich prospecting ground for the miner. Several new coal fields are being opened up in Alberta and British Columbia which will, in a few years, be supplying a large tonnage for the rapidly-growing population of western Canada as well as for export. An important deposit of copper ore is being developed in the Hidden Creek mine, near Goose bay, Observatory inlet, and preparations are being made for the erection of a smelter.

The Yukon district has hitherto been prominent, chiefly on account of its placer gold production, but the coal resources of this district are now becoming well known through the work of Mr. Cairnes, and its metalliferous deposits are already contributing to our production of silver and copper.

In Alberta, coal mining is an industry, the development of which will be measured by the growth in western population, while the same stimulus is also showing its effects in a rapidly growing production of all those products usually classed as structural materials, including cement, stone, clay products, lime, etc.

The utilization of natural gas resources in western Canada has hitherto been confined to the city of Medicine Hat, but the immediate future is to see large developments in this direction. A number of highly productive wells have been drilled at Bow island, 40 miles west of Medicine Hat, and the gas is to be piped 170 miles to Calgary, and also to Lethbridge, McLeod, and other towns and villages in southern Alberta.

Ontario has the greatest variety as well as the largest production of mineral products of any of the provinces. The nickel-copper deposits of the Sudbury district, which now supply a very large percentage of the world's requirements of nickel, are probably the most extensively developed, and (with the exception of iron) contain the largest ore resources of any metalliferous deposits in Canada.

The silver production from the Cobalt district, although still increasing in annual output and supplying about 14 per cent of the world's production, has probably attracted less attention during the past year than have the gold discoveries at Porcupine. The development of this latter district was considerably retarded by the unfortunate fires that swept the country in the month of July, accompanied by tragic loss of life as well as destruction of property. Already two mines have been sufficiently developed in the judgment of their owners to justify the erection of large mills, the opening of one of which was recently made the occasion for an elaborate celebration. Gold mining in Ontario in the past has been fraught with many vicissitudes, and the successful development of this new district may go far to atone for the losses that have been encountered in other parts of the Province.

The development of the iron ore resources of this Province offers considerable opportunity for an increased mineral production. Hitherto the production of iron ore has not been sufficient to meet the requirements of Ontario's iron blast furnaces, but the introduction of concentration methods in connexion with low-grade deposits would appear to promise a larger supply of domestic iron ore in the future.

The development of metallurgical industries in the Province is also worthy of note. Four plants are now in active operation treating the ores of the Cobalt district, and producing refined silver, white arsenic, and cobalt and nickel oxides.

Two small lead smelters are in course of construction at Kingston, and the re-opening of lead mines at Perth Road and elsewhere would appear to indicate a revival in the lead mining industry of the Province.

The already wide variety of minerals found in this Province was increased during the year by the discovery of mercury and tungsten, the former being found in some of the silver-bearing cobalt ores, and the latter in the form of scheelite in some of the gold quartz veins of Porcupine.

In the Province of Quebec marked increase is shown in the production of copper and sulphur ores. The production of asbestos has increased rapidly in recent years, and although this industry has suffered somewhat from over-production, nevertheless the applications and uses of asbestos are steadily increasing from year to year, and there can be no question of the successful operation of the mines themselves on a reasonable basis of capitalization and having due regard to the limitations of the market.

Another interesting development in the Province is the revival of gold mining in the alluvial deposits of Beauce county.

Coal production is the chief mining industry of the Maritime Provinces, and will no doubt long continue to remain so.

The iron and steel industry which is probably second only in importance to coal, has for a number of years been based almost entirely on iron ores imported from Newfoundland.

The gold output of Nova Scotia has unfortunately seriously fallen off. The discovery and development of tungsten deposits appears to promise an early production of this important mineral. The gypsum deposits of the Maritime Provinces are of enormous extent, and the output for many years will no doubt be limited only by the demand and market for this product.

Statistical details of production during 1911 will be found in the preliminary statement reprinted as an appendix to this report.

## REPORT COVERING THE OPERATIONS OF THE DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C., DURING THE YEAR ENDING DECEMBER 31, 1911.

There were 442 deposits of gold bullion, requiring 482 melts and 482 assays (quadruplicate check assays being made in each instance), including the assembling and remelting of the individual deposits after purchase into bars weighing about 1,000 troy ounces each, and the assaying of same. The aggregate weight of the deposits before melting was 39,784·70 troy ounces, and after melting 39,069·31 troy ounces, showing a loss in melting of 1·7982 per cent. The loss in weight by assaying was 5·62 troy ounces (base and parted silver), the average fineness of the resulting bullion, viz.: 39,063·69 troy ounces being ·800[2] gold and ·177 silver. The net value of the gold and silver contained in deposits was $647,416.38.

The gold bullion received came from the following sources:—

| Source. | Number of deposits. | Before melting. | After melting. | Net Value. |
|---|---|---|---|---|
| | | ozs. | ozs. | $ cts. |
| Yukon Territory | 44 | 2,073·61 | 2,021·02 | 34,994 39 |
| British Columbia | 374 | 32,176·08 | 31,523·07 | 525,746 83 |
| Alaska | 23 | 5,533·20 | 5,523·54 | 86,645 91 |
| California | 1 | 1·81 | 1·68 | 29 25 |
| | 442 | 39,784·70 | 39,069·31 | 647,416 38 |

| | | |
|---|---|---|
| Weight before melting | 39,784·70 | troy ounces. |
| Weight after melting | 39,069·31 | " |
| Loss by melting | 715·39 | " |
| Loss percentage by melting | 1·7982 | |

### Credits and Disbursements for the Purchase of Gold Bullion During the Year Ending December 31, 1911.

| | | |
|---|---|---|
| Unexpended balance—"Letter of Credit," January 1, 1911 | | $ 13,785 14 |
| Credits established during year ending December 31, 1911 | | 700,000 00 |
| "Letter of Credit" balance written off at close of fiscal year, March 31, 1911 | $ 37,383 74 | |
| Disbursements for purchase of bullion | 647,416 38 | |
| Unexpended balance, "Letter of Credit," December 31, 1911 | 28,985 02 | |
| | $713,785 14 | $713,785 14 |

### Disbursements for the Purchase of Gold Bullion and Receipts from Sale of Same During the Year Ending December 31, 1911.

| | | |
|---|---|---|
| Disbursements for purchase of bullion on hand, January 1, 1911, bars Nos. 399, 400, 411, 413, 414, 417 to 427 inclusive | | $ 7,514 60 |
| Disbursements for purchase of bullion during year ending December 31, 1911—Cheques Nos. 428 to 488 inclusive, and 1 to 381 inclusive | | 647,416 38 |
| Proceeds from sale of bullion during year ending December 31, 1911 | $641,750 21 | |
| Value of bullion on hand December 31, 1911, bars Nos. 346, 347, 350 to 381 inclusive | 13,591 37 | |
| Difference in favour of this office | | 410 60 |
| | $655,341 58 | $655,341 58 |

### Contingent Account for Year Ending December 31, 1911.

| | | |
|---|---|---|
| Unexpended balance, January 1, 1911 | | $ 25 40 |
| Funds provided per official cheques Nos. 1001, 1027, 1108, 3, 58, 214, 358, 470, 577, 661, 722, and 849 | | 1,689 00 |
| Amount remitted Receiver General, per draft No. 222, at close of fiscal year, March 31, 1911 | $ 20 25 | |
| Expenditure during year ending December 31, 1911 | 1,640 77 | |
| Unexpended balance, December 31, 1911 | 53 38 | |
| | $1,714 40 | $1,714 40 |

### Contingent Expenditure During Year Ending December 31, 1911.

| | |
|---|---|
| Fuel (gas) | $ 290 65 |
| Power | 157 30 |
| Express charges on bullion | 509 58 |
| Electric vault protection service | 300 00 |
| Postage | 10 00 |
| Telephones | 44 00 |
| Duty, freight, etc., on assayers' and melter's supplies | 32 18 |
| Assayers' and melter's supplies (purchased locally) | 182 35 |
| Sundries | 114 71 |
| | $1,640 77 |

### Proceeds from Residues Sold March, 1911.

| | |
|---|---|
| Residue sold to United States Assay Office, Seattle, Wash., U.S.A. (bar No. A 5). | $393 75 |
| Thirty-five empty acid bottles sold to B. C. Assay & Chemical Supply Co., Ltd., Vancouver, B.C. | 5 25 |
| | $399 00 |

### Residues on Hand, December 31, 1911.

| | |
|---|---|
| Recovered from sweepings, slags, old furnaces, old crucibles, etc., viz.—28·25 ounces, value | $383 63 |
| Twenty-four empty acid bottles. | |

### Miscellaneous Receipts.

| | |
|---|---|
| Draft No. 208, in favour of Deputy Minister of Mines (a payment for melting jewellery sweepings) | $ 3 00 |
| Draft No. 251, in favour of Deputy Minister of Mines (a payment for treating 60 lbs. slag) | 27 50 |
| | $30 50 |

The following shows the business done by the Assay Office since its establishment:—

| Year. | Number of deposits. | Weight (troy ounces) | Net value. |
|---|---|---|---|
| | | | $ cts. |
| 1901-2 (Fiscal) | 671 | 69,925·67 | 1,153,014 50 |
| 1902-3 " | 509 | 36,295·69 | 568,888 19 |
| 1903-4 " | 381 | 24,516·36 | 385,152 00 |
| 1904-5 " | 443 | 29,573·73 | 462,939 75 |
| 1905-6 " | 345 | 21,050·83 | 337,820 59 |
| 1906-7 (nine months) | 269 | 20,695·84 | 336,675 65 |
| 1907-8 (Fiscal) | 482 | 46,540·25 | 751,693 97 |
| 1908 (nine months) | 590 | 90,175·48 | 1,478,893 74 |
| 1909 (calendar) | 573 | 48,478 60 | 789,267 94 |
| 1910 " | 490 | 46,064 31 | 746,101 92 |
| 1911 " | 442 | 39,784 70 | 647,416 38 |

(Signed) **G. Middleton,**
*Manager.*

January 2, 1912.

G. Middleton, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

Sir,—I beg to inform you that we had the following assayers' supplies on hand on December 31, 1911, viz:—

| | |
|---|---|
| Silver nitrate crystals | 1 oz. |
| Calcic chloride | 1 lb |
| Lead foil (C.P.) | 85 lbs. |
| " granulated (C.P.) | 4 lbs. |
| Zinc, mossy (C.P.) | 3 ozs. |
| Litharge | 10 lbs. |
| Copper wire | ¾ spool |
| Argols | 5 lbs. |
| Flour | 8 lbs. |
| Nitric acid | 15 Winchesters. |
| Sulphuric acid | ¾ Winchester. |
| Hydrochloric acid | 1 " |
| Ammonia | 1⅓ " |
| Small clay crucibles | 8 only |
| Scorifiers, 4" | 4 |
| " 2¼" | 25 |
| Spare muffles | 3 |
| " doors | 4 |
| " supports | 14 |
| " back stops | 16 |
| " plugs | 5 |
| Bone ash ..about | 10 lbs. |
| Fireclay " | 5 lbs. |
| Cupels " | 4,200 |
| Gold cornets | 6·67 ozs. |
| " proof | 7·80 ozs. |
| Silver | 75·72 ozs. |

Yours obediently,

(Signed) **J. B. Farquhar,**
*Chief Assayer.*

January 2, 1912.

G. MIDDLETON, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

SIR,—I beg to inform you that we had on hand on December 31, 1911, in the Melting Department, the following supplies, viz:—

3 sets of linings, with supports and covers complete, for No. 1 furnace.
3 " " " " " No. 2 "
3 " " " " " No. 4½ "
3 " " " " " No. 7 "
2 Graphite crucibles, No. 6.
2 " " No. 10.
50 " " No. 16.
1 " " No. 30.
27 " " No. 40.
45 " " marked o°o
3 Crucible covers, No. 14.
1 Graphite stirrer.
1 lb. pot. nitrate.
16 lbs. carb. soda.
18 lbs. borax glass.

Your obedient servant,

(Signed) **D. Robinson,**
*Chief Melter.*

## ACCOUNTANT'S STATEMENT.

The following is a statement of the difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office, between April 1, 1910, and March 31, 1911:—

| | |
|---|---|
| Paid for bullion at Dominion of Canada Assay Office, Vancouver | $762,616 26 |
| Received for bars from United States Assay Office, Seattle | 763,322 08 |
| Difference in favour of Dominion of Canada Assay Office | $705 82 |

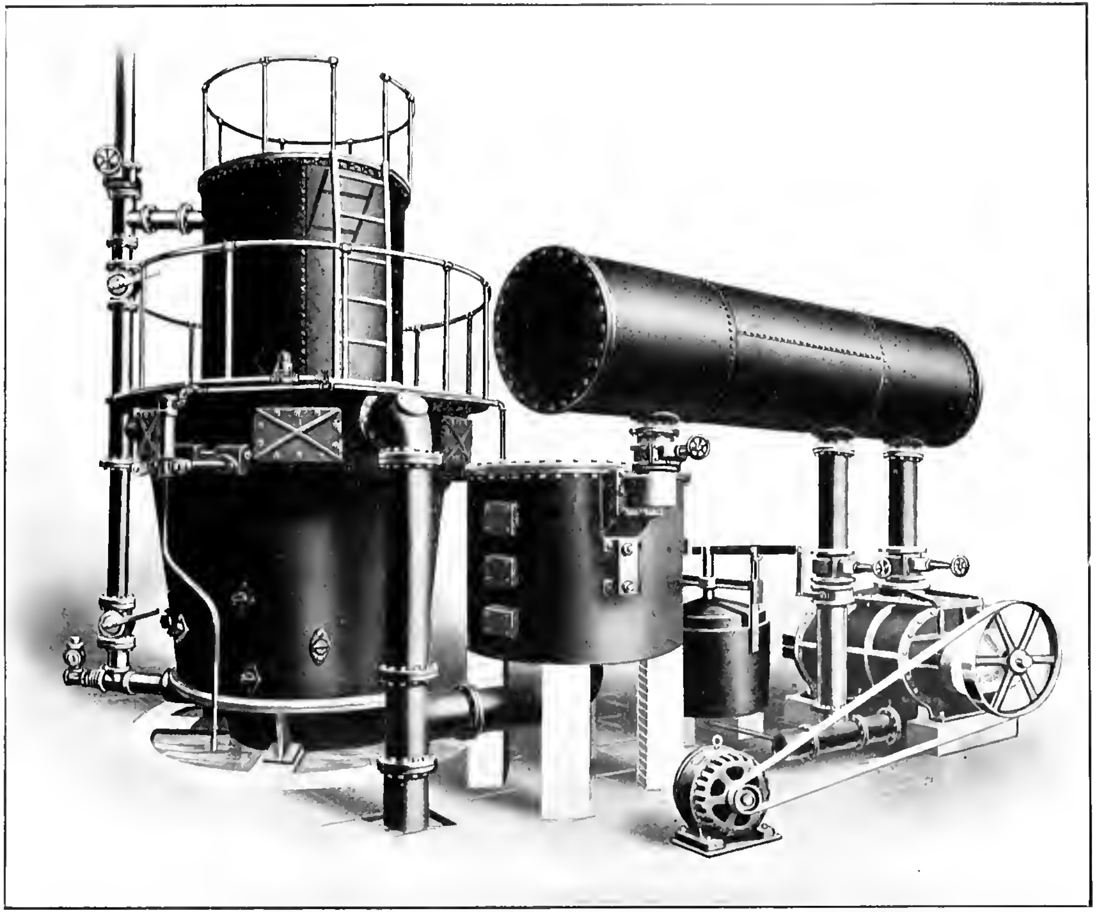
## STATEMENT OF DEPOSITS OF GOLD AND EARNINGS.

| | | |
|---|---|---|
| Deposits of gold | | $762,616 26 |
| Earnings:— | | |
| Value of residue sold United States Assay Office | $ 393 75 | |
| " 35 empty acid bottles sold B. C. Assay & Chemical Supply Co. | 5 25 | |
| Melting 50 ozs. native silver | 2 50 | |
| " jewellery sweepings | 3 00 | |
| | $404 50 | |
| Difference between amounts paid and received for bullion | 705 82 | |
| | 1,110 32 | |

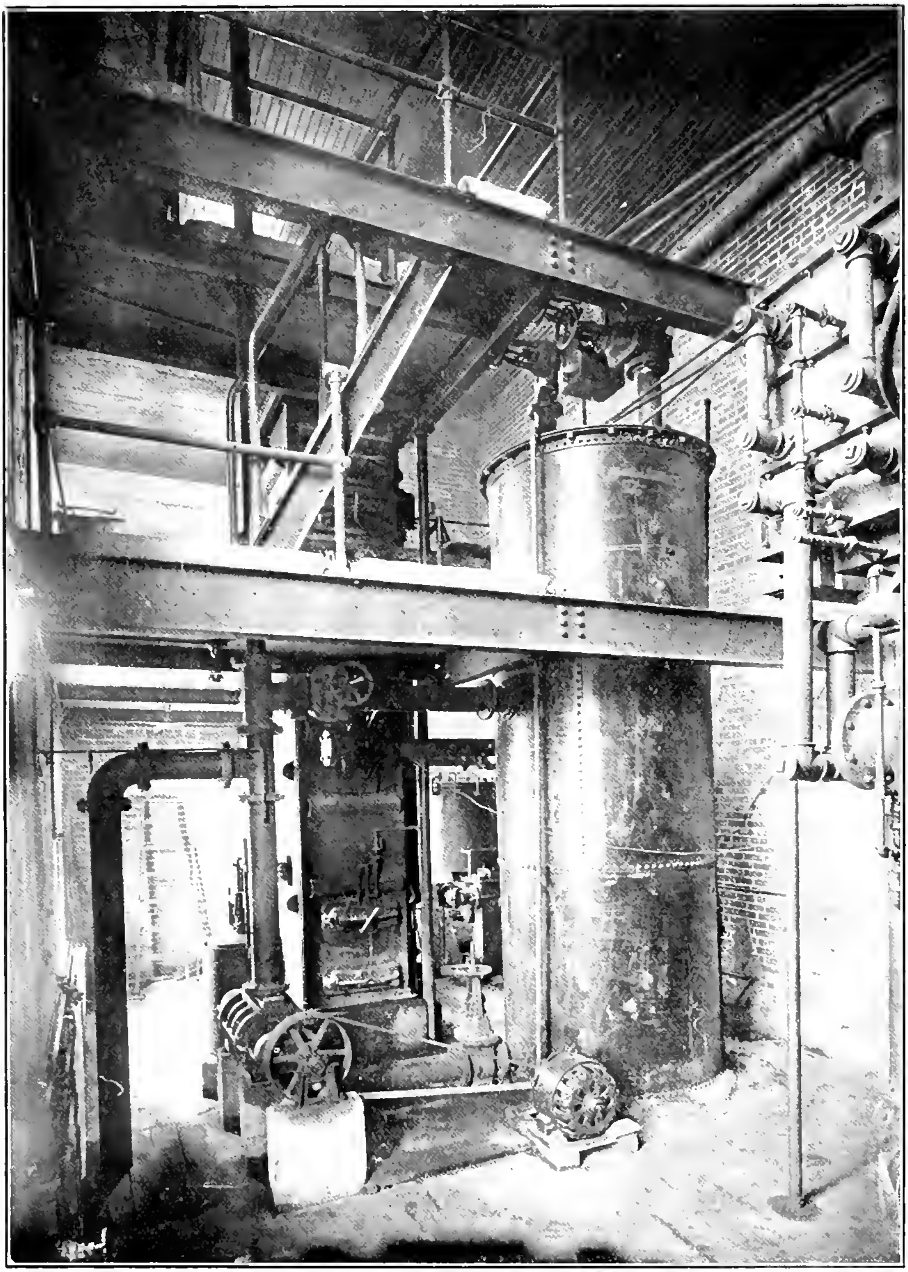
The following is a statement of appropriation, receipts, and expenditure of the Dominion of Canada Assay Office for the year ending March 31, 1911. and shows the unexpended balance to be $4,883.33:—

| | Appropriation. | Expenditure. |
|---|---|---|
| Appropriation, 1910-11 | $18,000 00 | |
| Receipts per the foregoing statement | 404 50 | |
| Difference between amounts paid and received for bullion | 705 82 | |
| Rent | | $ 1,500 00 |
| Fuel | | 283 33 |
| Power and light | | 159 76 |
| Postage and telegrams | | 66 43 |
| Telephone | | 68 50 |
| Express charges | | 608 49 |
| Assayers' supplies | | 375 46 |
| Printing and stationery | | 95 07 |
| Premium on bonds | | 570 00 |
| Contingencies | | 98 05 |
| Electric burglar alarm service | | 506 00 |
| Wages— | | |
| G. Middleton | | 2,650 00 |
| J. B. Farquhar | | 1,527 15 |
| D. Robinson | | 1,575 00 |
| A. Kaye | | 1,800 00 |
| G. N. Ford | | 1,368 75 |
| G. B. Palmer | | 975 00 |
| Balance unexpended | | 4,883 33 |
| | $19,110 32 | $19,110 32 |

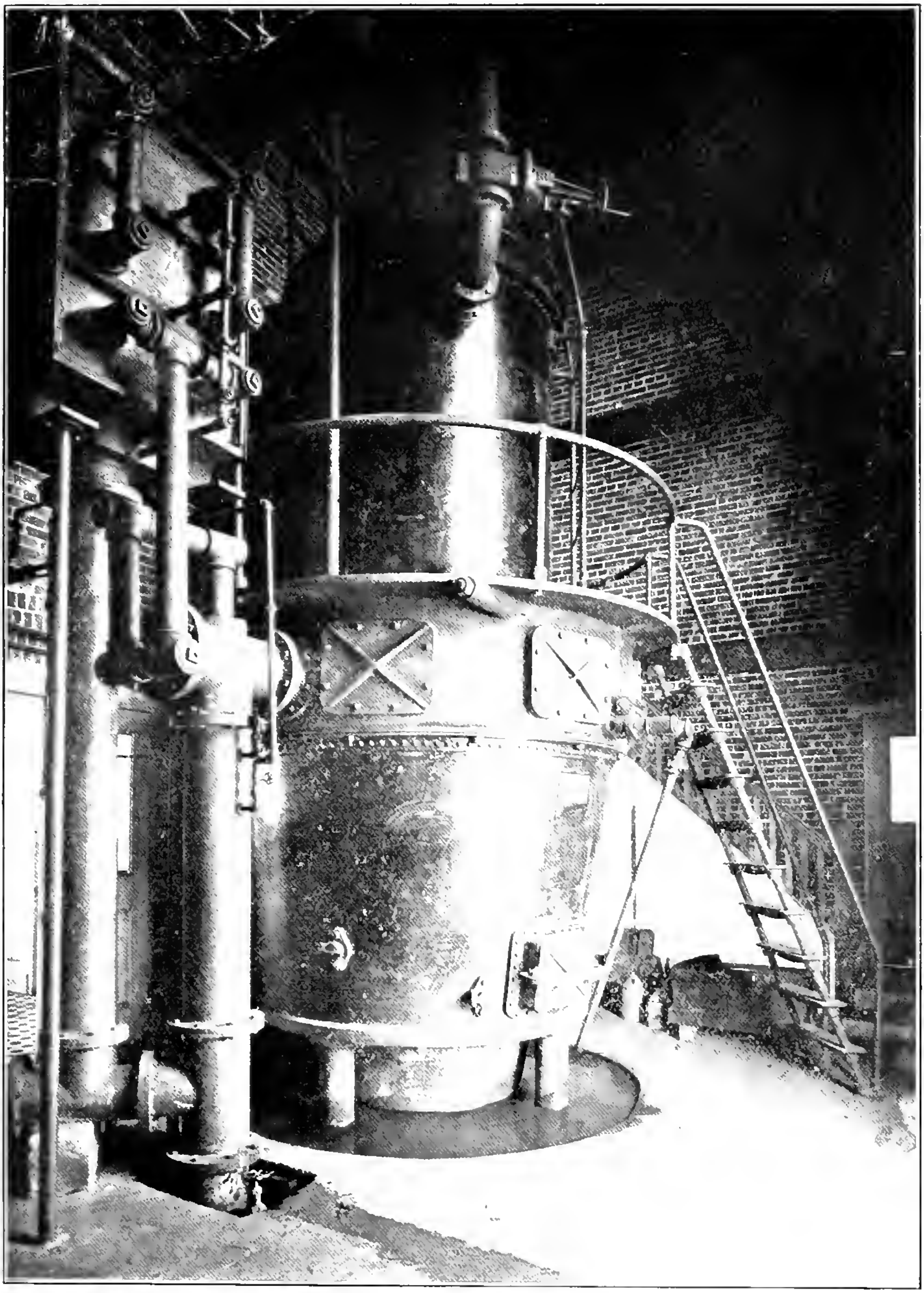
(Signed) Jno. Marshall,
*Accountant.*



General arrangement of Westinghouse double zone suction bituminous gas producer for the use of bituminous coal and lignite.



Gas receiver and motor exhauster set of the 125 h.p. Westinghouse suction bituminous gas producer installed in the Fuel Testing Station, Ottawa



125 h. p. Westinghouse suction bituminous gas producer installed in the Fuel Testing Station at Ottawa

## FUELS AND FUEL TESTING DIVISION.

*B. F. Haanel, B.Sc., Chief of Division.*

The work of this Division during the past year comprised: the completion of the tests with peat in the Körting peat producer gas plant: the chemical analysis and determination of the heating values of many samples of coals and peat, in addition to the regular chemical work carried on in conjunction with the producer trials: the delimitation and examination of several peat bogs in the Provinces of Ontario and Quebec, and the manufacture of peat at the Alfred peat bog.

*New Equipment.*—A Westinghouse double zone bituminous suction gas producer of 125 H.P. capacity has recently been installed (*see* Plate II). This producer is designed for the use of all kinds of bituminous coals and lignites and delivers a gas, free from tar (without any accessory cleaning apparatus), such as coke scrubbers, tar extractors, etc. Several plants of this type using coking bituminous coal and lignite, are in successful operation in the United States.

During the coming season a series of trials will be carried out with the bituminous coals and lignites mined in Canada, for the purpose of determining the suitability of these fuels for the production of power in a commercial producer gas power plant.

### RECONSTRUCTION OF KÖRTING PEAT GAS PRODUCER AND GAS-CLEANING SYSTEM.

The peat gas producer, as originally designed and erected, did not successfully burn or decompose all the tarry matter distilled from the peat; during the trials previously carried out, the tar carried past the gas-cleaning system was deposited on the admission and mixing valves and in the cylinder of the engine. This caused the valves and piston rings to stick, and consequently interfered with their proper working. To overcome this difficulty, it was found necessary to wash the cylinder with oil, soap, and water, and to apply gasoline to the valves one or more times during a ten-hour run. The operation of the plant was satisfactory in every other respect.

At the conclusion of the above-mentioned trials the Körting Brothers of Hanover, Germany, were informed of the failure of their producer to deliver a clean gas, as a result of which they requested the Department to send ten tons of peat to their works for the purpose of experimentation. After considerable investigation with a producer of different construction, they reported that the difficulty had been completely overcome.

One of their producer experts was, consequently, sent to Ottawa to make the necessary alteration and carry out a test trial. The expense thus incurred (including the payment for and shipment of the 10 tons of peat to Hanover, Germany) was entirely borne by the manufacturers.

The trials conducted by the Körting producer expert, showed that the producer had been manifestly improved, but that the trouble resulting from the deposition of tar had not been entirely eradicated. The technical staff of this Division, therefore, undertook a series of trials for the purpose of investigating not only the formation of tar, but the possibility of destroying this tar in the producer itself. As the result of their trials it was concluded that the tar could not be entirely destroyed in the producer itself, but must be removed in the cleaning system. After considerable experimenting, a cleaning system was devised which efficiently removed the bulk of the tarry matter from the gas.

The plant now gives entire satisfaction and can be operated for long periods—several weeks—without removing the valves for cleaning, or washing the cylinders of the engine during operation. The fuel consumption per B.H.P. hour when running at ¾ load, is between 2½ and 2¾ pounds of peat with a moisture content of between 25 and 30 per cent, and the consumption of cooling and cleaning water is very low.

Whenever coal costs $4 per ton, and when peat can be laid down at the producer plant for about $2.50 per ton, this type of power-plant will prove economical, efficient, and satisfactory in every respect. With an advance in the price of coal, the operators of producer plants can afford to pay a correspondingly higher price for the peat.

All power-plants utilizing peat fuel should be located on or adjacent to suitable bogs, in order to take advantage of the lowest possible cost at which the peat can be obtained.

Such plants would, through transmission lines, deliver for lighting, power, and other purposes the electrical energy thus generated to towns, villages, and municipalities not too far distant from the bog.

### COMPLETE REPORT OF PRODUCER TRIALS.

The complete report setting forth the full results of the trials carried out at the Fuel Testing Plant with the peat manufactured at the Victoria Road, Farnham, and Alfred peat bogs, is now ready for the press. This report will be fully illustrated and will contain detailed descriptions of tho plant, including the gas engine, producer, and gas-cleaning system.

Subjoined herewith will be found a report dealing with the work carried out by the chemical laboratory of the Fuel Testing Station.

Results of the investigation of the various peat bogs situated in the Provinces of Ontario and Manitoba are also herewith submitted by the engineer in charge of that work.

### MANUFACTURE OF PEAT AT ALFRED.

During the summer season of 1911, the manufacture of peat was carried on during a period of 93 working days. The total output during this time was 2,100 short tons gross, while the amount of peat, containing 25 per cent moisture, available for sale was 1,800 short tons. Of this tonnage 265 tons were sold to persons resident in the vicinity of Alfred, and 867 tons were shipped to Ottawa, Montreal, and other places. The balance is stacked on the field at the bog, and will be shipped to Ottawa from time to time for use at the Fuel Testing Station.

The cost of manufacturing peat at the Alfred bog will be dealt with in a bulletin now in the course of preparation.

## INVESTIGATION OF PEAT BOGS.

*A. Anrep, Jr., Peat Expert.*

In the early part of the season of 1911, in accordance with instructions, I continued the operation of the peat plant at Alfred, Prescott county, Ontario. On May 26, the plant at the Alfred peat bog, in full working order, was placed under the management of Mr. Carl Bengtsson.

Early in June, I left Ottawa for Manitoba—with a party consisting of Messrs. A. H. A. Robinson, J. H. Hooper, H. F. Collier, and E. Ericsson—to undertake the investigation of peat bogs, in order to ascertain the extent, depth, and quality of the peat contained therein. This investigation was begun at Lac du Bonnet—about 60 miles east of Winnipeg, or 4 miles west of Lac du Bonnet station.

### MANITOBA PEAT BOGS.

The peat bogs examined in Manitoba during the summer of 1911 were:—

(1) Lac du Bonnet peat bog, situated 4 miles west of Lac du Bonnet station on the Canadian Pacific railway, in township 14, range 10E.

(2) Transmission peat bog, situated 18 miles west of Point Dubois on the City of Winnipeg Power Construction railway, in township 15, ranges 11E—12E.

(3) Corduroy peat bog, situated 14 miles west of Point Dubois on the City of Winnipeg Power Construction railway, township 15, ranges 12E—13E.

(4) Boggy Creek peat bog, situated 12 miles west of Point Dubois on the City of Winnipeg Power Construction railway, township 15, ranges 12E—13E.

(5) Rice Lake peat bog, situated 7½ miles west of Point Dubois on the City of Winnipeg Power Construction railway, township 15, ranges 13E—14E.

(6) Mud Lake peat bog, situated 3 miles west of Point Dubois on the City of Winnipeg Power Construction railway, in township 15, range 14E.

(7) Litter bog (peat litter and peat fuel bog), situated 2 miles west of Point Dubois on the City of Winnipeg Power Construction railway, in township 15, range 14E.

(8) Julius peat litter bog, situated about 1 mile west of Shelley station on the Canadian Pacific railway, in township 12, range 12E.

### ONTARIO PEAT BOGS.

The peat bogs examined in Ontario during the summer of 1911 were:—

(1) Fort Francis peat bog, situated west of Fort Francis, in the townships of Crozier and McIrvine, in the district of Rainy River.

(2) Crozier peat bog, situated southwest of Fort Francis, in township Crozier, in the district of Rainy River.

(3) Coney Island peat bog, situated on Coney island, in the Lake of the Woods, west of Kenora.

Such bogs as appeared to possess economic possibilities—either as producers of peat fuel or peat litter—were thoroughly investigated: other bogs, however, which appeared to promise neither of these commercial advantages, were not examined in such great detail.

RECONNAISSANCE EXAMINATIONS: MANITOBA.

Reconnaissance examinations were made of the following bogs in various parts of the Province.

(1) White Mouth or Transcontinental peat bog, situated 2 miles east of Whitemouth station, and traversed by the Canadian Pacific railway and Transcontinental railway, in townships 4-13, ranges 12E—14E.

(2) Plumm peat bog, situated 1½ miles southwest of Whitemouth station, traversed by the Transcontinental railway, in township 11, range 11E.

(3) Netley marsh, situated 1½ miles east of Netley station, in township 16, ranges 4E—6E.

(4) Clandeboye bog, situated 2 miles west of Clandeboye station, in townships 13-16, range 3E.

(5) Big Grass marsh, situated about 2 miles east of Gladstone station, in townships 14-18, ranges 10W—11W.

(6) Douglas peat bog, situated about 13 miles east from Brandon or ½ mile from Douglas station, in townships 9-11, ranges 14-17.

(7) McGreary marsh, situated west of McGreary station, in townships 20-22, ranges 14W—15W.

(8) Ochre River marsh, situated south of Dauphin lake, in townships 24-24, ranges 15W—16W.

(9) Dauphin marsh, situated west of Dauphin lake, in townships 25-27, ranges 17W—18W.

Regarding those bogs of which reconnaissance examinations were made, indications are that they are either too shallow or that they are composed of material unfit for manufacturing into peat fuel. Possibly in some parts comparatively small areas of peat fuel may ultimately be found; although the results of our investigations afforded no indication that such would be the case. Moreover, a very long time would be required for the thorough investigation of such large areas. Under the circumstances, and taking into consideration the present sparsely settled conditions of the country, it was not considered advisable to attempt a detailed examination of these larger areas.

These investigations were continued during the greater part of June, July, August, and part of September.

Detailed descriptions, delimitations, and maps will be published in a separate report.

## CHEMICAL LABORATORY OF THE FUEL TESTING STATION.

*Edgar Stansfield, M.Sc., Chemist.*

The work of this laboratory still continues to be seriously hampered by the lack of suitable accommodation. Moreover, such will continue to be the case until a suitable laboratory is built and equipped; although recent alterations have made it possible to convert a room over the laboratory into a balance room and office—a change which distinctly alleviates the present trying conditions.

Apart from smaller apparatus and general supplies, the equipment of the laboratory has, during the present year, been augmented by the following additions:—

One Thwing pyrometer equipment, including an indicator with a three-point switch and a recorder capable of recording the temperatures at three different points; one Bristol pyrometer with indicator and recorder; one Bristol portable pyrometer for quick determination of high temperatures; one Smith recording gas calorimeter with sampling pump and motor; one Sargent tar determination apparatus; one $\frac{1}{8}$ H.P. electric motor; one electric signal clock; one Sian constant temperature drying oven; an electric tube furnace for making ultimate, organic analyses, designed by E. Stansfield and made by the Dominion Electric Company; and a Jewel water still was fitted with an electric heating device.

In addition to the setting up and testing the above apparatus, the work done in connexion with this laboratory included:—

Analyses of the fuels charged and ashes removed, gas analyses, and determinations of the tar in the gas during the different gas producer tests; examination of a solution adapted for use in fire extinguishers and known under the trade name of "Pyrene"; an investigation into the methods for the determination of moisture in coal and peat, and also the effect of hot drying on the calorific value of peat.

In addition to the above, the following analyses of samples of coals were made in the laboratory: 16 samples from Jasper park, Alta.; 1 sample from near Saunders cache, Alta.; 6 samples from Edmonton, Alta.; 5 samples from England; 1 sample of Pocahontas coal, and 1 sample of coal from South America. Analyses of samples of peat were also made as follows: 1 sample of peat from Bergeronnes, Saguenay county, Quebec; 4 samples from Farnham, Quebec; 15 samples from Alfred, Ontario; 1 sample from near Alfred, Ontario; 1 sample from Fitzroy Harbour, Ontario; 1 sample from western Ontario; 15 samples from Manitoba. Four samples of peat litter from Manitoba were also analysed.

## ORE DRESSING AND METALLURGICAL LABORATORY.

*George C. Mackenzie, B.Sc.*

The ore dressing and metallurgical laboratory has been in more or less continual operation throughout the year. A short description of this laboratory, its installation and purpose, will be found on page 48 of the Summary Report of the Mines Branch for 1910. No important changes have been made in equipment during the year.

Since the laboratory's installation, ten large and two small samples of magnetic iron ores, and one small sample of copper-nickel ore have been received, tested, and reported upon. Tests on two small samples of Goulais River ore, and two large samples from Wilbur, Ontario, were reported in the last summary. The present report will deal with seven of the remaining large samples and the small sample of copper-nickel ore.

Following is a list of the ores tested during the year:—

| Name of ore and number of test. | Locality. | Shipped by. | Weight of shipment. Tons. |
|---|---|---|---|
| 3. Robertsville.... .. ..... | Lots 3 and 4, con. IX, township of Palmerston, county of Frontenac, Ontario. | The Ontario Exploration Syndicate, Wilbur, Ont. | 5. |
| 4. Culhane........ .. ....... | N. ½, lot 21, con. VII, township of Bagot, county of Renfrew, Ont. | Thos. B. Caldwell, Esq., Lanark, Ont. | 3. |
| 5. Bathurst... .. ... ... ....... | Lot 12, range XVII, township of Bathurst, county of Gloucester, New Bruns. | The Canada Iron Corporation, Ltd., Montreal, Que. | 15. |
| 6. Nictaux-Torbrook, hematite vein. | County of Annapolis, Nova Scotia. | The Canada Iron Corporation, Ltd., Montreal, Que. | 15. |
| 7. Nictaux-Torbrook, shell vein | County of Annapolis, Nova Scotia. | The Canada Iron Corporation, Ltd., Montreal, Que. | 15. |
| 8. Goulais river... . ... ..... | Goulais River range, township 22, con. XII, District of Algoma, Ont. | The Lake Superior Corporation, Sault Ste. Marie, Ont. | 15. |
| 9. Nickeliferous pyrrhotite... | Nairn, Ont....... ........ | David A. Poe, Montreal, Que. | 5 pounds. |
| 10. Natashkwan Iron Sands. . | Natashkwan point, Saguenay county, Que. | Department of Mines, Ottawa. | 8 |

DEPARTMENT OF MINES
MINES BRANCH
OTTAWA

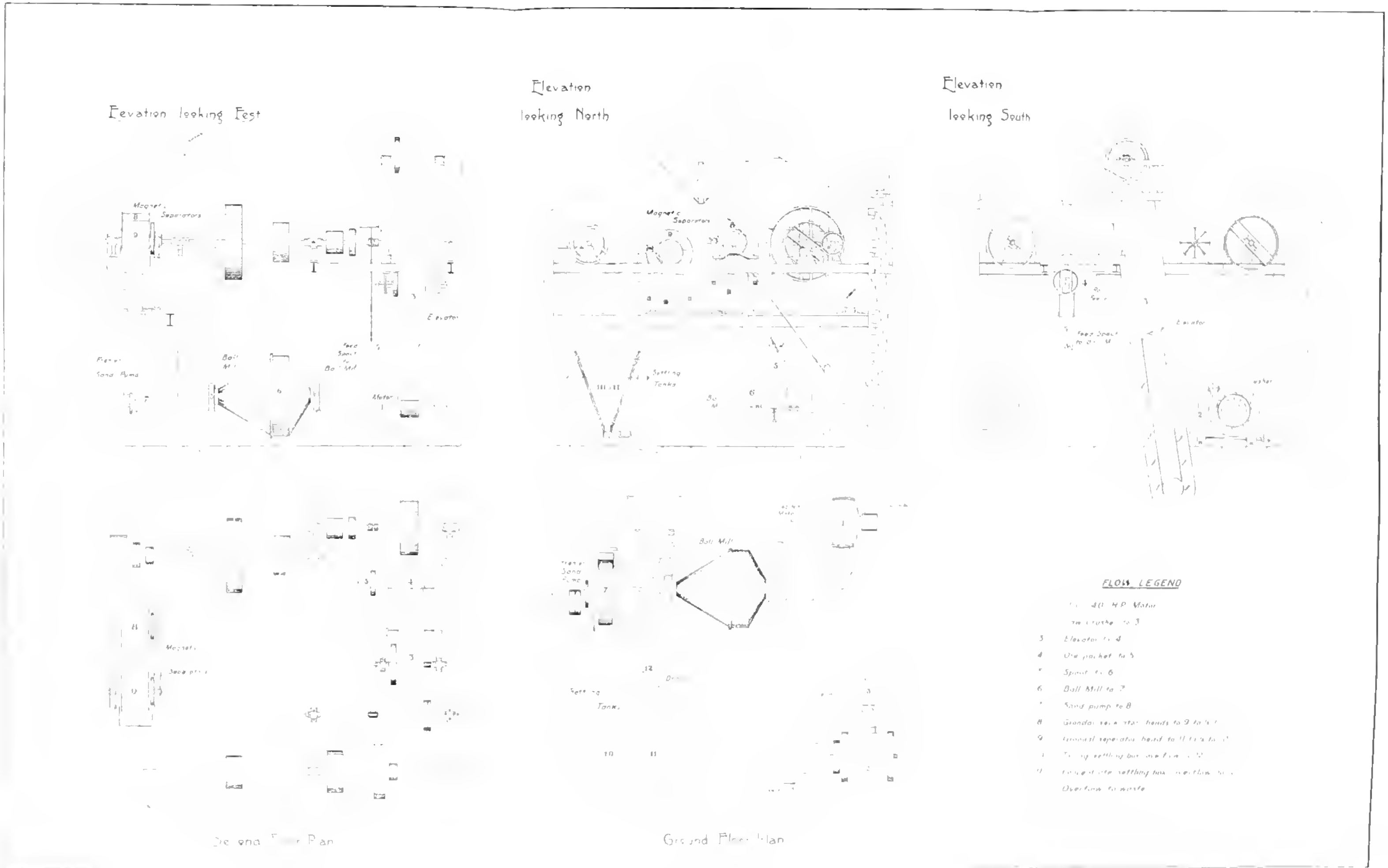



Fig 5

ORE DRESSING LABORATORY

TEST No. 3.

## Robertsville Ore, "Waste Dump."

Robertsville waste dump ore consists of crystalline magnetite irregularly distributed throughout a gangue of diorite country rock; a considerable amount of black hornblende and pink calcite with a smaller amount of white quartz is also associated with the magnetite.

The crystallization of the magnetite is rather coarse, and as the texture of the enclosing rock matter is granular and of somewhat friable nature, comminution and subseqnent concentration is easily accomplished by the Gröndal system of separation.

Both sulphur and phosphorus are present in very small amounts in the crude. In the concentrate sulphur has disappeared entirely and the percentage of phosphorus cut in half.

The percentage of iron recovered is very satisfactory, being over 91 per cent of the original iron content of the crude. This is an important item in the concentration of such low grade material, and has a direct effect upon costs of production, more especially if the cost of the crude delivered at the mill should be above the normal. The test has shown that 2·74 tons of crude are required to make a ton of concentrate of 70·5 per cent iron content, when saving 91·81 per cent of the original iron. Now, if the percentage of recovery should drop to 90, there will be required 2·79 tons of crude to make a ton of 70·5 per cent iron concentrate; an addition of 0·05 tons of crude per ton of concentrate. At first glance this appears to be an inconsiderable loss, but if the crude is costing $1 a ton delivered it means an additional cost of 5 cents on the crude per ton of concentrate. In a mill of 1,000 tons daily capacity, this loss would amount to $50 every 24 hours.

### Analyses of Crude Ore, Concentrate, and Tailing.

| —— | Crude Ore. | Concentrate. | Tailing. |
|---|---|---|---|
| Iron | 28·00 | 70·5 | 3·6 |
| Insoluble residue | 50·70 | 3·1 | |
| Sulphur | 0·004 | 0·00 | |
| Phosphorus | 0·028 | 0·014 | |
| Lime | 3·30 | 0·000 | |
| Magnesia | 1·90 | 0·06 | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{70\cdot5 - 3\cdot6}{28\cdot00 - 3\cdot6} = 2\cdot74$$

The percentage of iron in crude saved in the concentrate:—

$$\frac{100 \times 70\cdot5}{28\cdot00 \times 2\cdot74} = 91\cdot81$$

Units of tailing made per unit of concentrate: 1·74.

The percentage of iron in crude lost in the tailing:—

$$\frac{100 \times 3\cdot6 \times 1\cdot74}{28\cdot00 \times 2\cdot74} = 8\cdot17$$

Gross tons of concentrate made per gross ton of crude: 0·364.

TEST No. 4.

## Magnetic Concentration of Culhane Ore.

Culhane ore is a moderately fine-grained, crystalline magnetite, the gangue consisting of schistose material, calcite, and iron pyrites. The ore is extremely friable, the constituent minerals falling apart quite readily when rubbed with the hand.

Both sulphur and phosphorus are present in objectionable amounts, and as the iron content of the sample tested was under 48 per cent, the ore is distinctly a concentrating proposition.

Owing to the extremely friable nature of the ore, preliminary breaking with the Blake crusher was unnecessary, the ore being broken to egg size by hand and fed direct to the ball mill. It will be accepted, therefore, that Culhane ore is very easily pulverized, and this fact should have a decided effect on cost of treatment, since the comminution of the crude ore is one of the heaviest cost items in commercial magnetic separation.

Concentration has resulted in elevating the percentage of iron from 47·7 to 67, with a saving of over 95 per cent of the original iron content. Nearly 80 per cent of the sulphur in the crude has been eliminated. Phosphorus has not been reduced to the bessemer limit, but regarding the reseparation would probably yield a bessemer product.

Briquetting or nodulizing will be necessary to prepare the concentrate for blast furnace use, and either of these agglutinizing processes will yield a first-class furnace material practically free from sulphur.

### Analyses of Crude Ore, Concentrate, and Tailing.

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| Insoluble residue | 9·3 | 2·5 | |
| Iron | 47·7 | 67·0 | 6·6 |
| Lime | 4·2 | 0·10 | |
| Magnesia | 0·66 | 0·05 | |
| Phosphorus | 0·179 | 0·074 | |
| Sulphur | 1·65 | 0·357 | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{67 - 6·6}{47·7 - 6·6} = 1·47$$

The percentage of iron in the crude saved as concentrate:—

$$\frac{100 \times 67}{47·7 \times 1·47} = 95·5$$

Units of tailing made per unit of concentrate = 0·47.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 6·6 \times 0·47}{47·7 \times 1·47} = 4·5$$

Tons of concentrate made per ton of crude = 0·68.

## MAGNETIC CONCENTRATION OF BATHURST, NICTAUX HEMATITE VEIN, AND NICTAUX SHELL VEIN, ORES.

### *Introductory Note.*

All three of the ores tested for the Canada Iron Corporation are semi-magnetites, that is, they consist of a mineralogical mixture of magnetite and hematite.

The following magnetic concentration tests with these ores by the Gröndal process has shown that a fairly rich concentrate may be obtained, but only at the expense of a considerable loss of hematite in the tailing.

The recovery of iron and the purity of the concentrate produced, are factors depending on the degree of comminution to which the crude ores are subjected. Coarse crushing will effect a better saving of iron at the expense of the purity of the concentrate. Finer crushing will produce a purer concentrate, but will tend to increase the loss in iron.

Hence in the application of this process to the concentration of the ores under consideration, a point of economical recovery should be determined that will yield a concentrate at a cost figure commensurate with the initial value of the crude, and with the value of the concentrated product.

All concentrates produced by the Gröndal process will require nodulizing or briquetting.

## TEST No. 5.

## Magnetic Concentration of Bathurst Run of Mine.

Bathurst run of mine is a compact cryptocrystalline mixture of hematite, magnetite, and quartz. The ore possesses a somewhat laminated structure, although an alternate banding of the hematite, magnetite, and quartz is not apparent to the naked eye. Hematite and magnetite appear to be intimately associated in about equal proportions, the colour and streak of the ore varying from red to black, according to the proportion of ferric oxide.

Three tests were made on this ore, two of these being small preliminary tests and the third a final test. The first two were made with the view of arriving at suitable adjustment of the crushing and separating machinery. The final test was made at full capacity, and represents what may be expected from commercial practice.

The analyses of crude, concentrate, and tailing for each test are given below:—

| — | Crude Ore. | | | | | | Concentrate. | | | | | | Tailing. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe. | Insoluble. | FeO | $Fe_2O_3$ | P. | S. | Fe. | Insoluble. | FeO | $Fe_2O^3$ | P. | S. | Fe. | FeO | $Fe_2O_3$ |
| Test No. 5a Preliminary... | 47·1 | 17·5 | 14·9 | 50·7 | 0·816 | 0·050 | 60·2 | 9·3 | 24·2 | 59·1 | 0·356 | Trace | 38·8 | 10·2 | 44·1 |
| Test No. 5b Preliminary... | 46·9 | 18·0 | 15·2 | 50·1 | 0·780 | 0·136 | 57·3 | 10·0 | 23·0 | 56·3 | 0·380 | 0·054 | 38·7 | 10·9 | 43·1 |
| Test No. 5c Final ...... | 48·7 | 16·9 | 18·1 | 49·4 | 0·760 | 0·127 | 60·3 | 7·7 | 23·8 | 59·7 | 0·350 | 0·046 | 38·2 | 9·6 | 43·8 |

It will be noted that a considerable percentage of iron has entered the tailings and, therefore, must be considered as loss. This unavoidable loss in iron is due to the presence of hematite in the crude, which, being non-magnetic, readily entered the tailings. It may be suggested that a retreatment of the tails over ordinary concentrating tables would save a considerable portion of the hematite. This is open to doubt, however, from the fact that the hematite is slimed badly and its recovery in such condition is very difficult.

Concentration at a larger size, that is, with less comminution, would avoid to some extent this heavy loss of iron, but the concentrate produced would be of distinctly inferior grade.

If it is desired to produce a concentrate higher in iron and lower in phosphorus than the figures given for Test No. 3, it will be necessary to regrind this concentrate and reseparate. This would result in a further loss of iron, but would in all probability yield a bessemer product.

TEST No. 5A.—PRELIMINARY.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| —— | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| Iron | 47·1 | 60·2 | 38·8 |
| Insoluble residue | 17·5 | 9·3 | |
| Ferrous oxide | 14·9 | 24·2 | 10·2 |
| Ferric oxide | 50·7 | 59·1 | 44·1 |
| Phosphorus | 0·816 | 0·356 | |
| Sulphur | 0·050 | Trace. | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{60 \cdot 2 - 38 \cdot 8}{47 \cdot 1 - 38 \cdot 8} = 2 \cdot 57$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \times 60 \cdot 2}{47 \cdot 1 \times 2 \cdot 57} = 49 \cdot 73.$$

Units of tailings made per unit of concentrate: 1·57.

The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 38 \cdot 8 \times 1 \cdot 57}{47 \cdot 1 \times 2 \cdot 57} = 50 \cdot 32.$$

Tons of concentrate made per ton of crude: 0·389.

TEST No. 5B.—PRELIMINARY.

## Analyses of Crude Ore, Concentrate, and Tailing.

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| Insoluble residue | 18·0 | 10·0 | |
| Iron | 46·9 | 57·3 | 38·7 |
| Ferrous oxide | 15·2 | 23·0 | 10·9 |
| Ferric oxide | 50·1 | 56·3 | 43·1 |
| Phosphorus | 0·780 | 0·380 | |
| Sulphur | 0·136 | 0·054 | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{57·3 - 37·8}{46·9 - 37·8} = 2·14$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \times 57·3}{46·9 \times 2·14} = 57·09.$$

Units of tailing made per unit of concentrate = 1·14.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 37·8 \times 1·14}{46·9 \times 2·14} = 42·91.$$

Tons of concentrate made per ton of crude = 0·467.

TEST No. 5C.—FINAL.

## Analyses of Crude Ore, Concentrate, and Tailing.

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| Insoluble residue | 16·9 | 7·7 | |
| Iron | 48·7 | 60·3 | 38·2 |
| Ferrous oxide | 18·1 | 23·8 | 9·6 |
| Ferric oxide | 49·4 | 59·7 | 43·8 |
| Phosphorus | 0·760 | 0·350 | |
| Sulphur | 0·127 | 0·046 | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{60·3 - 38·2}{48·7 - 38·2} = 2·105$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \times 60 \cdot 3}{48 \cdot 7 \times 2 \cdot 105} = 58 \cdot 83.$$

Units of tailing made per unit of concentrate: 1·105.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 38 \cdot 2 \times 1 \cdot 105}{48 \cdot 7 \times 2 \cdot 105} = 41 \cdot 17$$

Tons of concentrate made per ton of crude: 0·475.

TEST No. 6

## Magnetic Concentration of Torbrook "Hematite Vein," Run of Mine.

Torbrook hematite vein is composed of a hard compact ore, consisting of intermixed, finely crystalline magnetite and hematite, the latter mineral being, for the most part, of the specular variety. The gangue is predominantly siliceous, although lime and magnesia are present in small amounts. Hematite and magnetite exist in about the proportion of 1 to 2·6 respectively,[1] the colour of the ore being grey-black.

Three tests were made on this ore. Analyses of crude ore, concentrate, and tailing for the three tests are as follows:—

[1] This proportion is figured from analyses of crude in Test No. 3 and is made on the assumption that the 14·9 per cent of FeO exists only in combination with the mineral magnetite. This is probably incorrect, as part of the FeO will be found in combination with $CO_2$, forming iron carbonate.

| | Crude Ore. | | | | | | | | Concentrate. | | | | | | | | Tailing. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe. | Insol. | FeO | $Fe_2O_3$ | CaO | MgO | P. | S. | Fe. | Insol. | FeO | $Fe_2O_3$ | CaO | MgO | P. | S. | Fe. | FeO | $Fe_2O_3$ |
| Test No. 6*a* Preliminary....... | 45·5 | 23·1 | 15·0 | 48·3 | 1·02 | 0·40 | 1·55 | 0·016 | 61·0 | 11·1 | 23·3 | 63·1 | 0·20 | 0·1 | 0·69 | 0·004 | 32·0 | 11·3 | 33·1 |
| Test No. 6*b* Preliminary....... | 47·8 | 22·2 | 14·1 | 51·4 | 1·36 | 0·20 | 1·50 | 0·020 | 61·3 | 10·4 | 21·7 | 63·4 | 0·30 | 0·05 | 0·64 | 0·001 | 32·4 | 7·3 | 38·1 |
| Test No. 6*c* Final. .......... | 47·2 | 21·7 | 14·9 | 50·8 | 0·86 | 0·40 | 1·41 | 0·011 | 61·6 | 9·9 | 21·6 | 63·7 | 0·28 | 0·20 | 0·54 | 0·005 | 33·0 | 9·4 | 36·7 |

It will be noted that separation has had the effect of producing a concentrate 14 per cent higher in iron than the original crude, depressing insoluble matter to less than one-half, and phosphorus to about one-third of the percentages found in the crude. This was effected only with the loss of considerable iron in the tailing as hematite, the recovery of the original iron being 65·6 per cent.

A reconcentration of the tailing for the recovery of hematite would probably be uneconomical, as the hematite is in slimed condition, and, therefore, difficult to save.

TEST No. 6A.—PRELIMINARY.

## Analyses of Crude Ore, Concentrate, and Tailing.

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| | % | % | % |
| Insoluble residue | 23·4 | 11·4 | |
| Iron | 45·5 | 61·0 | 32 |
| Lime | 1·02 | 0·20 | |
| Magnesia | 0·40 | 0·1 | |
| Phosphorus | 1·55 | 0·69 | |
| Sulphur | 0·016 | 0·004 | |
| Ferrous oxide | 15·0 | 23·3 | 11·3 |
| Ferric oxide | 48·3 | 63·1 | 33·1 |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{61 - 32}{45{\cdot}5 - 32} = 2{\cdot}15$$

The percentage of iron in the crude saved as concentrate:—

$$\frac{100 \times 61}{45{\cdot}5 \times 2{\cdot}15} = 62{\cdot}35$$

Units of tailing made per unit of concentrate = 1·15.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 32 \times 1{\cdot}15}{45{\cdot}5 \times 2{\cdot}15} = 37{\cdot}64$$

Tons of concentrate made per ton of crude = 0·465.

TEST No. 6B.—PRELIMINARY.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| —— | Crude. | Concentrate | Tailing. |
|---|---|---|---|
| | Per cent. | Per cent. | Per cent. |
| Insoluble residue | 22·2 | 10·4 | ........... |
| Iron | 47·8 | 61·3 | 32·4 |
| Lime | 1·36 | 0·30 | ........... |
| Magnesia | 0·20 | 0·05 | ........... |
| Phosphorus | 1·50 | 0·64 | ........... |
| Sulphur | 0·020 | 0·004 | ........... |
| Ferrous oxide | 14·1 | 21·7 | 7·3 |
| Ferric oxide | 51·4 | 63·4 | 38·1 |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{61\cdot3 - 32\cdot4}{47\cdot8 - 32\cdot4} = 1\cdot87$$

The percentage of iron in the crude saved as concentrate:—

$$\frac{100 \times 61\cdot3}{47\cdot8 \times 1\cdot87} = 68\cdot58$$

Units of tailings made per unit of concentrate: 0·87.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 32\cdot4 \times 0\cdot87}{47\cdot8 \times 1\cdot87} = 31\cdot42$$

Tons of concentrate made per ton of crude = 0·534.

TEST No. 6C.—FINAL.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| —— | Crude. | Concentrate | Tailing. |
|---|---|---|---|
| | Per cent. | Per cent. | Per cent. |
| Insoluble residue | 21·7 | 9·9 | ........... |
| Iron | 47·2 | 61·0 | 33·0 |
| Magnesia | 0·86 | 0·28 | ........... |
| Phosphorus | 1·41 | 0·54 | ........... |
| Sulphur | 0·011 | 0·005 | ........... |
| Ferrous oxide | 14·9 | 21·6 | 9·4 |
| Ferric oxide | 50·8 | 63·7 | 36·7 |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{61 \cdot 0 - 33 \cdot 0}{47 \cdot 2 - 33 \cdot 0} = 1 \cdot 97$$

The percentage of iron in the crude saved as concentrate:—

$$\frac{100 \times 61 \cdot 0}{47 \cdot 2 \times 1 \cdot 97} = 65 \cdot 6$$

Units of tailing made per unit of concentrate = 0·97.
The percentage of iron in the crude lost in tailing:—

$$\frac{100 \times 33 \cdot 0 \times 0 \cdot 97}{47 \cdot 2 \times 1 \cdot 97} = 34 \cdot 4$$

Tons of concentrate made per ton of crude = 0·508.

TEST No. 7.

## Magnetic Concentration of Torbrook "Shell Vein," Run of Mine.

Torbrook "Shell Vein" is very similar in physical characteristics to the "Hematite Vein," although the former is much more magnetic. The ore is siliceous, but contains considerably more lime than the hematite ore.

From the analysis of crude in Test No. 7*a*, the proportion of hematite to magnetite is calculated as 1 to 15, and the analysis of crude in Test No. 7*b* indicates that no free hematite is present. The analyses of the tailing, however, prove that free hematite does exist to some extent. For instance, if 8·1 per cent of FeO in the tailing is present as a constituent of true magnetite, it would mean that the tails contained 26 per cent of magnetite and only 6 per cent of hematite. That this is absurd may be proved by examination of the tails with a hand magnet.

It is evident, therefore, that part of the FeO is present in some other form than magnetite, probably as a constituent of iron carbonate ($FeO\ CO_2$). Irón carbonate being non-magnetic will escape with the tailing, constituting an appreciable loss, and (judging by the analyses) this loss may be mistaken for free magnetite in the tailing, unless the above explanation is understood.

Two tests were made with this ore. Analyses are as follows:—

| — | Crude Ore. | | | | | | | | Concentrates. | | | | | | | | Tailings. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe. | Insol. | FeO | $Fe_2O_3$ | CaO | MgO | P. | S. | Fe. | Insol. | FeO | $Fe_2O_3$ | CaO | MgO | P. | S. | Fe. | FeO | $Fe_2O_3$ |
| Test No. 7*a* Preliminary ...... | 41·7 | 19·0 | 16·8 | 40·8 | 3·96 | 0·75 | 1·00 | 0·015 | 59·8 | 8·3 | 25·7 | 56·8 | 0·28 | 0·32 | 0·61 | 0·005 | 27·7 | 11·3 | 27·0 |
| Test No. 7*b* Final. .. ...... | 42·5 | 18·4 | 19·0 | 39·6 | 5·5 | 0·37 | 1·03 | 0·033 | 60·5 | 8·5 | 21·8 | 62·1 | 0·58 | trace. | 0·62 | 0·005 | 22·8 | 8·1 | 23·6 |

Concentration has increased the iron content from 42 to 60 per cent, has cut the percentage of insoluble residue in half, and depressed phosphorus from 1·0 to 0·6 per cent. The percentage of iron saved with this ore is 74·5, a considerable advance over the figures obtained for iron recovery in the tests on Bathurst ore, and Torbrook "Hematite Vein."

Reconcentration of the tailing for recovery of hematite would probably not be profitable.

TEST No. 7A—PRELIMINARY.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| | % | % | % |
| Insoluble residue | 19·0 | 8·3 | |
| Iron | 41·7 | 59·8 | 27·7 |
| Lime | 3·96 | 0·28 | |
| Magnesia | 0·75 | 0·32 | |
| Phosphorus | 1·00 | 0·61 | |
| Sulphur | 0·015 | 0·005 | |
| Ferrous oxide | 16·8 | 25·7 | |
| Ferric oxide | 40·8 | 56·8 | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{59{\cdot}8-27{\cdot}7}{41{\cdot}7-27{\cdot}7}=2{\cdot}3$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100\times 59{\cdot}8}{41{\cdot}7\times 2{\cdot}3}=62{\cdot}4$$

Units of tailing made per unit of concentrate = 1·3.

The percentage of iron in the crude lost in tailing:—

$$\frac{100\times 27{\cdot}7\times 1{\cdot}3}{41{\cdot}7\times 2{\cdot}3}=37{\cdot}6$$

Tons of concentrate made per ton of crude = 0·435.

TEST No. 7B—FINAL.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| — | Crude. | Concentrate. | Tailing. |
|---|---|---|---|
| | % | % | % |
| Insoluble residue | 18·4 | 8·5 | |
| Iron | 42·5 | 60·5 | 22·8 |
| Lime | 5·5 | 0·58 | |
| Magnesia | 0·37 | trace. | |
| Phosphorus | 1·03 | 0·62 | |
| Sulphur | 0·033 | 0·005 | |
| Ferrous oxide | 19·0 | 21·8 | 8·1 |
| Ferric oxide | 39·6 | 62·1 | 23·6 |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{60 \cdot 5 - 22 \cdot 8}{42 \cdot 5 - 22 \cdot 8} = 1 \cdot 91$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \times 60 \cdot 5}{42 \cdot 5 \times 1 \cdot 91} = 74 \cdot 5$$

Units of tailing made per unit of concentrate = 0·91.
The percentage of iron in the crude lost in the tailing:—

$$\frac{100 \times 22 \cdot 8 \times 0 \cdot 91}{42 \cdot 5 \times 1 \cdot 91} = 25 \cdot 5$$

Tons of concentrate made per ton of crude = 0·523.

TEST No. 8.

## Magnetic Concentration of Goulais River Magnetite Iron Ores.

The Goulais River ore is extremely fine-grained. It consists almost entirely of a mixture of silica and magnetite alternating in narrow bands, the two constituents varying in their proportions widely. The leaner bands of quartz contain considerable iron, and the richer bands of magnetite appreciable amounts of silica.

The crude ores are low in iron, the Blue Cross sample carrying 33·9 per cent. and the Black Cross sample 36·8 per cent. Hence, to render the ores of economic value, concentration of the iron content and elimination of silica is necessary. Sulphur exists in only a small amount, 0·056 and 0·05 per cent, respectively.

Two methods of concentration suggest themselves as of possible practicability in bringing the ore up to a merchantable grade. First, to grind the ore to about 8 mesh and pass the product over a dry magnetic separator, using comparatively weak magnets so that only the highest grade of the ore would be separated as concentrate. This would, from the nature of the ore, entail a heavy loss of iron in the tailings. However, analyses of the separate sizes of the concentrate show that an iron content of only about 45 per cent is probably the best which could be expected.

The second method is concentration by the Gröndal process with very fine grinding, which is necessitated by the extremely fine state of division of the magnetite and gangue.

A preliminary run gave a concentrate of 53 per cent iron, with 6 per cent of iron in the tails. The screen test on the ball mill discharge from this run showed that 76 per cent passed 150 mesh; analyses of screen tests on concentrate product showed that material which passed 200 mesh carried over 60 per cent iron, whereas that which remained on the 150 mesh contained only about 42 per cent. On this account, it was decided to try the effect of regrinding the concentrate in a pebble mill. This dual grinding and separation is the method used at Sydvaranger, in Sweden, where ores of a somewhat similar nature occur, though in the Sydvaranger plant the first grinding in the ball mill is not so close as was that of the Goulais River ore.

The retreatment of the first concentrate did not bring about the expected benefit. The first concentrate from the test reported below gave a product carrying 50·5 per cent iron, with 4·3 per cent in the tailings. This concentrate, reground so that 76 per cent passed 200 mesh and re-separated, showed an increase in iron content of only 3 per cent.

It is probable that, on account of the extreme fineness of the ground material, the particles of magnetite were swept up in such masses as to prevent free escape of the siliceous material.

In place of direct regrinding and retreatment of the concentrate, classification, or sizing with Callow screens might be advisable; in which case concentrate that had passed 150 mesh and assaying about 58 per cent Fe could be dewatered and sent to the briquetting plant. This product would constitute at least 50 per cent of the whole after allowing for a considerable inefficiency in screening.

The oversize might then be reconcentrated either with or without further grinding. Below is a summary account of the tests.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| — | Crude. | Concentrate. | Tailing |
|---|---|---|---|
| Iron | 33·9 | 50·5 | 4·3 |
| Insoluble residue | 52·1 | 30·9 | |
| Sulphur | 0·056 | traces. | |
| Phosphorus | 0·090 | 0·046 | |
| Lime | 0·20 | | |
| Magnesia | 0·10 | | |

*From the above Analyses.*

The units of crude required per unit of concentrate:—

$$\frac{50{\cdot}5 - 4{\cdot}3}{33{\cdot}9 - 4{\cdot}3} = 1{\cdot}57$$

The percentage of iron in the crude saved as concentrate:—

$$\frac{100 \times 50{\cdot}5}{33{\cdot}9 \times 1{\cdot}57} = 94{\cdot}8$$

The units of tailings made per unit of concentrate = 0·57.
The percentage of iron in crude lost in the tailing = 5·2.

**Sieve Test, with Analyses, of 1st Concentrate.**

| —— | % | % Iron. |
|---|---|---|
| On 50 mesh | 1·75 | 44·4 |
| Through 50 on 60 " | 1·43 | 45·8 |
| " 60 " 70 " | 2·03 | 41·7 |
| " 70 " 80 " | 0·30 | 41·3 |
| " 80 " 90 " | 2·54 | 40·5 |
| " 90 " 100 " | 2·85 | 42·6 |
| " 100 " 120 " | 1·63 | 41·0 |
| " 120 " 150 " | 4·58 | 41·5 |
| " 150 " 200 " | 17·31 | 46·3 |
| " 200 mesh. | 65·58 | 61·4 |
| Total | | 100 |

**Analyses of Products of Retreatment.**

| | 1st Concentrate. | 2nd Concentrate. | Tailing. |
|---|---|---|---|
| Iron | 50·5 | 53·5 | 5·7 |
| Sulphur | Trace. | Trace. | |
| Phosphorus | 0·046 | 0·047 | |
| Insoluble residue | 30·9 | 25·2 | |

*From the above Analyses.*

The units of 1st concentrate required per unit of 2nd concentrate:—

$$\frac{53\cdot5-5\cdot7}{50\cdot5-5\cdot7}=1\cdot067.$$

Units of crude required per unit of 2nd concentrate = 1·067 × 1·57 = 1·68, or 0·595 unit of 2nd concentrate per unit of crude ore.

The percentage of iron in the crude saved as final concentrate:—

$$\frac{100\times53\cdot5}{33\cdot9\times1\cdot68}=93\cdot9.$$

Units of tailings made per unit of 2nd concentrate by retreatment of 1st concentrate = 0·067.

Units of tailings made per unit of 2nd concentrate = 0·68, or 0·405 units of tails per unit of crude ore.

A further test was made upon another sample of the Goulais River ore, marked with a black cross. In this test, the effect of lowering the strength of the magnets in the reconcentration was tried.

Two and one-third tons of the ore were taken, but in this case the ball mill grinding was not carried to quite such a fine stage, 76 per cent passing 150 mesh, whereas in the preceding test 82 per cent passed that size.

The concentrates from this separation were reground so that 76 per cent passed 200 mesh. In reconcentrating, a current of 3 amperes at 110 volts was first tried, but this was found to be too low to give a separation, so the current was raised to 4·1 amperes upon the first magnet, and 4·2 amperes upon the second.

The result was only a small improvement in the iron content of the concentrate, and this with a much heavier loss of iron in the tailing.

**Second Test on Goulais River Magnetite Ore Sample, marked with Black Cross.**

Machines and adjustments as in previous test, except as stated below.

*Mechanical Condition of Ball Mill Discharge.*

| First Grinding of Crude. | | % | Regrinding of Concentrates. | | % |
|---|---|---|---|---|---|
| On | 20 mesh | 0·6 | | | |
| Through | 20 on 30 | 0·8 | | | |
| " | 30 " 40 | 0·8 | | | |
| " | 40 " 50 | 1·8 | | | |
| " | 50 " 60 | 1·2 | On | 60 mesh | 1·01 |
| " | 60 " 70 | 2·0 | Through | 60 on 70 | 2·01 |
| " | 70 " 80 | 0·8 | " | 70 " 80 | 0·2 |
| " | 80 " 90 | 1·6 | " | 80 " 90 | 0·8 |
| " | 90 " 100 | 2·01 | " | 90 " 100 | 1·2 |
| " | 100 " 120 | 5·21 | " | 100 " 120 | 1·41 |
| " | 120 " 150 | 6·41 | " | 120 " 150 | 5·23 |
| " | 150 " 200 | 11·62 | " | 150 " 200 | 11·47 |
| " | 200 | 65·13 | " | 200 | 76·66 |
| | | 99·98 | | | 99·99 |

Current used upon magnets for first concentration:—

1st magnet, 5·2 amperes at 108 volts.
2nd magnet, 5·4 amperes at 108 volts.

Currents used upon magnets for reconcentration:—

1st magnet, 4·1 amperes at 110 volts.
2nd magnet, 4·2 amperes at 110 volts.

**Analyses of Crude Ore, Concentrate, and Tailing.**

| — | Insoluble Residue. | Iron. | Phosphorus. | Sulphur. |
|---|---|---|---|---|
| Crude | 50·1 | 36·8 | 0·096 | 0·050 |
| Concentrate | 26 | 54·1 | 0·046 | Trace. |
| Tailing | | 6·6 | | |
| *Reconcentration.* | | | | |
| Final concentrate | 19·2 | 58·6 | 0·047 | |
| Tailing | | 15·4 | | |

*From the above Analyses.*

Units of ore required per unit of first concentrate =

$$\frac{54\cdot1-6\cdot6}{36\cdot8-6\cdot6}=1\cdot57$$

or 0·637 units of concentrate per unit of crude ore.

Units of ore required per unit of final concentrate =

$$\frac{58\cdot6-15\cdot4}{54\cdot1-15\cdot4}=1\cdot12 \text{ and } 1\cdot12\times1\cdot57=1\cdot75$$

or 0·571 units of final concentrate per unit of crude ore.

The percentage of iron in crude saved in the first concentrate =

$$\frac{100 \times 54 \cdot 1}{36 \cdot 8 \times 1 \cdot 57} = 93 \cdot 64$$

The percentage of iron in the crude saved in the final concentrate =

$$\frac{100 \times 58 \cdot 6}{36 \cdot 8 \times 1 \cdot 75} = 90 \cdot 99$$

Units of tails per unit of first concentrate = 0·57.
Units of tails per unit of final concentrate = 0·75.
The percentage of iron in crude lost in tailing, first concentration = 6·36.
The percentage of iron in crude lost in tailing finally = 9·01.

THIRD TEST ON GOULAIS RIVER MAGNETITE.

A third test was made with the view of producing a richer concentrate, by certain adjustments of the separators. Results of this test will be incorporated in a later report.

TEST No. 9.

## Report on Magnetic Concentration of Pyrrhotite Ore, from Mr. D. A. Poe, Montreal.

The sample of ore submitted was heavily mineralized with pyrrhotite. The gangue, which is basic, shows serpentinization and similar changes of decomposition. Chemical analyses showed the pyrrhotite to contain a certain quantity of nickel and copper, though the usual minerals, pentlandite and chalcopyrite, which carry these elements, were not evident to the eye. On this account, an attempt to separate the nickel from the copper by mechanical means is not likely to meet with any practical success. A test by hand magnet, after crushing to pass a 40 mesh screen, showed this to be the case. The crude ore containing 2·84 per cent nickel and 0·76 per cent copper, gave a concentrate carrying 3·62 per cent of nickel and 0·70 per cent copper, which amounted to 68·3 per cent by weight of the original ore. The tailings show a slight increase in copper containing 0·89 per cent with 1·16 per cent of nickel.

So far as elimination of gangue alone, for the purpose of lessening smelter, freight, and other charges is concerned, magnetic concentration by means of a separator with very powerful magnets, such as a machine of the Wetherill type, would in all probability give a satisfactory saving of the nickel content, though the loss in copper would be considerable.

A roasting of the crushed ore which would save a subsequent roasting of the concentrates preparatory to smelting, would cause all the metallic contents of the ore to become magnetic, or, in case of water separation, would prevent loss from floating slimes. It is possible, however, that a counterbalancing loss might be caused by soluble sulphates formed in roasting, going into solution.

On account of the small amount of gangue present, judging from the sample sent, the treatment best adapted would be direct smelting after preliminary roasting, with bessemerizing of the matte and subsequent separation of the nickel and copper.

TEST No. 10

## Investigation of St. Lawrence River Titaniferous Iron Sands.

During the months of July and August an examination was made of the magnetic iron ore beach sands at Natashkwan, county of Saguenay, Quebec.

The examination consisted in blocking out a grassy, dune area, 3 miles long and from 200 to 600 feet wide, behind the beach at Natashkwan point. This area was then sampled at 250 ft. intervals with ordinary sand augers, to an average depth of 16 feet. One hundred and fifty-eight holes were put down in the above area, a sample of sand from each hole being bagged and marked with its survey number and depth.

Samples were also taken in the bush behind the dune area, but as the ground was very wet, preventing any appreciable depth being attained with the augers, these samples are not regarded as reliable. Samples were taken from the banks of the Great Natashkwan river, above the first falls, 12 miles from the mouth. These samples, although not rich in iron, indicate that the beach deposits have originated from the gradual breaking down of deposits of titaniferous iron ore in situ, said to be 50 miles up river.

In all, about eight tons of samples were accumulated and shipped to Ottawa for analyses and magnetic separation tests. The methods employed in resampling each bag of sand and in carrying out magnetic separation tests are as follows:—

Each bag of sand was dried to bone dryness and cut down to 100 grammes on a Jones sampler. The balance of the sand from each bag was then weighed in a measured box to ascertain its weight per cubic foot. It was then rebagged for subsequent Gröndal magnetic separation.

It should be remarked that the taking of an average sample of the dry sand is not an easy matter. The ordinary method of coneing and quartering would have been very inaccurate, inasmuch as the particles of magnetite and ilmenite accumulate at the bottom of the cone, repeated coneing and mixing simply making matters worse. Therefore, the Jones sampler was employed throughout the tests, and although the results do not indicate close accuracy they are sufficiently reliable for this class of work.

Each sample of 100 grammes, representing its respective bag of sand, was then tested for percentage of magnetic concentrate by means of an ordinary horse-shoe magnet. These separation tests were made under water, the percentages obtained representing percentages of magnetic concentrate for respective bore-holes.

Tabulated data for all bore-holes are as follows:—

## NATASHKWAN MAGNETIC IRON SANDS.

### Percentages of Magnetic Concentrate and Weight per Cubic Foot.

| Bore-hole. | Depth of Hole. | Concentrate. | Weight per cub. ft. of Crude Sand. |
|---|---|---|---|
| Number. | Feet. | Per cent. | Pounds. |
| 1 | 21 | 3.5 | 99.5 |
| 2 | 19 | 2.0 | 98.5 |
| 3 | 18 | 7.0 | 99.5 |
| 4 | 20 | 4.5 | 101.5 |
| 5 | 14 | 1.5 | 97.5 |
| 6 | 18 | 5.5 | 106.0 |
| 7 | 16 | 4.5 | 99.5 |
| 8 | 21 | 5.0 | 104.5 |
| 9 | 18 | 12.0 | 114.0 |
| 10 | 16 | 2.5 | 99.5 |
| 11 | 19 | 3.0 | 98.5 |
| 12 | 21 | 9.0 | 106.0 |
| 13 | 13 | 2.5 | 103.5 |
| 14 | 17 | 4.0 | 100.5 |
| 15 | 21 | 6.0 | 100.5 |
| 16 | 13 | 2.0 | 95.5 |
| 17 | 14 | 20.5 | 126.0 |
| 18 | 20 | 7.5 | 105.5 |
| 19 | 13 | 2.0 | 99.0 |
| 20 | 17 | 9.0 | 105.5 |
| 21 | 18 | 6.0 | 99.5 |
| 22 | 10 | 4.0 | 100.5 |
| 23 | 16 | 8.0 | 109.0 |
| 24 | 18 | 7.5 | 100.5 |
| 25 | 11 | 4.5 | 105.5 |
| 26 | 15 | 8.5 | 103.5 |
| 27 | 20 | 2.5 | 97.5 |
| 28 | 11 | 5.5 | 101.5 |
| 29 | 15 | 9.0 | 106.5 |
| 30 | 15 | 18.5 | 105.5 |
| 31 | 12 | 2.5 | 107.5 |
| 32 | 14 | 14.5 | 121.5 |
| 33 | 17 | 6.5 | 107.0 |
| 34 | 12 | 3.0 | 108.0 |
| 35 | 17 | 22.0 | 131.5 |
| 36 | 18 | 10.5 | 106.0 |
| 37 | 13 | 6.0 | 107.5 |
| 38 | 17 | 16.5 | 125.5 |
| 39 | 20 | 10.0 | 116.5 |
| 40 | 15 | 3.0 | 101.0 |
| 41 | 16 | 13.5 | 119.0 |
| 42 | 17 | 8.5 | 110.0 |
| 43 | 15 | 7.5 | 109.0 |
| 44 | 16 | 16.5 | 119.5 |
| 45 | 18 | 3.5 | 108.5 |
| 46 | 13 | 10.5 | 112.5 |
| 47 | 15 | 23.0 | 123.5 |
| 48 | 22 | 3.0 | 95.5 |
| 49 | 13 | 11.0 | 114.5 |
| 50 | 18 | 7.0 | 107.0 |
| 51 | 21 | 5.0 | 102.5 |
| 52 | 14 | 17.5 | 120.0 |
| 53 | 15 | 24.0 | 128.0 |
| 54 | 19 | 7.5 | 106.0 |
| 55 | 15 | 14.0 | 116.0 |
| 56 | 20 | 10.5 | 106.5 |
| 57 | 13 | 5.0 | 101.5 |
| 58 | 21 | 2.0 | 101.5 |
| 59 | 20 | 9.5 | 115.5 |
| 60 | 18 | 7.0 | 107.5 |
| 61 | 20 | 15.0 | 118.0 |
| 62 | 21 | 16.5 | 115.5 |
| 63 | 13 | 15.5 | 115.0 |
| 64 | 19 | 12.5 | 123.5 |

NATASHKWAN MAGNETIC IRON SANDS.—*Continued.*

## Percentages of Magnetic Concentrate and Weight per Cubic Foot.

| Bore-hole. | Depth of Hole. | Concentrate. | Weight per cub. ft. of Crude Sand. |
|---|---|---|---|
| Number. | Feet. | Per cent. | Pounds. |
| 65 | 20 | 7·5 | 113·5 |
| 66 | 21 | 3·5 | 98·0 |
| 67 | 16 | 12·0 | 112·5 |
| 68 | 20 | 5·0 | 106·5 |
| 69 | 20 | 5·5 | 99·5 |
| 70 | 16 | 13·5 | 124·5 |
| 71 | 18 | 10·5 | 107·5 |
| 72 | 18 | 11·5 | 105·5 |
| 73 | 15 | 9·0 | 104·0 |
| 74 | 19 | 2·0 | 98·5 |
| 75 | 18 | 16·0 | 113·5 |
| 76 | 14 | 8·0 | 103·5 |
| 77 | 20 | 6·5 | 110·5 |
| 78 | 19 | 8·0 | 95·5 |
| 79 | 11 | 11·5 | 106·0 |
| 80 | 20 | 13·0 | 109·0 |
| 81 | 19 | 10·5 | 107·0 |
| 82 | 10 | 9·5 | 118·5 |
| 83 | 19 | 13·0 | 108·5 |
| 84 | 18 | 10·0 | 105·5 |
| 85 | 11 | 1·5 | 95·5 |
| 86 | 19 | 10·0 | 109·5 |
| 87 | 19 | 6·5 | 107·0 |
| 88 | 9 | 10·0 | 107·0 |
| 89 | 19 | 14·0 | 104·0 |
| 90 | 17 | 7·5 | 106·5 |
| 91 | 11 | 10·5 | 110·5 |
| 92 | 18 | 6·5 | 106·5 |
| 93 | 7 | 9·0 | 104·5 |
| 94 | 12 | 11·5 | 117·5 |
| 95 | 16 | 7·5 | 112·5 |
| 96 | 17 | 12·0 | 110·5 |
| 97 | 19 | 11·5 | 110·5 |
| 98 | 15 | 7·0 | 95·5 |
| 99 | 6 | 9·0 | 107·0 |
| 100 | 14 | 19·5 | 126·5 |
| 101 | 22 | 6·0 | 101·0 |
| 102 | 21 | 2·0 | 99·0 |
| 103 | 20 | 4·0 | 100·5 |
| 104 | 19 | 7·0 | 104·5 |
| 105 | 21 | 9·5 | 105·0 |
| 106 | 22 | 11·0 | 97·5 |
| 107 | 16 | 7·0 | 108·0 |
| 108 | 21 | 7·0 | 104·5 |
| 109 | 19 | 13·5 | 100·5 |
| 110 | 19 | 2·5 | 96·0 |
| 111 | 22 | 17·0 | 117·5 |
| 112 | 19 | 2·5 | 105·5 |
| 113 | 16 | 11·5 | 116·0 |
| 114 | 20 | 15·5 | 124·0 |
| 115 | 16 | 6·0 | 107·0 |
| 116 | 9 | 16·0 | 123·5 |
| 117 | 17 | 9·5 | 112·0 |
| 118 | 14 | 21·0 | 135·5 |
| 119 | 12 | 6·0 | 107·5 |
| 120 | 18 | 8·5 | 105·5 |
| 121 | 16 | 16·0 | 118·0 |
| 122 | 10 | 13·5 | 123·0 |
| 123 | 18 | 7·5 | 103·5 |
| 124 | 16 | 29·0 | 127·5 |
| 125 | 16 | 9·0 | 115·0 |
| 126 | 19 | 7·5 | 104·0 |
| 127 | 16 | 0·5 | 95·5 |
| 128 | 14 | 15·0 | 115·5 |

NATASHKWAN MAGNETIC IRON SANDS.—*Concluded.*

## Percentages of Magnetic Concentrate and Weight per Cubic Foot.

| Bore-hole. | Depth of Hole. | Concentrate. | Weight per cub. ft. of Crude Sand. |
|---|---|---|---|
| Number. | Feet. | Per cent. | Pounds. |
| 129 | 16 | 5·5 | 103·5 |
| 130 | 10 | 4·0 | 102·0 |
| 131 | 16 | 8·5 | 109·5 |
| 132 | 18 | 3·5 | 106·0 |
| 133 | 15 | 8·0 | 106·5 |
| 134 | 17 | 17·5 | 123·5 |
| 135 | 17 | 5·5 | 108·5 |
| 136 | 16 | 28·5 | 139·5 |
| 137 | 14 | 14·0 | 115·0 |
| 138 | 17 | 6·0 | 113·5 |
| 139 | 15 | 6·5 | 110·5 |
| 140 | 16 | 6·5 | 106 |
| 141 | 14 | 8·0 | 116 |
| 142 | 19 | 9·5 | 116·5 |
| 143 | 12 | 9·5 | 111·0 |
| 144 | 19 | 7·5 | 103·5 |
| 145 | 22 | 15·5 | 116·5 |
| 146 | 9 | 3·0 | 102·5 |
| 147 | 10 | 3·5 | 100·5 |
| 148 | 14 | 5·5 | 106 |
| 149 | 22 | 6·5 | 99·5 |
| 150 | 18 | 7·5 | 108·5 |
| 151 | 11 | 4·5 | 100·5 |
| 152 | 16 | 23·0 | 126·5 |
| 153 | 13 | 6·5 | 110·5 |
| 154 | 16 | 11·5 | 114·5 |
| 155 | 5 | 12·0 | 110·0 |
| 156 | 14 | 10·0 | 114·0 |
| 157 | 10 | 3·5 | 100·5 |
| 158 | 14 | 18·0 | 119·5 |

Arithmetical averages of the above results are as follows:—

| Depth of Hole. | Concentrate. | Weight of Crude Sand. |
|---|---|---|
| Feet. | Per Cent. | Pounds. |
| 16·3 | 9·45 | 109·75 |

It will be noted that the weight per cubic foot of the dry sand does not vary according to the percentage of magnetic material. This may be accounted for by the fact that the percentages of ilmenite do not vary with the percentage of magnetite; a sample may contain much ilmenite and little magnetite, or vice versa.

Concentrates and tailings from the above hand separation tests were collected, sampled, and assayed, with the following results:—

| —— | Concentrates. | Tailings. |
|---|---|---|
| Fe | 68 10 | 8 30 |
| $TiO_2$ | 2 5 | 3 17 |
| $SiO_2$ | 1 00 | ... |
| P | 0 023 | ... |
| S | Trace. | .... |

CALCULATION OF TONNAGES IN DUNE AREA EXAMINED.

The dune area under examination was subdivided into blocks 250 feet wide and from 200 to 600 feet long. Sample bore-holes were put down at each corner and also at the mid-point of the two longer sides of each block, hence each block is represented by six bore-holes.

Based on the data on percentages of magnetic concentrate and weight per cubic foot of raw sand given on previous pages, calculations for tonnages of raw sand and magnetic concentrate were made, volumes being calculated by prismoidal formula. A summary of the results of these calculations is as follows:—

| | |
|---|---|
| Number of blocks.. .. .. .. .. .. | 55 |
| Total area.. .. .. .. .. .. .. .. | 817,566 sq. yds. = 168·92 acres. |
| Total volume.. .. .. .. .. .. .. | 4,443,892 cub. yds. |
| Average depth of bore-holes... .. | 16·3 feet. |
| Average weight of raw sand per cubic foot.. .. .. .. .. .. .. | 107·5 pounds. |
| Total weight of raw sand.. .. .. .. | 5,784,246 gross tons. |
| Total weight of magnetic concentrate.. .. .. .. .. .. .. .. .. | 501,111 gross tons. |
| Average per cent of magnetic concentrate.. .. .. .. .. .. | 8·66 per cent. |
| Average ratio of raw sand to magnetic concentrate. .. .. .. .. | 11·54 : 1. |

The above figures show that at least 500,000 tons of magnetic concentrate, containing 68·10 per cent of metallic iron, may be recovered from an area of 168·92 acres, at an average depth of 16 feet.

This tonnage is disappointingly small and it is doubtful if it would be found profitable to work, especially under the adverse conditions that obtain on the coast. It is believed, however, that magnetic concentrate will be found below an average depth of 16 feet, and as several holes put down by previous investigators have proved magnetic concentrate at a depth of from 35-45 feet, it will be a safe assumption to consider 30 feet as the workable depth of the raw sand over the area of 168·92 acres. There is no intention to assume that 8·66 per cent of magnetic concentrate will be found over this area at the depth of 30 feet. This would, of course, about double the total tonnage of magnetic concentrate as recorded above. The proof of its existence would entail a test drilling of the whole area at short intervals to the aforementioned depth.

The above remarks refer only to a comparatively small, treeless area along the shore. Behind the grassy dunes lies a wooded country of from four to five times the size of the former. There is no well founded reason why magnetic concentrate should not be found under this wooded area also. The whole of Natashkwan point for some miles along the coast is made ground, the accumulated yearly deposits of sand brought down from the interior by the Great Natashkwan river. As previously mentioned, it was found impossible to bore this wooded ground, as water prevented any appreciable depth being made with the sand augers. A reliable examination would require a well equipped sludge drill for taking accurate samples of the watery sands.

GRÖNDAL MAGNETIC SEPARATION TESTS.

The hand tests recorded on previous pages were made on samples of equal weight, *i.e.*, 100 grammes; it was, therefore, necessary to bring all bags of sand to an equal weight in order that the Gröndal machine tests would compare with the hand tests. This was accomplished with the aid of the Jones sampler to ensure proper distribution of the magnetic particles; at the same time a general sample of the crude sand was obtained for analysis.

The crude sand was then fed through a 10 mesh screen to remove chips, grass, etc., and thence direct to the separators, with the following result:—

**Analyses of Crude Sand, Concentrate, and Tailing.**

| — | Fe. | $TiO_2$ | Insol. Res. | S. | P. |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| Crude sand | 14·70 | 4·43 | 76·00 | 0·006 | 0·006 |
| Concentrates | 67·20 | 3·51 | 7·45 | 0·043 | 0·012 |
| Tailings | 8·30 | 4·70 | ... | ... | ... |

| | |
|---|---|
| Weight of crude sand fed to separators | 10,930 pounds |
| Weight of concentrate recovered | 1,087 " |
| Percentage of concentrate recovered | 9·95 per cent. |
| Ratio of crude sand to concentrate recovered | 10·05 : 1 |

The above concentrate was then ground in the Hardinge pebble mill and fed again to the separators for reconcentration.

**Analyses: 1st Concentrate; 2nd Concentrate; 2nd Tailing.**

| — | Fe. | $TiO_2$ | Insol. Res. | S. | P. |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| 1st concentrate | 67·20 | 3·51 | 7·46 | 0·012 | 0·043 |
| 2nd concentrate | 69·8 | 2·37 | 2·74 | 0·006 | 0·015 |
| 2nd tailing | 43·5 | 11·62 | ... | ... | ... |

| | |
|---|---|
| Weight of 1st concentrate fed to separators | 1,064 pounds |
| Weight of 2nd concentrate recovered | 890 " |
| Percentage of 2nd concentrate recovered | 84·03 per cent. |
| Ratio of 1st concentrate of 2nd concentrate recovered | 1·19 : 1 |

*Recapitulation.*

10·05 units of raw sand required per unit of 1st concentrate,
1·19 units of 1st concentrate required per unit of 2nd concentrate,
∴ $10·05 \times 1·19 = 11·96$ units of raw sand required per unit of 2nd concentrate,
or, raw sand yields 8·36 per cent of 2nd concentrate.

*Calculation, from Analyses, of Iron Saved.*

First concentration:—

$$\frac{67{\cdot}20 - 8{\cdot}30}{14{\cdot}70 - 8{\cdot}30} = 9{\cdot}04 \text{ units of crude required per unit of 1st concentrate.}$$

$$\frac{67{\cdot}20 \times 100}{14{\cdot}7 \times 9{\cdot}04} = 50{\cdot}5 \text{ per cent iron saved.}$$

Second concentration:—

$$\frac{69{\cdot}8 - 43{\cdot}5}{67{\cdot}2 - 43{\cdot}5} = 1{\cdot}1 \text{ units of 1st concentrate required per unit of 2nd concentrate.}$$

$$\frac{69{\cdot}8 \times 100}{67{\cdot}2 \times 1{\cdot}1} = 94{\cdot}42 \text{ per cent of iron saved.}$$

Percentage of original iron saved in second concentrate =

$$\frac{50{\cdot}5 \times 94{\cdot}42}{100} = 47{\cdot}68.$$

A recrushing and reseparation of the second concentrate was made in an effort to depress $TiO_2$ below 1 per cent. Analyses for this test are not yet completed.

A complete report on Natashkwan sands will be issued at an early date: this report will be illustrated and will contain much data that is unavailable at present.

ENLARGEMENT OF THE ORE DRESSING AND METALLURGICAL LABORATORIES.

The fact that the installation at Ottawa of the present testing plant for magnetic iron ores has met with evident approval and appreciation from men engaged in the iron and steel industry has led to the conviction that a considerable enlargement of plant will be of distinct value to the general mining and metallurgical industries.

A well equipped testing laboratory will enable officers of the Mines Branch to carry out test work and research investigation in connexion with the dressing and metallurgical treatment of various Canadian ores. The need of such a laboratory is apparent with the statement that no such experimental research plant at present exists in Canada.

The machinery already installed is crowded into a small room at the Fuel Testing Station to an extent that absolutely precludes the addition of more apparatus. This condition is, however, to be improved by the immediate construction of a substantial addition to the present building.

The new building, which will be under construction by the time this report is published, will have a floor space of 57 × 75 feet, and will contain, besides a large mill room, several laboratories for analytical work.

The milling machinery to be installed will, it is expected, consist of both standard and small sized units to meet various requirements, and, although some time may elapse before the equipment is completed along modern lines, the laboratory will eventually possess sufficient latitude and elasticity to cope with the more general demands of the mineral industry in Canada.

ORE DRESSING AND CONCENTRATING LABORATORY.

During the current year, general approval of the purpose and work of the ore-dressing and concentrating laboratory operated under the direction of the Mines Branch, has been expressed by the mining public. The conditions which appeared to require the establishment of such a laboratory, as well as the results which it was hoped would be attained, have already been referred to in the Summary Report for 1910.

A scarcity in the domestic supply of high grade iron ore on the one hand, and extensive but as yet undeveloped deposits of low grade iron ore on the other, may, in a word, be considered as among the chief conditions which to-day confront the Canadian iron masters and determine the output of Canadian furnaces. By concentration of our lower grade ores, and by the elimination of such impurities as sulphur, phosphorus, and titanium, when present in excess, it is hoped that large iron deposits, which up to the present time have been considered as of little or no value, may become profitable sources of supply for our own blast furnaces.

During the year just closed, trial shipments of low grade iron ores were received from Robertsville, Goulais river, and Culhane, in the Province of Ontario; from the Natashkwan river, in the Province of Quebec; from the Gloucester iron deposits, in the Province of New Brunswick, and from the Nictaux-Torbrook deposits in Nova Scotia. Tests of these ores regarding their adaptability to concentration and purification, by means of the Gröndal magnetic separation, were carried out under conditions approximating, as nearly as possible, those of commercial practice. A sample of nickeliferous pyrrhotite from a deposit near Nairn, Ont., was also tested with a view to determining the treatment best adapted for extracting the nickel and copper content.

The above work was carried out in the ore-dressing laboratory of the Mines Branch under the direction of Mr. G. C. Mackenzie, and detailed results, as well as an outline of methods employed, will be found in his report. In addition to this work Mr. Mackenzie also spent a part of the field season in a systematic examination of the deposit of iron-bearing sands lying along the north shore of the St. Lawrence, near the mouth of the Natashkwan river. Previous investigation carried on at various times by different parties has resulted in a considerable divergence of opinion regarding the possible economic value of these sands. The enormous deposits which are known to exist, not only on the Natashkwan, but elsewhere as well along the lower St. Lawrence, render the accurate determination of their probable value a matter of considerable importance. Consequently the results of Mr. Mackenzie's work in the field and of the subsequent concentration in the laboratory of a shipment of the iron-bearing sands will be read with interest. It appears, however, that further investigation will be required to finally determine the commercial value of these deposits.

The work of the ore-dressing laboratory has, during the past year, been considerably handicapped owing to insufficient accommodation. Contemplated alterations in the plant will, it is expected, greatly improve conditions in this respect.

# THE BUILDING AND ORNAMENTAL STONES OF THE MARITIME PROVINCES.

BY

*Professor William Arthur Parks, B.A., Ph.D.*

Acting upon instructions received from the Director, I spent three and a half months of the field season of 1911 in the examination of quarries in the Maritime Provinces and Quebec. Leaving Toronto on June 3, I was engaged in the Maritime Provinces until August 21 and spent the rest of the time in the Province of Quebec, arriving in Toronto on September 21.

The information obtained in New Brunswick, Nova Scotia, and Prince Edward Island will be used in the preparation of a Report on the Building and Ornamental Stones of the Maritime Provinces, which will form the third part of a monograph on the building and ornamental stones of Canada. The field work in Quebec was confined to the region north of the St. Lawrence river; the data obtained will be reserved until the southern part of the Province has been examined.

The economic production of stone for structural purposes in the Maritime Provinces is practically confined to granite and sandstone. A brief account of the condition of the industry is given below for each Province separately.

## NEW BRUNSWICK.

*Granite.*—The red, pink, and grey granites of St. George and the black granites of Bocabec, in Charlotte county, are being quarried by several firms; the product is nearly all manufactured into monuments in the extensive mills at St. George. In this county also, there is a small and intermittent production of grey granite from the vicinity of St. Stephen.

Near Hampstead, on the St. John river, the so-called Spoon Island stone is worked in two extensive quarries by D. Mooney & Company, of St. John. Both pinkish and grey, rather coarse-grained stone is obtained which is employed for monuments, for building, and for the making of paving blocks.

The rough grey granite boulders which are so plentifully scattered over the area north of McAdam Junction, in York county, are cut into building blocks by different operators and employed for structural purposes in Woodstock and other towns.

Near Bathurst in Gloucester county, a coarse-grained granite is from time to time quarried for local use.

*Sandstone.*—Roughly speaking, the sandstones of New Brunswick may be classified into red, grey, olive-green, and brown types. An excellent red freestone is quarried near Sackville, in Westmorland county, by the Sackville Freestone Company. The formation at this point is very favourable for the profitable extraction of stone. Large quantities are quarried and dressed by a modern plant, the product, in many cases, being shipped to a distance.

True grey sandstones occur along the Gloucester coast of Chaleur bay; they are quarried by two companies for the making of grindstones. The cost of quarrying is, however, too great to allow this material being put on the market as a building stone.

Olive-green sandstone is quarried in Northumberland, Kent, and Westmorland counties.

The quarry region in Northumberland is situated on the Miramichi river, near Newcastle. Two firms are now actively engaged—the Miramichi Quarry Company, Quarryville, and Adam Hill, Cassilis. C. E. Fish, of Newcastle, proposes to reopen the old French Fort quarries at an early date.

In Kent county, olive-green sandstone is quarried near Notre Dame, on the Moncton and Buctouche railway, by Hall and Irving, of Moncton.

Westmorland county was for many years the chief seat of the freestone industry in New Brunswick. At the present time a great many of the old quarries near Shepody bay and Cumberland basin are idle. H. Read and Company are operating a quarry at Northport, and the Dorchester Stone Works have a small quarry on the point between the Petitcodiac and Memramcook rivers. Near Shediac, Dr. E. G. Smith is producing a stone which may be included in this class.

Brown sandstone is quarried by the Read Company, at Wood point, in Westmorland, for grindstones, and the Cape Bald Freestone Company, of Port Elgin, is getting out building blocks at Cape Bald, on the eastern coast of Westmorland.

Crystalline limestone is largely quarried for the manufacture of lime at St. John, with the incidental production of a small amount of rough building stone.

The pure white gypsum at Hillsborough, in Albert county, has, in the past, been employed as a decorative stone, but there is no production for that purpose at present. The porphyritic felsites of Passamaquoddy bay, the Tobique valley, and elsewhere may have a future value as decorative stone but they are not at present utilized.

## NOVA SCOTIA.

*Granite.*—A greyish, coarse-grained, and porphyritic granite is quarried by several firms along the Northwest Arm, near Halifax. At Terrence bay, a coarser and lighter coloured type was quarried for the construction of the Bank of Commerce in Halifax.

On the west side of Shelburne harbour, in Shelburne county, a very fine grey granite was formerly obtained. The character of the stone and the excellent shipping facilities should encourage the further exploitation of this deposit.

At Nictaux, in Kings county, are extensive exposures of an excellent fine-grained grey granite resembling the famous stone from Barre, Vermont. The Middleton Granite and Marble Company, Thelbert Rice, S. Williamston, and John Kline, of Halifax, are quarrying this stone for structural and monumental purposes.

*Sandstone.*—The sandstones of this Province are, for the most part, of an olive-green or reddish colour, and are obtained more particularly in Cumberland and Pictou counties.

The most important quarry of red stone is that of the Amherst Red Stone Quarry Company, near Amherst. Two small operators are producing a reddish stone near River John, in Pictou county. At Toney river and other places along this coast, as well as at Whycocomagh and Judique, Inverness county, Cape Breton, there was a former production of red sandstones.

Olive-coloured sandstones were at one time extensively quarried along the coasts of Chignecto bay and Northumberland strait, in Cumberland, Pictou, and Antigonish. In Cape Breton they were obtained, more particularly, on Boularderie island and at points near Sydney. At the present time there are only two quarries worthy of mention here, although small amounts of stone are raised by other operators. The quarries of the Wallace Stone Company, at Wallace, in Cumberland county, have furnished stone for many of the chief buildings in eastern Canada, and are still in active operation. The Pictou Quarry Company, of Pictou, produces a fine grade of stone which rivals the Wallace product in popularity.

*Metamorphosed Slate.*—A hard stone of this character is quarried on the Northwest Arm below Halifax. The product is largely employed for purposes of rough construction and, in some few cases, has been used in buildings of a higher type.

*Crystalline Limestone.*—The demand for flux in the steel plants has led to the opening of very large quarries at Marble mountain and George river, in Cape Breton. Good exposures have in consequence been made which reveal the shattered nature of the formation. Although fair-sized pieces of considerable beauty could be obtained from time to time, there does not seem to be much promise of success in the operation of these quarries for marble. Variegated crystalline limestones of marble quality are known to occur at other points in Cape Breton: among these may be particularly mentioned Whycocomagh and Eskasoni. No positive evidence was obtained that these deposits are capable of economic working, as they are much covered by soil and present only isolated exposures.

*Felsite-breccia.*—Along the coast of Richmond and Cape Breton counties, and more particularly on the north shore of Scatari island, handsome, varicoloured felsite-breccias occur. Although this material could not be secured in very large blocks, pieces of sufficient size for many decorative purposes could be readily obtained. Somewhat less brilliant but still handsome felsites may be obtained at many points in Pictou, Antigonish, and Guysborough counties.

## PRINCE EDWARD ISLAND.

The only stone suitable for building produced in this Province is a red and not very durable sandstone of the Permo-Carboniferous age. Small and unimportant quarries have been opened at many places, but the only production at present is from Swan's quarry, near Charlottetown.

In the Maritime Provinces, as in other parts of the country, the stone industry has suffered severely from the general introduction of cement for purposes of construction. Those quarries which formerly produced heavy stone of a coarse type for bridge building and other works of a like nature are practically all closed. The long haul by rail to the chief centres of consumption is a deterrent factor in the profitable working of the finer grades of sandstone. The failure of the numerous quarries about the head of the Bay of Fundy has been ascribed to the almost prohibitive duty imposed by the United States Government. This same factor has had much to do with the closing of the granite quarries at Shelburne. It is encouraging to observe that Wallace, Pictou, Sackville, Amherst, and Miramichi stone can be profitably quarried and shipped to points as far distant as Toronto. It should be remembered also that many of the old quarries at Mary point, Demoiselle creek, Boudreau, etc., were operated almost entirely without machinery. Strong companies with modern equipment might well be able to revive the industry in this district.

The granite quarries of Charlotte county are handicapped by the long haul by team into St. George, by the small scale on which operations are conducted, and by the fact that no outlet is found for the large amount of debris. The stone has been quarried for monumental or large structural work only: in consequence, immense piles of material have accumulated from which paving blocks and even building stone of fair size could easily be cut. It is stated that an effort is being made to form a company embracing the various interests. It is to be hoped that such an attempt may meet with success, for such a company could concentrate the quarrying, provide better means of transportation, and devise ways for the utilization of the smaller stone.

# SUMMARY REPORT ON THE SUDBURY NICKEL FIELD.

*Professor A. P. Coleman, Ph.D.*

Owing to the increase in the world's demand for nickel the Sudbury region, which supplies more than 60 per cent of the whole output, is now receiving an unusual amount of attention. The two old companies are extending their mining operations and are increasing their known reserves of ore either by diamond drilling to determine the extent of deposits which they already own or, where possible, by acquiring new ones. In addition another company is developing hitherto unworked deposits in preparation for the erection of smelters and other works for treating their ores; and a fourth is on the look out for properties of value not yet controlled by the three companies earlier in the field.

Owing to these conditions and also to the further opening up of the region by roads and railways, it is evidently an opportune time to note the advances in the Sudbury nickel field, to revise the latest map of the district, now six years old, and to prepare a report bringing up to date our knowledge of this important mining region.

Under instructions from Dr. Eugene Haanel, Director of Mines, this work was undertaken during the summer of 1911: in continuation of my two previous seasons work in the same field, studying the relationships of the more important mines.

By way of preparation, advantage was taken early in the summer, of a visit to Europe, to examine the only regularly working nickel mine in Europe, at Evje, in Norway, and to inspect the smelter at Evje, and the refinery at Christiansand, where, under the management of Mr. Hybinette, the nickel and copper in the matte are separated and refined electrolitically. The process is apparently a commercial success, since the works are being enlarged. The Mond nickel refinery at Clydach, Wales, was visited also, by the kind permission of the Mond Nickel Company: where a totally different method of treating the matte (derived from the Sudbury region) has also become a commercial success, so that the plant is to be greatly enlarged.

On July 8, Sudbury was reached and plans were made to revise the map of the region prepared for the Bureau of Mines of Ontario in 1905, and to visit every mine, whether now working or not, and also all known prospects of promise.

As all the known deposits are more or less directly connected with the basic edge of a great synclinal sheet of norite merging into micropegmatite, the summer months, until the first of October, were devoted to an examination of this basic edge.

The work was begun at the Trillabelle mine, at the southwest end of the boat-shaped syncline, and was carried southwest past the Chicago and Sultana mines to Victoria mines, the property of the Mond Company. The mine is working upon two ore-bodies of comparatively small horizontal dimensions, but of astonishing continuity, since they have been followed downwards for 1,600 feet without a break, and promise to go on indefinitely. Victoria mine is by far the deepest mine in Ontario and is surpassed by only one or two in British Columbia.

From Victoria mine the basic edge was followed northeast to the Crean Hill mine, belonging to the Canadian Copper Company, where very interesting relationships are found, since the country rock to the south has been thrust over the norite along a gently inclined fault plane. In this process the greenstone of the country rock was greatly shattered and ores from beneath penetrated all the fissures. It is probably owing to this fact that more copper than nickel is produced by this mine, a very unusual feature not observed elsewhere in the region except at the old Copper Cliff mine.

The small but wonderfully rich Vermilion mine, famous for its platinum and gold, lies a short distance southwest of Crean Hill. Northeast of Crean Hill the basic edge has disclosed no large ore-bodies for 6 miles, at which point Gertrude mine, the property of the Lake Superior Corporation, was worked some years ago. A mile and a half farther east is the Creighton mine, the largest operating nickel mine in the world, situated where a bay of the norite projects southeast into the country rock of granitoid gneiss. The Creighton has the richest ore of any large mine in the region, and now furnishes about half of the nickel of the world. The diamond drill has proved that the ore-body continues for a long distance beyond the present workings, so that there are large reserves of ore.

The next important group of mines is on the Copper Cliff offset, where the famous Copper Cliff mine, more than 1,000 feet deep, is no longer working; though No. 2, a larger pipe-like ore-body, is being worked a little to the north.

Farther to the northeast none of the mines are working except the Garson, 12 miles from Copper Cliff; but shafts are being sunk on the Frood, or No. 3, mine by the Canadian Copper Company, and on the Frood Extension by the Mond Company. Diamond drilling has proved that this long outcrop of ore dips toward the basic edge of the norite, and that the deposit is much the largest in the district, quite surpassing the Creighton in quantity, though not equalling it in grade of ore.

Diamond drill work has also been carried on at the Mount Nickel mine, north of the Frood, showing the presence of a good body of ore.

The Garson mine, recently opened up by the Mond Company, now produces more ore than the Victoria mine. Here, as at Crean Hill, a great fault has shifted and fractured the norite and greenstone, breaking them into large irregular blocks, between which the ore has been deposited; though here the fault plane is nearly vertical. Here, too, copper ore is unusually abundant, about equalling the nickel in amount.

On what may be called the Eastern Nickel Range two new finds have been made, and the diamond drill has shown that some of the old properties are of more importance than was suspected. The Whistle mine at the north end of the range is being rapidly developed, and has proved to contain a great amount of ore. It has been connected by the Nickel Range railway with the Northern Ontario Branch of the Canadian Northern.

Much diamond drilling is being carried out on properties of the Northern Nickel Range by the Dominion Nickel and Copper Company with some very encouraging results, and this range, now almost inaccessible except on foot, will probably soon be reached by a westward extension of the Nickel Range railway.

Following the basic edge of the norite from Bowell township southwest to the region of Trillabelle mine completes the circuit of the nickel-bearing eruptive. Along this portion ore has been found at four points, but there has been little advance in development for a number of years.

The work of the past summer has resulted in a large number of changes in the map of the nickel ranges, most of them, however, of small extent. The results of the work confirm the opinion held by geologists and most mining men, that the ore deposits are the result of magmatic segregation from the norite-micropegmatite sheet with which they are connected. It is of interest to find that almost all the development work now being done, especially the diamond drilling, is closely checked in accordance with the geological principles resulting from the theory mentioned above, so that the work of the geologists who mapped the region is of direct practical value to the mine owners.

Advances in the metallurgy of the ores are being made by the Canadian Copper Company in increasing the proportion of green to roasted ore smelted, giving an approach to pyritic smelting, in the construction of a reverberatory furnace to treat fines and flue dust, and in the introduction of immense converters with a basic lining to replace the small acid-lined converters.

The Mond Company are now constructing a new and much enlarged smelter at Coniston, conveniently placed, with good railway connexions between their two producing mines.

The Dominion Nickel and Copper Company are developing their ore-bodies, some of which are now known to be large, so as to be sure of a plentiful supply before beginning a smelter.

In an unostentatious way the Sudbury mining district is making rapid and yet solid advances, and bids fair to be the most steadily prosperous metal mining region of Canada. The peculiar character of the ore-bodies which follow the margin of a great mass of eruptive rock dipping away to unknown depths, suggests that mining may follow them also to great depths, giving a permanency to the camp which cannot be hoped for in most other mining regions.

# COPPER AND PYRITES.

*Alfred W. G. Wilson.*

## PYRITES INDUSTRY.

The manufacture of chemicals and chemical products forms the most important group of the industries of any country. Sulphur is a mineral product which is basic to the chemical industries. Directly or indirectly, it enters into the manufacture of a vast number of products. It occurs native in certain regions of past or present volcanic activity. It also occurs in association with copper, iron, and other metals, forming sulphides of these metals; of these compounds, iron pyrites is an important commercial source of sulphur.

In Canada native sulphur occurs only as a mineralogical curiosity; the sulphides of iron and copper are, however, found in many places, and in some few localities they occur in bodies large enough to be mined profitably.

During the past two years many inquiries have been received from firms in the United States with respect to Canadian pyrites. A brief investigation, made about two years ago, while studying the copper industry of Canada, led me to recommend the preparation of a special bulletin on pyrites and its uses. The purpose of this bulletin was to stimulate our pyrite mining industry by drawing the attention of producers to the large market for this product which lies at their doors. It was also hoped that Canadian consumers of sulphur might be attracted to our home product and its possibilities.

The winter months of the year 1911 were spent in the compilation of this report on pyrites and its uses. Publication has been delayed by causes beyond the control of this Department. Advantage is being taken of this delay to revise and expand the text, and it is hoped that it will be published early in the present year.

During the year 1910, eight firms (six in Ontario and two in Quebec) were mining and shipping pyrites ores in Canada. During the past year only seven firms have been mining ore, but several of these firms have done extensive development work. No new properties have come into the market, though a good deal of prospecting work is under way.

The following table compiled from statistics furnished by Mr. John McLeish, Chief of the Division of Mineral Resources and Statistics, will serve as an index to the magnitude of the Canadian pyrites industry during the last six years.

**Canadian Pyrites Industry, 1906-1911.**

| Calendar Year. | Production. Tons of 2,000 lbs. | Value in dollars. | Tons Exported. | Value. | Balance stocked or Home Consumption. |
|---|---|---|---|---|---|
| 1906 | 42,743 | 169,990 | 26,050 | 65,349 | 16,693 |
| 1907 | 46,243 | 212,491 | 25,056 | 80,139 | 21,187 |
| 1908 | 47,336 | 224,824 | 17,283 | 96,600 | 30,053 |
| 1909 | 64,644 | 222,812 | 35,798 | 156,644 | 28,846 |
| 1910 | 53,870 | 187,064 | 30,434 | 110,071 | 23,436 |
| 1911 | 82,666 | 365,820 | 32,302 | 120,585 | 50,564 |

It is to be noted that in calculating tonnages for statistical purposes, the actual sulphur content is not considered. The sulphur content of Canadian pyrites ores varies from 32 to 50 per cent. the average being probably about 42 per cent.

Small amounts of foreign pyrites, chiefly Spanish ore, are imported into Canada, but these importations are lumped under the heading, "Ores all other," in the Canadian Customs returns, and no statistics are available to indicate the tonnage. The Canadian home consumption is probably fairly well represented by the difference between the production and the exports, as very few of the mines stock large quantities of ore.

Returns published by the United States Government show that in the year ending June 30, 1911, 894,281 tons (2,240 lbs. each) of pyrites ore, containing not less than 25 per cent sulphur, were imported. During the same period, the home production was in the neighbourhood of 200,000 tons, and the amount exported was very small; hence, the annual consumption of pyrites in the United States is in the neighbourhood of one million tons.

The greater portion of the pyrites ore imported into the United States comes from Spain and enters through Atlantic ports, Boston, New York, and Philadelphia chiefly. From some of these ports a considerable tonnage finds its way to chemical works located on or near the Great Lakes.

Data compiled in my office, and obtained by direct correspondence with United States' consumers indicate that there exists, at the present time, in the vicinity of the Great Lakes alone, a market for more than 200,000 tons of pyrites ore suitable for acid-making—nearly four times Canada's whole present annual production. A very considerable portion of this market is supplied by domestic ores, but no data are at hand to determine the proportion of domestic and foreign ores now used in the vicinity of the Great Lakes. We find from the reports of the Customs Department that more than half the Canadian pyrites which is exported finds its way to the eastern market in the United States; hence the tonnage which reaches the Great Lakes market from Canada is very small. Inasmuch as freight rates to lake ports from many Ontario points, at which pyrites deposits occur, are comparatively low, it would appear as if this market offers great possibilities to owners of pyrites deposits in that Province.

Pyrites suitable for acid-making should contain as much sulphur as possible. Pure pyrites contains 53·4 per cent sulphur. The greater number of acid-makers demand a product containing not less than 42 per cent sulphur; there are, however, a few large consumers who purchase ore as low as 37 per cent. Practically all purchasers demand that the ore be free from arsenic, though in certain fertilizer works, ore, otherwise desirable, will be accepted if the arsenic content does not exceed one per cent. The ore should also be free from copper, zinc and lead, lime and magnesia, fluorine, chlorine and selenium. Ore containing pyrrhotite, as well as pyrite, is not desirable, though it will be purchased by some consumers, if the sulphur content is not too low.

The present price on the New York market for domestic, non-arsenical pyrites is about 12 cents per unit of sulphur, f.o.b. railway, for furnace size. Domestic non-arsenical fines are quoted at rates between 10 and 12 cents per unit. Arsenical ore brings a slightly lower rate, while non-arsenical Spanish ore usually commands a higher price

At the present price of 12 cents per unit, ore containing 40 per cent sulphur would be worth $4.80 per ton f.o.b. New York. In the Great Lakes market, Canadian pyrites of suitable quality should command a slightly higher price. According to the last report of the Ontario Bureau of Mines, the average price, at the mine, for Ontario pyrites, during the year 1910, was $2.90 per ton. The average sulphur content of this ore is not given.

Contracts with consumers are usually made for periods varying from two to five years; a minimum sulphur content and a minimum tonnage delivery per month are usually specified. It may be an advantage to Canadian producers or prospective producers to know that I heard a number of complaints about irregular deliveries and too low sulphur. How well founded these complaints were, I am not able to say. However, it is necessary to remember that a reputation for promptness is highly desirable in obtaining and in holding a large and important market of this kind.

The very small margin, which remains for the producer between mining costs and receipts for a low grade ore like pyrites, often makes it difficult for some owners to carry development work far enough in advance of mining to ensure a regular output. The mining of pyrites ore will be profitable in itself, only where large tonnages are produced and marketed. The small producer, who places his product on the market instead of utilizing it in a plant of his own, not only has to be content with a smaller margin of profit, but he will have greater difficulty in keeping his ore up to grade; under such conditions it also will usually be difficult to maintain a uniform output. Consequently, the small producer must expect to have difficulty in marketing his product.

In this connexion, it might be pointed out that a Pyrites Producers' Association for marketing the output of various mines would materially aid a number of the smaller properties now in course of investigation and would be of advantage to the industry as a whole. It would also be found that such an association would be of benefit to owners and producers in a number of other matters where mutual support and co-operation are desirable.

Owners of pyrites properties will be interested to know that there is some prospect of the development of a larger home market for pyrites ores. The question of the utilization of pyrites ore in the manufacture of sulphide pulp is being investigated by a number of large paper manufacturers. This process is in successful operation in many European plants, and will probably be introduced into Canada in the near future if a regular supply of suitable ore can be guaranteed for a sufficiently long term of years. This subject will be discussed more fully in the complete report on pyrites and its uses.

## THE COPPER INDUSTRY.

The field work of this season was confined to British Columbia. During the summer, visits were paid to all the operating mines and to all the smelters in British Columbia treating ores of copper. The shortness of the time available for field work made it impossible to visit the copper prospects and other properties around the head of the Portland canal and in the Yukon, where exploration and development work is in progress. For the same reason, many localities in British Columbia, where copper minerals have been discovered, but where mining development has not yet taken place, were omitted from the itinerary. The return journey was made through the United States for the purpose of visiting some of the larger copper-producing districts, such as Ely and Bingham Canyon. Visits were also made to several of the large concentrating plants and smelting works in Utah, Montana, and elsewhere.

British Columbia has been, for many years, Canada's most important producer of copper. For the year 1912 the statistical returns show a slight increase in the production over previous years. That this increase is not greater can be attributed in a considerable measure to the closing of the Crowsnest collieries during nearly eight months of the year because of a strike among the miners. Because of this strike, the three large smelting industries, operating in south central British Columbia, were compelled to import coke from Pennsylvania, with resultant higher costs per pound for the copper produced. About the middle of August, it became necessary for the smelter of the Granby Consolidated Mining and Smelting Company, at Grand

Forks, to shut down. The mines at Phœnix were also closed at the same time. Work at the collieries has now been resumed and the Granby Company's mines and smelter resumed operations late in the month of December.

*Mining Industry.*—Inasmuch as it is hoped that the report on the copper industries of Canada will be completed during the present year, it is not necessary to discuss the season's operations of the various copper-producing corporations. It may be noted, however, that the three largest operators, the Canada Consolidated Mining and Smelting Company, the Granby Consolidated Mining and Smelting Company, and the British Columbia Copper Company, were all engaged in exploring various undeveloped properties, with a view to the discovery of new commercial bodies of ore.

Probably the most important development work is that of the Granby Company at their Hidden Creek mines on Goose bay, Observatory inlet. Here, by a system of tunnels and supplementary diamond drilling, a large body of sulphide ore has been developed. A tonnage, estimated at about 6,000,000 tons of 2 per cent ore, or about 12,000,000 tons of 1·65 per cent ore, has been shown to be present. In addition, development work has shown a very considerable tonnage of ore of a higher grade—above 5 per cent—and a large tonnage of lower grade. A large force of men has been employed during the year on development work, and in preparing for the operation of the property on a large scale. It is altogether probable that a smelter will be erected at Granby bay to treat the ores from this mine.

The erection of a smelter at this point will be a matter of considerable importance to the owners of many prospects along the Pacific coast of British Columbia. There are numerous indications of copper ores at many points, and the possibility of marketing copper ores near at hand will undoubtedly stimulate further prospecting and may lead to the development of other important mines.

During the year extensive development work has also been in progress at the Britannia mines on Howe sound, and a very considerable tonnage has been mined and shipped. On Texada island the Marble Bay mine continued to ship bornite ore; exploration work was in progress at the Cornell mine and at the Little Billy. Some prospecting work was also in progress on several claims on the Queen Charlotte islands.

*Smelting Industry.*—During the year, three smelters were practically in continuous operation—Tyee Copper Company at Ladysmith, British Columbia Copper Company at Greenwood, and Canada Consolidated Mining and Smelting Company at Trail. The plant of the Granby Consolidated Mining and Smelting Company, at Grand Forks, was closed from the middle of August until about the middle of December, on account of a shortage of Alberta coke. Advantage was taken of the shutdown to make a number of alterations and improvements and to install a new plant for slag distribution. In brief, the slag is to be granulated by water and sluiced to central bins. From these bins, it will be elevated by belt conveyers to a transverse distributer belt which stands 120 feet above the present dump. By this means, the capacity of the present space available for slag dump will be greatly increased.

The plants of these operating companies will be described in some detail in the forthcoming general report.

A series of experiments in the use of oil for fuel have been in progress at Van Anda, Texada island, for some time. The Dominion Oil Smelting Company, of Vancouver, have erected an experimental oil-burning furnace in the building of the old smelting works at this point. This furnace is based on the patents of James J. Andersen. As the result of a series of experimental runs, the original construction has been remodelled. The plan and section of the remodelled furnace are shown in the adjoining sketches and will serve to give a general idea of its construction. Further details will be found in Canadian Patent, Number 104553. An experimental run was made under the supervision of Thomas Kiddie, M.E., of Vancouver, in July, 1911. Mr. Kiddie reports that the cost of oil consumed should approximate 30 to 35 cents per ton of ore smelted, and he estimates the saving of labour costs at the furnace at 9 cents per ton of ore smelted.

After this run, the furnace was remodelled along lines recommended by Mr. Kiddie, and at another run, made in November, a fuel cost of 33·6 cents per ton was attained, Mr. W. C. Thomas, Metallurgist, of Vancouver, being in charge. Further experimental runs are contemplated.

# I.

## THE IRON ORE DEPOSITS ALONG THE CENTRAL ONTARIO RAILWAY.

*E. Lindeman, M.E.*

During the field season of 1911, the examination of the iron ore deposits along the Central Ontario railway was continued by the writer.

The points visited were as follows:—

Blairton mine—Lots 7 and 8, concession I, Belmont township.

Belmont mine—Lot 19, concession I, Belmont township.

Maloney mine—Lot 18, concession I, Marmora township.
Lots 12, 13, and 14, concession I, Marmora township.
Lot 17, concession II, Marmora township.

Seymor mine—Lot 11, concession V, Marmora township.

St. Charles mine—Lot 19, concession XII, Tudor township.

Horten mine—Lot 57, Hastings Road, Tudor township.
Lot 17, concession XI, Lake township.
Lots 19 and 20, concession IV, Lake township.

Baker mine—Lot 18, concession XVIII, Tudor township.

Emily mine—Lot 7, concession XIX, Tudor township.
Lot 8, concession XV, Tudor township.

Coe Hill mine—Lots 15, 16, concession VIII, Wollaston township.

Jenkins mine—Lots 17, 18, concession VIII, Wollaston township.
Lots 9 and 10, concession XV, Wollaston township.

Ridge—Lots 17, 18, concession II, Wollaston township.
Lots 16, 17, concession III, Wollaston township.
Lot 28, concession XXVIII, Chandos township.

Bessemer—Lots 1-5, concession VI, Mayo township.

Rankin property—Lot 10, concession IX, Mayo township.

Childs property—Lots 11, 12, concession IX, Mayo township.

Stevens property—Lots 13, 14, concession IX, Mayo township.

Kennedy property—Lot 17, concessions V and VI, Carlow township.
Lot 30, concession XIII, Dungannon township.

Bow lake—Lot 21, concessions X and XI, Faraday township.

During the summer magnetometric and topographical surveys were made of the following properties:—

Blairton mine.
Belmont mine (topography).

St. Charles mine.
Baker mine.
Ridge property.
Coe Hill mine.
Jenkins property.
Rankin " (topography).
Childs " (topography).
Stevens "
Kennedy "
Bow lake "

In this work the writer had the advantage of the able assistance of Messrs. W. M. Morrison and O. G. Gallagher.

LOCATION.—The iron ore occurrences covered by the season's field work are situated along the Central Ontario railway, between Central Ontario Junction and the village of Bancroft, the distance between these two points being 60 miles.

The distance of the various deposits from the railway varies from 12 miles down to a few hundred feet.

HISTORY.—Some of the iron ore deposits in Hastings and Peterborough counties have been known for many years, and as early as 1820 an attempt was made, at Marmora, to manufacture pig iron from magnetite, taken from Blairton mine.

The venture does not seem to have met with any success, however, and operations were discontinued.

In 1867, the Blairton mine was opened again and mining was carried on until 1875. In 1882, the building of the Central Ontario railway was commenced, with the object of opening up the numerous iron ore deposits of North Hastings. At this time mining operations were commenced at Coe Hill and in several other places, but it was soon found that the iron ore contained so much sulphur as to be unmarketable, and the mines were closed. In 1906, a part of the Bessemer and Barrys Bay railway was built, connecting the ore deposits at Bessemer with the Central Ontario railway at a point about 1 mile south of L'Amable station. Mining operations were carried on by the Mineral Range Iron Company, until the beginning of 1908, when the properties were leased to the Canada Iron Furnace Company.

This Company continued operations until April, 1910. In the spring of 1911, the Bessemer, Child, Coe Hill, and Blairton properties were acquired by a corporation known as the Canada Iron Mines, Limited. This new Company commenced mining operations at Bessemer in August, 1911, and intends to erect in the near future a magnetic concentration plant at Trenton for the treatment of their ores.

GEOLOGY.—The greater portion of the area is occupied by Archæan rocks, consisting of crystalline limestones interstratified with a series of gneisses and schists and intruded by various igneous rocks such as granites, syenites, diorites, and gabbros. On the denuded surface of these Archæan rocks the various sediments constituting the lowest beds of the Palæozoic series have been deposited. These latter are found in the most southerly portion of the area, covering the older rocks in the form of a more or less continuous sheet. The crystalline limestne of the district generally has a coarse texture, and is more or less impure, owing to the presence of various silicates. The rocks which have been classified as gneisses are probably all of sedimentary origin. They sometimes represent alterations of more or less highly argillaceous sediments, while others are rich in quartz and seem to appear to mark transitions to true quartzites.

Associated with the gneisses, and often passing into them, are dark-coloured basic schists, which have been grouped by Adams and Barlow under the general name of amphibolite.[1] Their chief constituents are hornblende and feldspar, but pyroxene and biotite often take the place of the hornblende in part. Regarding the origin of this series, while some of the rocks very likely are altered intrusions cutting through the limestone, others are undoubtedly of sedimentary origin representing certain harder, more or less siliceous bands in the original limestone.

The granites of the area generally have a coarse texture and are grey to reddish in colour. They show for the most part a distinct foliation, though in many places the foliated structure gives way to a granitoid one, and every stage of transition, from a typical granite to granite gneiss, can be seen.

The syenites have a coarse texture and are of a reddish colour, their chief constituent being a red feldspar. They often seem to grade into the granite and granitic gneiss, and there seems to be good reason to believe that they are simply a differentiation phase of the granite magma.

The gabbros or diorites have all the character of great basic intrusions, and are generally perfectly massive. Like the granite and syenite they cut through the limestone and associated gneisses and amphibolites, sending dyke-like masses into them and holding inclusions of the same.

ORE DEPOSITS.—The iron ores found in the district may be divided into three groups:—

(1) Magnetite occurring along or near the contacts of limestones and schists with various igneous rocks.

(2) Titaniferous magnetite.

(3) Hematite.

Of these groups the first is the most important. Titaniferous magnetites, occurring as magmatic segregations in the gabbro are known in several places throughout the district. Judging from the magnetic attraction, the extent of these deposits seems, however, to be very limited. Owing to this and their chemical composition, they are, therefore, at the present time, of no practical importance.

An average sample taken by the writer from Horten mine, lot 57, Hastings Road, of Tudor, gave the following analysis:—

| | |
|---|---|
| Iron | 46·60 |
| Insoluble | 29·00 |
| Phosphorus | 0·020 |
| Sulphur | 0·061 |
| Titanium, $TiO_2$ | 10·00 |

Another sample taken from lot 17, concession XI, of Lake, gave:—

| | |
|---|---|
| Iron | 45·80 |
| Insoluble | 30·71 |
| Phosphorus | 0·009 |
| Sulphur | 0·070 |
| Titanium, $TiO_2$ | 12·22 |

Hematite has in the past been mined from several places in the vicinity of Madoc, but all the old mines are now closed. None of these deposits have been examined by the writer.

CONTACT MAGNETITE DEPOSITS.—This type of ore deposit occurs as steeply dipping lenses and irregular masses along or near the contact of crystalline limestones and associated schists with granite, syenite, or gabbro-diorite. Associated with the magnetite are numerous ferruginous silicates such as pyroxene, hornblende, epidote, and garnet. Usually a considerable amount of calcite is also present.

The following table shows the analyses of some of the magnetites belonging to this class:—

[1] See Memoir No. 6, of the Geological Survey, Canada.

| Name of Mine. | Name of Township. | Lot and Concession. | Metallic Iron. | FeO. | $Fe_2O_3$. | Phosphorus P. | Sulphur. | Titanium $TiO_2$. | Lime CaO. | Magnesia MgO. | Alumina $Al_2O_3$. | Silica $SiO_2$. | Insoluble matter. | Manganese Oxide. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blairton mine | Belmont | 7, 8, con. I | 50·10 | | | 0·046 | 1·423 | 0·10 | 3·52 | 1·64 | 1·73 | 9·88 | | |
| Belmont mine | " | 19, con. I | 51·20 | | | 0·032 | 0·371 | 0·10 | 1·87 | 3·93 | 0·25 | 12·10 | | |
| St. Charles mine | Tudor | 19, con. XII | 42·00 | | | 0·080 | 0·832 | | | | | | 31·85 | |
| Baker mine | " | 18, con. XVIII | 38·70 | | | 0·200 | 3·317 | | | | | | 37·10 | |
| Coe Hill mine | Wollaston | 15, 16, con. VIII | 47·30 | | | 0·018 | 2·215 | | | | | | 30·90 | |
| Jenkins mine | " | 17, 18, " | 35·30 | | | 0·054 | 0·522 | 0·10 | | | | | 46·08 | |
| No. 4, Bessemer | Mayo | 4, con. VI* | 54·29 | | | 0·019 | 0·062 | | 6·86 | 1·35 | 2·02 | 9·84 | | |
| No. 4, Bessemer | " | 4, con. VI† | 42·50 | | | 0·030 | 0·300 | | 13·05 | 2·80 | 2·79 | 19·20 | | |
| Rankin property | " | 10, con. IX | 42·70 | | | 0·104 | 0·215 | 0·10 | 8·08 | 1·74 | 3·80 | 15·87 | 31·00 | |
| Child property | " | 11, con. IX | 42·00 | | | 0·066 | 0·160 | 0·10 | 7·75 | 2·00 | 3·35 | 12·53 | 31·30 | |
| Stevens property | " | 13, con. IX | 30·70 | | | 0·080 | 0·015 | | | | | | 23·00 | |
| Kennedy " | Carlow | 17, con. VI | 43·70 | | | 0·118 | 0·102 | | | | | | 10·50 | |
| Bow Lake " | Faraday | Lot 21, cons. X, XI | 51·00 | 21·80 | 45·30 | 1·94 | 0·070 | 0·50 | 7·14 | 1·78 | 1·73 | 9·03 | | |

* Average analysis of the shipping ore supplied by the Canada Iron Furnace Co.

† Average sample of discarded ore.

All the analyses, with one exception, represent average samples taken by the writer during the field work. It will be seen that the metallic iron content varies in these samples from 54 down to 30 per cent. The iron content of the ore varies considerably, however, within the same ore deposit. Thus we often find rich portions of the ore made up chiefly of magnetite embedded in others of considerably lower grade and composed of magnetite, amphibole, pyroxene, epidote, garnet, etc., while in other places again the gangue minerals predominate, practically to the exclusion of the magnetite. The best quality of ore averages about 54 per cent, but considerable cobbing would have to be done in order to keep the output of any of the mines up to that standard. A large percentage of the ore does not contain more than 30 to 45 per cent, while some contains less. The sulphur content of the ores is variable, but generally high, owing to the presence of iron pyrites, and occasionally, as at Coe Hill, of pyrrhotite.

In some cases the pyritous portions can be separated by cobbing the ore, while in others the sulphides are so abundant and so finely distributed throughout the ore as to render its elimination by such a process impossible. The phosphorus in the samples taken varies, with one exception, from 0·018 to 0·200 per cent.

*Extent of Ore Bodies.*—Owing to the lack of sufficient development, and to the exceedingly irregular character of the ore bodies, it is impossible, at present, to estimate with even an approximate correctness, the quantity of ore available in this district. It seems, however, that often the irregularity of the ore bodies has hardly been sufficiently recognized, since many property owners assume that the ore occurs in regular beds, and therefrom erroneously infer the continuity of the ore deposits between widely separated outcrops. Thus in some cases, most exaggerated estimates of the amount of ore available are formed. The same error seems to have been frequent in using the dip needle. If, for instance, a few high magnetic readings have been obtained in some places lying several hundred or even thousands of feet apart, it has often been assumed that a continuous bed of ore existed.

The fallacy of such a conclusion is evident. Reliable conclusions regarding the probable extent of the ore-bodies can only be obtained by taking systematic magnetic readings sufficiently close together and modifying and interpreting the data thus obtained in the light of other evidence, geological, or topographical.

Occurrences of magnetite are very common in the district. Indeed, they are so abundant that in certain areas they may be found on every lot, but only in a few places do the results of our investigation *indicate* the presence of ore in such a quantity as to render the deposits of economic importance. Among these the following deposits deserve special mention:—

No. 4 deposit at Bessemer.
Rankin and Child properties.
Blairton mine.
Belmont mine.
The Ridge property.

No. 4 deposit at Bessemer has been proved to a depth of 100 feet by actual mining, with all indications of a considerably greater depth. According to the magnetometric survey, the total length of this deposit may be estimated at about 1,000 feet, the western end extending 450 feet under Little Mullets lake. The area of this deposit is roughly estimated at 50,000 square feet.

On the Rankin property magnetite ore has been exposed by a stripping 300 feet × 68 feet. Most of the area is, however, heavily drift-covered, and no diamond drilling has so far been done; but, judging from the strength, continuity, and breadth of the magnetic area shown by the magnetometric survey of Mr. H. Fréchette, it would seem very probable that both the Rankin and the Child properties contain ore-bodies of considerable proportions.

The total area of these two properties within which ore is likely to occur, is roughly estimated at 412,000 square feet It is, however, impossible to say how large a percentage of this area is actually occupied by ore until further development has been done.

At the Blairton there are two ore-bodies of some importance. On the southern deposit ore has been mined to a depth of 125 feet from a large open pit.

The probable ore area of this deposit does not seem to exceed to any great extent the boundaries of the pit and is about 27,000 square feet. Diamond drilling has proved the ore to a vertical depth of at least 550 feet.

The other deposit has been opened up on the hillside near Crow lake. Judging from the magnetometric survey, the total length of this deposit may be estimated at about 560 feet, its northern end extending about 130 feet under the lake. On the hillside immediately west and south of the open-cut several strongly positive magnetic areas alternating with some strong negative ones indicate an irregular distribution of magnetite in the country rock. The total area within which ore is likely to occur in this part of the field is roughly estimated at 128,000 square feet.

Judging from the magnetometric survey made by Mr. B. F. Haanel, and confirmed by a few natural exposures, the probable ore area of the Belmont may be roughly estimated at 43,000 square feet. Considerable diamond drilling was done some years ago on this property, and seven drill-holes, cutting the ore-body, were sunk at angles varying from 45 to 90 degrees. The results of these diamond drill-holes are, however, not so promising as the magnetometric survey would indicate, but show nevertheless a limited amount of good magnetite, besides a considerable quantity of low grade ore suitable for magnetic concentration.

At the Ridge property the summer's investigation has disclosed several strongly magnetic areas, of which the two largest show an attraction of 60 degrees or more, over an area of about 37,000 square feet each. With no outcrops of ore available, it is impossible at present to foretell their economic importance; but the promising results of the magnetometric survey ought to stimulate further investigation of this property in the form of diamond drilling.

## PROSPECT OF DEVELOPMENT.

Iron mining has in the past, with few exceptions, been rather disappointing in this district. In some cases this has been due to the high sulphur content of the ore, in others to the irregular character of the ore deposits and the intimate association of the magnetite with the surrounding gangue and country rocks. Hand-picking of the ore was, therefore, in most cases necessary. This not only increased the cost of mining, but was in some places of little or no use. From what the writer was able to ascertain during his field work, it seems unlikely that any one of the deposits in the district could at the present time be profitably mined without submitting the ore to a magnetic concentration process. It may be that no single deposit contains ore reserves large enough to warrant the erection of a concentrating plant of sufficient capacity to ensure the profitable working of such a process. But should further development confirm the expectation which the result of the investigation of some of the above-mentioned deposits indicates, it should be possible by a consolidation of some of these properties to carry on mining operations on a sufficiently large scale to make the erection of a large concentrating plant feasible. The ore of these properties is well adapted for magnetic concentration, but a large percentage will undoubtedly have to be crushed rather fine in order to get a satisfactory separation of the magnetite from the associated gangue-minerals.

## II.

## CALABOGIE IRON-BEARING DISTRICT.

During the summer of 1911, the iron ore deposits near Calabogie, in Renfrew county, were also examined by the writer. Magnetometric and topographical surveys were made of the following properties:—

Martel mine—Lot 13, concession X, Bagot township.
Lot 16, concession IX, Bagot township.
Lot 16, concession VIII, Bagot township.

Bluff Point mine—Lot 16, concessions X, XI, Bagot township.

Culhane mine—Lot 21, concession VII, Bagot township.

Black Bay mine—Lot 22, concession XI, Bagot township.

In this work the writer was assisted by Mr. N. D. Bothwell, who performed his duties in a highly satisfactory manner.

*Location of the District.*—All the above-mentioned ore deposits are situated within an area of about 25 square miles. The district is traversed by the Kingston and Pembroke railway, with Calabogie station situated at the issue of the Madawaska river from Calabogie lake. By a spur-line, about half a mile long, the Bluff Point mine is connected with the railway, while all the other mines are situated within a radius of 2¾ miles from Calabogie station. The distance from Calabogie to Sharbot Lake, the junction of the Kingston and Pembroke railway with the Canadian Pacific's Montreal-Toronto line, is 42·5 miles, and to Kingston 89 miles.

*History.*—Mining operations in the district were commenced in 1881 by an American syndicate, which did some development work on the property now known as the Bluff Point iron mine. During the following winter, the work was continued by the Calabogie Iron Company. The ore was hauled by teams over Calabogie lake to Barryvale, which was at this time the terminus of the Kingston and Pembroke railway. In 1883, the ore deposit known locally as No. 4, on lot 16, concession VIII, was opened up by sinking a shaft 45 feet deep. The mining operations ceased, however, in the autumn of the same year, but were resumed in 1886, when a shaft 300 feet deep, and passing through 8 feet of ore, was sunk on the Bluff Point property. In the autumn of 1886, the property was leased to the American Mining Company, which continued operations until the following year, when the mine was again closed down. In 1894, all the ore available in the stock-piles at the mine was shipped to Radnor, Quebec, by the Canada Iron Furnace Company. Since then mining operations were carried on from time to time until the year 1901.

The total amount of ore which is reported to have been shipped from the Bluff Point and No. 4 mines is about 9,000 tons.

The Culhane and the Black Bay mines were also opened up in the eighties. No shipment of ore was ever made from the Culhane mine, but from the Black Bay mine about 10,000 tons are reported to have been shipped. The ore-body had a width of 7 to 8 feet and was worked to a depth of 15 to 20 feet.[1] The ore ran about 52 to 53 per cent in metallic iron with a very low sulphur content.

The Coe mine, or, as it is now locally known, the Caldwell mine, on the east half of lot 16, concession IX, was opened up in 1883 by Mr. Coe, from Madoc, who operated the property under lease. Subsequently the property was bought by Mr. T. B.

[1] Report of the Royal Commission on the Mineral Resources of Ontario, page 36.

Caldwell, of Lanark, and a number of openings were made by the Hamilton Steel and Iron Company, which acquired a lease of the property. The amount of ore shipped from this property is reported to be about 10,000 tons. This had to be hauled about a mile and a half by road to the end of the spur-line at the Bluff Point mine.

From the Wilson, or Martel mine, about 4,000 tons of ore are reported to have been mined and shipped. The ore was of very good character, and the width of the deposit at a depth of 59 or 60 feet was about 9 feet.

*Geology.*—The area is chiefly made up of crystalline limestone associated with various schists and intruded by granites, syenites, diorites, and other dark-coloured, basic rocks. The general strike of the stratified rocks is northeast and southwest, with a dip varying considerably in different places. At the Bluff Point mine this is about 30 degrees towards the southeast; near the Calabogie station the layers are almost flat, while at the Culhane and Black Bay mines the formation dips towards the northwest at an angle of about 30 degrees.

Some of the chlorite and mica schists associated with the limestone, as for instance those at the Bluff Point mine, seem to be simply alteration phases of the limestone produced by the metamorphic action of the intrusive rocks, while others may represent altered argillaceous clayey bands interstratified with the limestone.

*Ore Deposits.*—The iron ore of the district consists of magnetite which occurs in lenses and irregular masses associated with the igneous rocks along or near their contact with the crystalline limestone. Generally the limestone forms one wall of the deposits while the other is made up of one or other of the igneous rocks. In the few places where the limestone can not be seen in actual contact with the ore, it is always found outcropping in the immediate vicinity of the same. The quality of the ore varies considerably, not only in the various mines but also within the same deposit, owing to the amount of gangue-rock present. In some cases ore consisting of almost pure magnetite is observed; in others the magnetite is found closely associated with hornblendic, micaceous, and chloritic material, and often a gradual or sudden change of rich ore into such a gangue rock takes place.

The following table gives a number of analyses representing average samples taken by the writer and analysed by Mr. H. Leverin, of the Mines Branch.

| Locality. | Iron. | Silica. | Insol. | Alumina. | Lime. | Magnesia. | Phosphorus | Sulphur. | Titanium. |
|---|---|---|---|---|---|---|---|---|---|
| | Fe. | $SiO_2$ | | $Al_2O_3$ | CaO | MgO | P. | S. | $TiO_2$ |
| "Tommy R. pit," lot 16, con. IX, Bagot... | 38·30 | ..... | 16·10 | ...... | .... | | 0·233 | 0·020 | |
| "T. P. pit," lot 16, con. IX, Bagot... ... | 50·59 | 10·26 | ..... | 4·82 | 3·33 | 5·86 | 0·289 | 0·012 | 0·25 |
| "Holden pit," lot 16, con. IX, Bagot..... | 60·91 | 4·60 | ..... | 3·60 | 1·77 | 2·83 | 0·578 | 0·100 | 0·10 |
| Campbell mine, lot 16, con. VIII, Bagot... | 47·86 | 10·60 | ...... | 4·27 | 4·45 | 6·90 | 0·330 | 0·080 | 0·25 |
| South half of lot 16, con. IX, Bagot...... .. | 47·81 | 15·00 | ...... | 3·85 | 4·86 | 7·05 | 0·390 | 0·015 | 0·25 |
| Martel mine, lot 13, con. X, Bagot......... | 58·71 | 7·10 | ..... | 1·55 | 2·05 | 5·70 | 0·056 | 0·230 | Trace. |
| Pluff Point mine* ... ... ......... .... | 59·50 | 9·10 | .... | 4·80 | 0·01 | ..... | 0·170 | 0·160 | |
| Culhane mine... ................... | 47·70 | .... | 9·3 | .... | 4·20 | 0·66 | 0·179 | 1·65 | |
| Black Bay mine .... .................... | 51·60 | ..... | 15·85 | ... | ..... | . | .... | ..... | |

* Average sample by Canada Iron Furnace Co.

It will be seen from the above table that the best quality of the ore averages about 61 per cent of iron, while in other places it does not average more than 47 per cent. The sulphur content varies from 0·012 to 1·65 per cent with the phosphorus ranging from 0·170 to 0·578 per cent, thus putting the ore in the non-Bessemer class.

*Extent of Ore-bodies.*—Judging from the magnetometric surveys, the ore deposits of the district are of an extremely irregular character. This has already been proved

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DEPARTMENT OF MINES

MINES BRANCH

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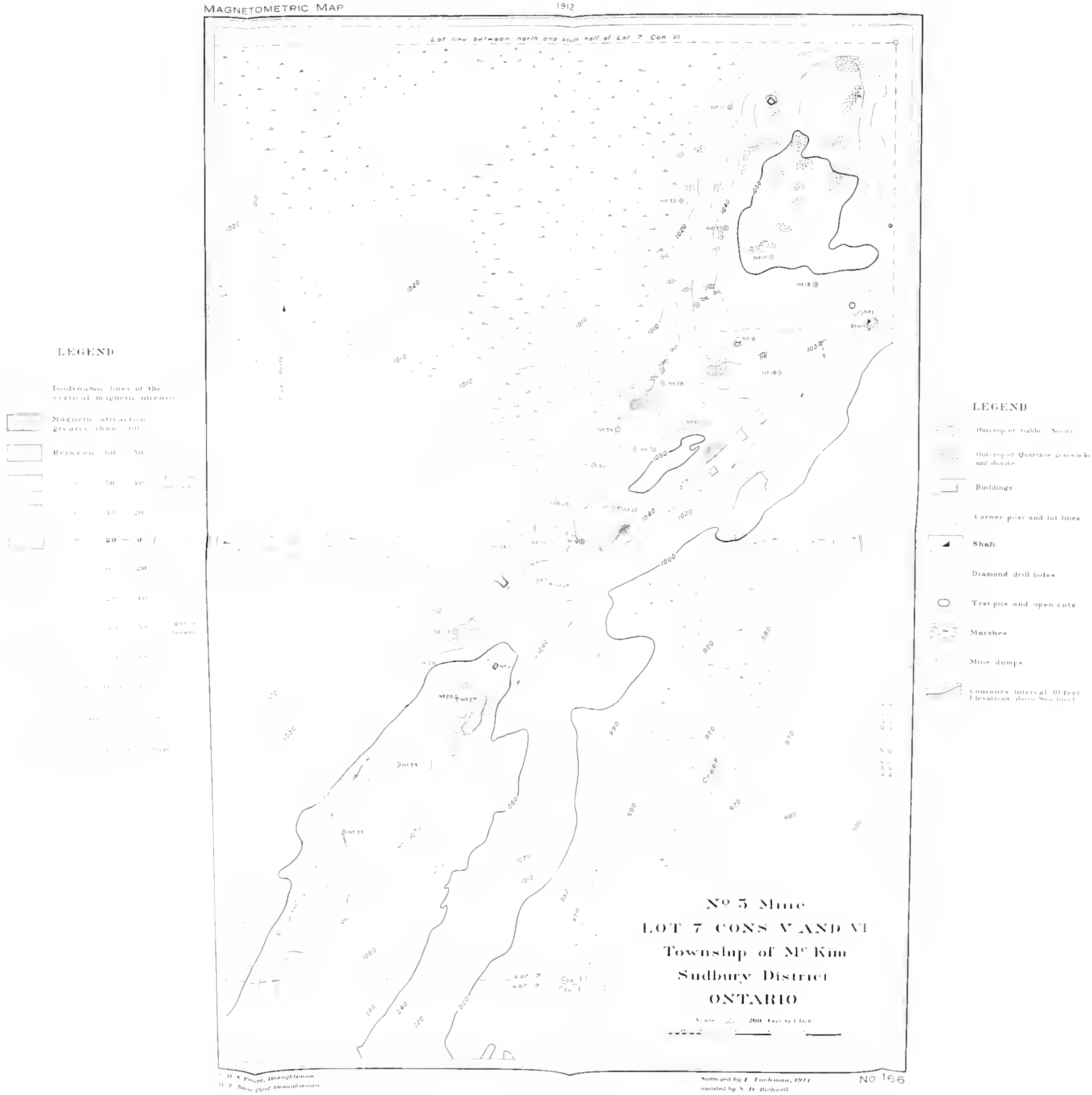
MAGNETOMETRIC MAP




No 166

in many cases by actual mining work. In width the larger deposits vary from 1 to 12 feet with a maximum length of about 150 feet, while others are much smaller. It seems, therefore, that the district is not likely to become an iron-ore producer of any importance, though a limited amount of ore might yet be taken from some of the mines.

## III.

## MAGNETOMETRIC SURVEY OF A NICKELIFEROUS PYRRHOTITE DEPOSIT IN THE SUDBURY DISTRICT.

During the latter part of the field season of 1911, a magnetometric survey of No. 3 mine was made by the writer, assisted by Mr. N. D. Bothwell. This property is situated about 3 miles north of the town of Sudbury, on lot 7, concessions V and VI, in the township of McKim.

On this property a considerable amount of diamond drilling has been done during the last three years by the Canadian Copper Company, the results of which show the presence of a large deposit of nickeliferous pyrrhotite.

The object of the survey of this area was to ascertain the value of the magnetometric method in exploring for nickeliferous pyrrhotite deposits, as this deposit afforded a good opportunity of comparing the results of the magnetometric survey with those obtained from the diamond drilling. An area of about one-eighth of a square mile in extent was examined. It forms the southern part of the Frood and Stobie nickel range, an off-shoot from the main southern nickel range.

Beginning at the southwest end of the area, the rusty surface of the norite is first encountered near the boundary line between concessions V and VI, as a band indistinctly separated from the adjoining greywacke and schist. The norite rises as a ridge which is generally red-brown from the gossan, but is cut off on the surface by a narrow interruption of quartzite about 500 feet southwest of the place where the main shaft is now being sunk. The rusty norite rises again and widens greatly until, about 600 feet northeast of the new shaft, it reaches a width of about 700 feet. Quartzite and greywacke are in contact with the norite on the southeast side, while on the northwest the rocks are more varied. The rock in immediate contact is, however, generally quartzite. Beyond these rocks, which rise against each side of the norite, there are broad swamps.

*Magnetometric Survey.*—A base line was laid out and chained, starting from the northeast corner of the south half of lot 7, concession VI, and running for a distance of about 3,500 feet in a southwesterly direction roughly following the strike of the gabbro formation. At 25 ft. intervals, cross lines were measured, and at a distance of every 25 feet along these lines observations were taken for both the vertical and horizontal magnetic intensity by means of a Thalen-Tiberg magnetometer. By means of these observations, it was possible to trace the pyrrhotite-bearing norite formation for a distance of over half a mile. The only break in the formation indicated by the magnetic map, is where the narrow interruption of quartzite takes place. Here a break about 50 feet wide is noticed in the positive magnetic intensity. By diamond drill-hole, No. 36, it has, however, been proved that the norite formation is interrupted by quartzite to a depth of about 800 feet, but that below this level it is continuous, though a narrowing of the same very likely takes place. The area occupied by the norite formation generally shows a weak positive magnetic attraction from 0 up to 20 degrees. Within this area are, however, numerous small singular patches showing negative attraction. Small areas with strong positive attraction are also occasionally found. These are always accompanied by strong negative areas lying side by side.

The general impression that the magnetic map seems to give is that the pyrrhotite is rather evenly disseminated throughout the whole gabbro mass, with a concentration of the mineral taking place here and there. If such a concentration takes place near the surface it undoubtedly produces the strong magnetic disturbances which are occasionally met with, while at greater depth its effect on the magnetic needle would be rather slight.

Through the courtesy of Mr. D. H. Browne, of the Canadian Copper Company, the writer was given the opportunity of comparing the results of the magnetometric survey with the records of the diamond drilling. The latter has proved that such a concentration of the pyrrhotite takes place here and there in the gabbro mass. It has also shown that this concentration of pyrrhotite does not always mean higher copper and nickel values in the ore, as in several of the areas showing a strong magnetic attraction, little or no difference has been found in the percentage of these two metals from that obtained in places where the magnetic readings are only a few degrees. The ore area blocked out by the diamond drilling coincides in this case remarkably well with that of the positive magnetic attraction, while outside of this the quartzite greywacke and diorite are situated. The depth to which the ore-body has been proved is about 1,200 feet. Down to about 400 feet the copper and nickel values are comparatively low, but below this level they average together about 4 to 5 per cent.

The conclusion arrived at in regard to the applicability of the method in exploring for copper and nickel deposits in the district may be stated as follows:—

In places where the formation is covered with swamps and drift, the approximate position of pyrrhotite deposits can be determined. It is to be remembered, however, that as it is not the pyrrhotite itself but the minerals associated with it, *i.e.*, copper pyrite and pentlandite, which make up the chief value of the ore, and as the proportion of these minerals as compared with the pyrrhotite varies considerably, the percentage of copper and nickel may be low even when a strong magnetic field is obtained.

Hence the discovery of magnetic attraction is by no means to be considered as an absolute proof of the existence of a deposit of workable ore. A steady and continuous attraction, though weak, is, however, a good indication that an ore-body may be found. Having ascertained the approximate location of a magnetic body by a magnetometric survey, diamond drilling or some other method of exploring must be used in order to ascertain the quality and character of the deposit.

# INVESTIGATION OF THE CANADIAN MARKET: FOR VARIOUS MINERAL PRODUCTS IN A CRUDE OR PARTIALLY PREPARED STATE.

*Howells Fréchette, M.Sc.*

In the summer of 1911 an investigation was commenced for the purpose of determining what minerals are at present in use in the manufacturing industries of Canada, their source, the uses to which they are put, the degree of purity required for the various processes in which they are used, and the physical condition in which the minerals are purchased.

Before commencing the gathering of data, it was deemed best to consult with the Canadian Manufacturers' Association and explain to them the objects of the investigation, as the endorsement of that body would aid in dealing with the individual manufacturer.

After talking over the matter with Mr. W. H. Rowley, President of the Association, the following letter was sent to the Secretary:—

DEPARTMENT OF MINES,
MINES BRANCH,
OTTAWA, May 31, 1911.

To the Secretary,
Canadian Manufacturers' Association,
Traders' Bank Building, Toronto, Ont.

DEAR SIR,—Yesterday I had an interview with Mr. W. H. Rowley, regarding an investigation which is to be carried on by me for the Dominion Department of Mines.

This Department is constantly receiving inquiries for information with respect to the industrial uses for many non-metallic minerals and with respect to the market for them. Canadian manufacturing establishments import large quantities of these minerals, either in the raw or in a partially manufactured state, while the greater part of the Canadian production of these is exported. It is, therefore, evident that there should be a larger home market for non-metallic products, were information as to the trade requirements and markets more generally known. The Department has little or no information with respect to the needs of our manufacturers in this regard, and I have been instructed to visit the larger manufacturing centres in Canada to learn what mineral substances are used in the various manufacturing industries and to study the trade requirements of each industry.

It is proposed to ask the various manufacturers for information under the following headings:—

1. Class of manufactured product (such as paint, wall paper, rubber goods, electrical goods, etc.).

2. What minerals or mineral products (other than metals) are used, and for what purpose.

3. Quantities and prices.

4. If purchased as minerals, in what form? (crushed, pulverized, etc.).

5. If purchased as mineral products, what is the nature of the material, the product of what mineral or minerals, and what is the treatment through which it has passed?

6. What is the valuable constituent of the mineral? (*e.g.*, magnesite-magnesia or carbonic acid).

7. What is the percentage of purity required in each?

8. What are the deleterious impurities, and up to what percentage are they allowable?

9. Analyses.

10. Specifications used in purchasing.

11. Source of supply.

12. If foreign, why are Canadian materials not used?

13. Does the manufacturer wish to be placed on a list of consumers of the minerals used by him?

Any information supplied will be treated as absolutely confidential, where the manufacturer so desires.

It is expected that the results of this investigation will prove useful not only to the producers of minerals in Canada, but to the manufacturers also.

In carrying out this work, I am convinced that the endorsement of the investigation by the Canadian Manufacturers' Association would greatly aid me in dealing with the individual manufacturers.

Mr. Rowley advised me to write to you and ask you to be good enough to bring the matter before the Executive Council, and ask them for their endorsement.

As I expect to begin work within a week or two, your early attention will be much appreciated.

Yours very truly,

(Signed) **Howells Fréchette,**

*Chief Engineer, Non-Metal Mines Division.*

*Reply.*

CANADIAN MANUFACTURERS' ASSOCIATION,
TORONTO, June 16, 1911.

HOWELLS FRÉCHETTE, Esq.,
Chief Engineer, Non-Metal Mines Division,
Mines Branch, Department of Mines, Ottawa.

MY DEAR SIR,—As promised in a previous letter, I presented your communication of May 13 to the meeting of our Executive Council held yesterday afternoon. After hearing your proposition, as outlined in your letter, the Council expressed its approval of the efforts your Department is making to secure information regarding non-metallic minerals, and it has authorized me to inform you that the members of the Association, individually and collectively, will do all they can to facilitate your work. You can inform any manufacturers whom you are circularizing in connexion with your work that your plans have the endorsation of the Council and the Association. I do not think that any of our members will refuse to answer the questions outlined in your letter, but if you should meet with any unexpected difficulties in this connexion, I shall be pleased to hear further from you, when, no doubt, we can assist you in overcoming them.

Yours faithfully,

(Signed) **H. D. Scully,**

*Assistant Secretary.*

Owing to the absence of a complete list of manufacturers, it was necessary to compile lists from directories and telephone books, as well as from the list published by the Canadian Manufacturers' Association. As a result, many firms not manufacturers were included. A total of 1,313 firms were visited, and may be classified as follows:—

| | |
|---|---|
| Manufacturers | 1,097 |
| Branches and subsidiary companies, returns of which are included in the foregoing | 18 |
| In liquidation or out of business | 47 |
| Representatives of foreign manufacturers | 38 |
| Mining companies | 13 |
| Agents, wholesale and retail dealers | 102 |
| | 1,313 |

These 1,097 manufacturers represent over sixty industries. Of these, 357 reported that they used very little or no non-metallic minerals. The remaining 740, representing over fifty industries, use minerals.

The following list gives the minerals in use, and the number of firms reported as using each:—

| | | | |
|---|---|---|---|
| Common clay | 55 | "Rough stuff" | 1 |
| Pipe-clay | 2 | "Rubbing brick" | 1 |
| China-clay | 76 | Rotten stone | 51 |
| Ganister | 11 | Hone | 5 |
| Fireclay | 148 | Lithograph stone | 10 |
| Slip clay | 4 | Yellow ochre | 28 |
| Stone clay | 6 | Sienna and umber | 11 |
| Sagger clay | 5 | Hematite | 42 |
| Ball-clay | 7 | Magnetite | 2 |
| Special clays | 4 | Pyrite | 2 |
| Quartz | 18 | Sulphur | 46 |
| Pebbles | 1 | Keystone filler | 6 |
| River and lake sand | 97 | Slate | 15 |
| Moulding sand | 192 | Slate (ground) | 3 |
| Blast sand | 7 | Mica schist | 4 |
| Fire sand | 23 | Asbestos and asbestic | 52 |
| Glass sand | 6 | Barytes | 25 |
| Silica sand and silex | 94 | Calcite | 1 |
| Limestone | 32 | Cryolite | 2 |
| Lime | 36 | Graphite | 198 |
| Marble | 28 | Gypsum | 11 |
| Chalk | 2 | Plaster of Paris | 23 |
| Whiting | 44 | Feldspar | 18 |
| Emery | 109 | Fluorspar | 15 |
| Corundum | 14 | Magnesite | 12 |
| Garnet | 3 | Mica | 48 |
| Chromitron | 1 | Pyrolusite | 24 |
| Pumice | 140 | Onyx | 2 |
| Fuller's earth | 13 | Phosphate rock | 6 |
| Infusorial earth | 4 | Salt | 22 |
| Tripoli | 114 | Talc | 132 |
| Blue grit | 2 | Witherite | 1 |
| Water stone | 1 | Peat litter | 1 |

Although the data collected is not yet ready for publication, it has manifested its usefulness in furnishing information with which to reply to numerous correspondents. It may also be pointed out that while visiting the manufacturers many questions were answered regarding the availability of Canadian minerals.

This investigation will be continued during 1912, and later a full report will be published. During 1911, Mr. Fréchette was assisted by Mr. H. Bradley, B.Sc.

# THE GYPSUM AND SALT INDUSTRIES OF CENTRAL AND WESTERN CANADA.

*L. H. Cole, B.Sc.*

The field season of 1911 was spent in central and western Canada visiting the districts in which gypsum and salt are produced, and the industries connected with the production and preparation of these minerals for market were studied in detail. Deposits of gypsum and salt are usually more or less closely associated, as a consequence of which it appeared more advantageous to carry on the two investigations concurrently.

## The Gypsum Industry.

### ONTARIO.

The only district in Ontario which is producing gypsum at the present time, lies along both banks of the Grand river, in the southwestern part of the Province. So far as is known, this district extends from a point about 4 miles to the southeast of the town of Cayuga, to a point about 1 mile to the northwest of the town of Paris. Although actual exposures of gypsum can be seen at only a few places along the river, the continuity of the deposits may be traced by means of the log records of the numerous gas and oil wells of that district.

The gypsum occurs interbedded with dolomite. Two or more distinct beds are being worked, the upper of which is very irregular, but yields chiefly a variety of pure, white gypsum, adapted to the manufacture of the best grades of plaster of Paris and alabastine. An analysis of material from the upper bed is as follows:—

| | |
|---|---|
| CaO.. .. .. .. .. .. .. .. .. .. .. .. .. | 32·70 per cent. |
| $SO_3$.. .. .. .. .. .. .. .. .. .. .. .. .. | 46·88 " |
| $H_2O$.. .. .. .. .. .. .. .. .. .. .. .. .. | 20·66 " |
| Insoluble.. .. .. .. .. .. .. .. .. .. .. .. | 0·06 " |
| Total.. .. .. .. .. .. .. .. .. .. .. .. | 100·30* per cent. |

* F. G. Wait, analyst.

It is this bed that has been worked the most frequently, the first material having been taken out in the early sixties. It is never continuous for any great distance, but where found, usually holds its thickness very consistently, the interruptions occurring abruptly with very little warning. The areas of gypsum vary from 100 yards up to half a mile or more in diameter, and have an average thickness of about 4 feet.

The material of the lower of the beds at present being worked is of a greyish colour, but this bed is marked by a greater degree of continuity than the one with the whiter variety of gypsum. In many cases, drilling records indicate an entire absence of the upper bed, the first gypsum to be encountered being the grey variety. Up to the present time, this bed, where developed, has been very uniform in quality and of a thickness of about 11 feet. The gypsum is adapted to the manufacture of a fairly good variety of stucco, but, owing to its colour, cannot be used for the finer grades of plaster of Paris.

Four companies own properties in this district. Of these, two are producing steadily, while the others are just commencing operations.

*The Alabastine Company of Paris.*—This Company is the oldest among those actively engaged in the district, and has two mines and two mills in operation. The larger of these mines is at Caledonia, and is working in the grey gypsum. Here the rock, after passing up an incline to the top of the mill, is crushed and calcined, and the various grades of hard wall plaster prepared. A short spur line from the Grand Trunk railway to the mill affords easy shipping facilities. The second mine operated by this Company is located about 3 miles to the southeast of Caledonia, and produces white gypsum of a very pure quality. From this mine the crude material is hauled by wagon to the mill at the north of the town where it is ground and calcined. From there it is sent to Paris to the Company's second mill, where it is used in the manufacture of Church's alabastine, a wall tint that has calcined gypsum as its principal ingredient.

*The Crown Gypsum Company.*—This Company is working in the uppermost bed of the series. Its mine is located in Haldimand county, about 1½ miles to the southeast of the village of York. An incline driven on a slope of 1 in 10 taps the bed at a depth of 70 feet. The gypsum rock mined is a very pure and white variety, but the bed does not average more than 4 feet in thickness. The rock is taken over a narrow-gauge railway, 3 miles in length, to the Company's mill situated at Lythmore, on the Michigan Central railway. At this mill all the various grades of wall plaster and plaster of Paris are manufactured.[1]

*The Toronto Plaster Company.*—This Company has taken over the complete plant of the Imperial Plaster Company, consisting of a mine 2 miles southeast of Cayuga, and a small mill at Toronto. Both mine and mill were idle during the summer, but preparations are now being made to resume operations shortly.

*The Caledonia Gypsum Company.*—The property of this Company, on which there is a small crushing plant,[2] lies to the north of the town of Caledonia and just west of the Alabastine Company's holding. Up to the present time work has been confined to prospecting, and only a small tonnage has been crushed and shipped for use in the manufacture of cement.

## MANITOBA.

The gypsum industry of this Province is each year assuming greater importance. Although deposits are known to exist in several districts, active production is confined to one locality. These deposits, which lie from 10 to 12 miles in a northwesterly direction from Lake St. Martin, are of large extent, exposures being found over an area of about 8 square miles. A branch of the Canadian Northern railway, 180 miles in length, extends north from Winnipeg to these deposits, and shipments are now being made by a continuous rail route to the mills at Winnipeg.

The gypsum lies near the surface, the overburden being seldom more than 4 feet. The surface of the country has been dissected by erosion, which has produced numerous hummocks and hollows, having a maximum relief of about 20 feet.

The gypsum bed shows stratification and the rock is fairly soft. Consequently it has been found that light charges of powder will so loosen the material that it can then be readily handled by steam shovels. The bed consists of a top covering of gypsum earth about 1 foot in thickness, underneath which the solid gypsum extends to a depth of some 60 feet.

The r ck is being loaded by a steam shovel, working in a face about 20 feet in height and 30 feet in width, directly into bottom dump, steel ore cars of 40 tons capacity, which lie on a siding of the Canadian Northern railway.

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[1] Since this mill was visited last June, fire has completely destroyed the plant.
[2] Since this mill was visited last June, fire has completely destroyed the plant.

An analysis of the average material shipped to the mill is as follows:—

| | |
|---|---|
| CaO.. .. .. .. .. .. .. .. .. .. .. .. .. .. | 32·60 per cent. |
| $SO_3$.. .. .. .. .. .. .. .. .. .. .. .. .. | 44·88 " |
| $H_2O$.. .. .. .. .. .. .. .. .. .. .. .. .. | 20·80 " |
| Insoluble.. .. .. .. .. .. .. .. .. .. .. .. | 1·40 " |
| Total.. .. .. .. .. .. .. .. .. .. .. .. | 99·68* per cent. |

* H. A. Leverin, analyst.

This sample also contains small quantities of $CaCO_3$ and $MgCO_3$. The material shows a very faint tinge of brown.

Two companies, the Manitoba Gypsum Company and the Dominion Plaster Company, control the greater part of these northern deposits.

*The Manitoba Gypsum Company.*—The present output of this Company is about 250 tons a day. Its quarry, previously described, is located at Gypsumville, the northern terminus of the Canadian Northern Railway branch line from Winnipeg, while its mill is situated on the outskirts of the latter city. In treating the crude, the rock, after crushing, is subjected to a preliminary drying in a Cummer rotary calciner, which materially reduces the length of time required for subsequent treatment in the kettles.

All grades of wall plaster are produced, and these find a ready market in the western provinces. Plaster board and asbestos plaster are also being manufactured in small quantities.

*The Dominion Plaster Company.*—The property owned by this Company lies in the northern part of the Province and is adjacent to the holdings of the Manitoba Gypsum Company. Up to the present time, operations on this property have been confined to a small amount of surface stripping in order that an estimate of the extent of the deposit could be made. No rock has as yet been shipped. A mill, situated in Winnipeg, is nearing completion, and will, when in operation, treat about 200 tons of crude rock per day.

*Other Properties.*—A new discovery of gypsum was made during the summer (1911) in the southern part of the Province. A syndicate of Winnipeg men, while drilling in the valley of a stream about 18 miles to the east of Dominion City, on the Canadian Pacific railway, encountered a deposit of very pure and hard, white gypsum at a depth of 325 feet. This deposit consists of a series of beds, having in all a total thickness of about 115 feet, while the maximum thickness of any single bed is about 50 feet. In view of the fact that the same series of beds has been found in each of two drill-holes, put down at a distance of more than one-fourth of a mile apart, it may be inferred that the gypsum is continuous over a considerable area. Samples taken from the drill-core were crushed and analysed with the following result:—

| | |
|---|---|
| CaO.. .. .. .. .. .. .. .. .. .. .. .. .. .. | 31·72 per cent. |
| $SO_3$.. .. .. .. .. .. .. .. .. .. .. .. .. | 45·32 " |
| $H_2O$.. .. .. .. .. .. .. .. .. .. .. .. .. | 20·45 " |
| Insoluble.. .. .. .. .. .. .. .. .. .. .. .. | 2·00 " |
| Total.. .. .. .. .. .. .. .. .. .. .. .. | 99·49* per cent. |

* F. G. Wait, analyst.

The above is a very pure gypsum and should prove to be of considerable value. Small samples, which were crushed and calcined, produced a very quick-setting, strong plaster.

BRITISH COLUMBIA.

*Grande Prairie Deposits.*—One of the first discoveries of gypsum in the Province of British Columbia was that of a deposit situated about 11 miles east of Grande Prairie, in the southern part of the Kamloops Mining Division. This gypsum occurs on the north side of the Vernon-Kamloops wagon road, and is about 26 miles in a northwesterly direction from the town of Vernon. Two exposures, about 1½ miles distant from each other, are to be seen on the hillside on the north bank of the Salmon river. Prospecting work, which has been confined to the more easterly of these outcrops, consists of a tunnel some 40 feet long, driven in the middle of the deposit. Gypsum earth in a very finely divided state, overlies the whole surface.

At the eastern exposure the gypsum has a dip of about 80° to the north, with a strike approximately east and west. The extent of the exposure is not very great, being about 200 feet along the strike and some 300 feet north and south. Throughout its length the tunnel passes through a nearly pure and white, massive variety of gypsum. An analysis of a sample, representing the material in both sides of the drift, is as follows:—

| | |
|---|---|
| CaO | 32·60 per cent. |
| $SO_3$ | 46·87 " |
| $H_2O$ | 20·80 " |
| Insoluble | 0·06 " |
| Total | 100·33* per cent. |

* H. A. Leverin, analyst.

The material is very uniform throughout and can be manufactured into a very high grade of plaster. The extent of the deposit has yet to be determined, since, apart from the tunnel referred to above, no prospecting has been done. The slope of the hill is about 40° and is covered sparsely with bunch grass and scattered pine trees.

The more westerly of the two exposures, outcrops along the steep side of the narrow valley, and near the summit of the northern ridge. This exposure stands out plainly as a white area among the rocks of the district. It consists on the surface of a badly disintegrated mass of gypsum rock with fragments of limestone derived by erosion from the cliffs of altered limestone overlying the gypsum. Residual pinnacles of limestone with eroded bases, remain in place in the deposit. No development work has been done and no idea of the extent of the deposit could be obtained. The material, at the surface, is badly broken and weathered. A sample taken gives the following analysis:—

| | |
|---|---|
| CaO | 31·60 per cent. |
| $SO_3$ | 45·61 " |
| $H_2O$ | 20·00 " |
| Insoluble | 1·80 " |
| Total | 99·01* per cent. |

* H. A. Leverin, analyst.

This sample also contains $CaCO_3$ and $MgCO_3$ in small quantities. In view of the fact that extensive development work is contemplated by the owners, it is probable that in the near future a considerable tonnage of the best grades of plaster will be produced from these deposits.

*Spatsum Deposits.*—Two exposures of gypsum occur on the hills forming the west bank of the Thompson river, immediately opposite Spatsum, a station on the main line of the Canadian Pacific railway, 189 miles northeast of Vancouver. These outcrops are located about 2,000 feet apart. Sufficient prospecting has not been carried on to enable one to determine whether or not these outcrops belong to the same deposit. The surface of the surrounding country is covered with alluvium, and supports a growth of bunch grass and scattered pine. The two spurs of the hill on which these outcrops occur, appear as large white masses and are visible for a long distance. At the surface, these outcrops consist of a very poor grade of gypsite or gypsum earth, mixed with altered limestone. The whole mass is badly disintegrated and streaked with stains of iron oxide. These exposures lie about 600 to 650 feet above the river, the slope of the hill being about 40°, and in some places steeper. Owing to the steep pitch, the effects of weathering have been considerable and fresh rock surfaces are hard to find.

In the more southerly of the two outcrops, a tunnel has been driven for a distance of 25 feet, and from the end of this tunnel a winze has been sunk to a depth of 30 feet. The tunnel cuts through a band of solid gypsum, having a thickness of 5 feet and a dip of about 35° to the northwest. Apart from this band, the tunnel and winze pass through highly altered broken limestone, mixed with a small amount of an inferior grade of gypsum. An analysis of the pure material, taken from the tunnel, gave the following results:—

| | | |
|---|---|---|
| $CaO$ | 32·70 | per cent. |
| $SO_3$ | 46·72 | " |
| $H_2O$ | 20·60 | " |
| Insoluble | 0·04 | " |
| Total | 100·06* | per cent. |

* H. A. Leverin, analyst.

This is very nearly a theoretically pure gypsum. The material can be readily mined and sent across the river by aerial tramway to the Canadian Pacific Railway tracks. In a short time the Canadian Northern railway will be operating trains along the base of the hill in which the deposits occur.

*The Industrial Finance and Development Company.*—The area controlled by this Company consists of three claims, each 1,500 feet square. These claims are situated on the slope of a hill, at a distance of about one-half mile north of Merritt, a town on the Nicola branch of the Canadian Pacific railway. The timber growth on the property consists of a few scattered pine, while the surface is covered with the usual bunch grass.

The gypsum in this instance is probably due to the action of sulphur vapours and springs on the limestone which is present in considerable quantities in this district. The heated vapours become oxidized, resulting in the production of $H_2SO_3$ and $H_2SO_4$, and these react on the limestone. The final result is the formation of gypsum with the liberation of $CO_2$. These reactions probably take place underground, and the resultant gypsum so formed, is carried upward and deposited from the solutions as they pass over the surface. The gypsum itself occurs in a very finely divided state, and the fact that the crystals are not cemented together, not only facilitates handling, but results in the elimination of heavy crushing. Although the crude rock contains considerable vegetable matter, this fact does not appear to affect its tensile strength. It presents no difficulties as regards calcination, and forms a quick-setting, strong, and reliable plaster. On account of its colour, which is a light tinge of brown, it cannot be used for very fine or finished work where whiteness is the essential requirement; but for the manufacture of ordinary coarse stucco, it fulfils all conditions. Moreover, being admirably suited for use as a retarder in cement, and as a fertilizer for certain soils, the output should command a steady market in British Columbia.

The following analysis indicates the quality and composition of the loose material composing this deposit:—

| | |
|---|---|
| CaO | 33·80 per cent |
| $SO_3$ | 43·00 " |
| $H_2O$ | 20·60 " |
| Insoluble | 0·50 " |
| Total | 97·90* per cent |

* H. A. Leverin, analyst.

This sample contains a little $CaCO_3$ and $MgCO_3$. The material is a gypsum earth or gypsite of a very good quality.

Very little stripping would be required in connexion with this deposit, the average depth of the overburden being about 1 foot. Owing to lack of development work, the average thickness of the bed cannot as yet be determined. Several prospect pits have shown a thickness varying from 3 to 8 feet. Complete and systematic stripping could be carried on to advantage, while a series of test pits would not only determine the depth of the deposit but would also furnish data for an estimate of the quantity of gypsum available.

The property lies within easy access of the railway, from which a spur could connect with an incline tram line from the centre of the deposits. In a mill handling this material, the preliminary heavy crushing could be dispensed with for reasons previously stated, thus allowing the product to go direct from the mine to the buhr mills.

*Tulameen Deposits.*—Reports of the discovery of gypsum in the Tulameen district were noted in many of the western newspapers during the spring of 1911. A deposit outcropping along the banks of Granite creek—a small tributary stream which enters the Tulameen river some 10 miles above Princeton, B.C.—has been staked by Mr. H. Churchill, of Rossland, B.C. From Mr. Churchill's description, it would appear that this is another deposit of gypsite resulting from the action of sulphur vapours on limestone. The earthy material is very similar in appearance to that of the Merritt deposit, and an analysis gave the following results:—

| | |
|---|---|
| CaO | 31·48 per cent. |
| $SO_3$ | 44·32 " |
| $H_2O$ | 22·32 " |
| Insoluble | n.d. " |
| Total | 98·12* per cent. |

* F. G. Wait, analyst.

Lumps of solid gypsum, pure white and greatly eroded, which were picked up in the creek bed, indicate the possible presence of this form of the mineral in place in the vicinity. No development work has as yet been done on the property.

Although the production of gypsum in Canada during 1911 showed a decrease, as compared with that of the previous year, the value of the product showed an increase of $44,417 over that of 1910. The following table shows the production of the Provinces of Ontario, Manitoba, and British Columbia, during the past five years:—

| Year. | Ontario. | | Manitoba. | | British Columbia. | |
|---|---|---|---|---|---|---|
| | Quantity in tons. | Value. | Quantity in tons. | Value. | Quantity in tons. | Value. |
| | | $ | | $ | | $ |
| 1907 | 10,404 | 52,417 | ........ | ........ | ........ | |
| 1908 | 10,389 | 42,456 | 14,500 | 111,500 | ........ | |
| 1909 | 11,731 | 48,278 | 17,000 | 170,000 | ........ | |
| 1910 | 15,055 | 67,229 | 19,500 | 195,000 | ........ | |
| 1911 | 27,399 | 98,018 | 43,000 | 372,000 | 780* | 1,875 |

* First production from this Province.

That the demand for gypsum products for building, etc., is ever on the increase, is evidenced by the heavy imports into the western provinces through the ports of entry of Vancouver, Victoria, Calgary, and Winnipeg. The large deposits of the mineral in Manitoba and in British Columbia can supply gypsum of a quality equal to any of that imported. Considering the steadily increasing demand, the next few years should witness several new properties added to the list of western producers.

## The Salt Industry.

### ONTARIO.

At present there is, in Canada, but one district where salt is produced. The area included in this district, lies in the southwestern peninsula of Ontario and borders on the eastern shores of Lake Huron, the St. Clair river, Lake St. Clair, and the Detroit river. The most northerly point at which salt is found is at Kincardine, and the southern limit lies below Sandwich. This area, underlain by the salt beds, may be said to approximate in shape the segment of a circle. In such a segment, Kincardine and Sandwich would constitute the northern and southern limits, while its greatest width—about 60 miles—would lie to the east of Sarnia.

The salt occurs interbedded with limestone of the Devonian age, the salt beds varying in thickness from 20 feet upwards, according to the locality.

All the salt obtained from this district is secured from the evaporation of waters which have been allowed to remain in contact with the salt beds until a saturated solution had been formed. The water employed is derived either from natural underground springs, or else is forced down through the cased drill-holes penetrating the salt beds. A second casing inside the larger one permits of the saturated brine being pumped to the surface and thence to the settling tanks. The brine produced in this district is very pure and seldom requires the addition of any chemicals to precipitate impurities. An analysis of brine taken from one of the salt wells in this district showed the following composition:—

| | |
|---|---|
| $NaCl$ | 26·6415 per cent. |
| $CaCl_2$ | 0·1895 " |
| $MgCl_2$ | 0·1884 " |
| $CaSO_4$ | 0·2757 " |
| $H_2O$ | 72·7049 " |
| Total | 100·0000* per cent. |

* F. G. Wait, analyst.

The kettle-method of evaporation, formerly used in this district, has now entirely been replaced, either by the open-pan or by the vacuum-pan process.

*Open-pan Process.*—There are two open-pan systems for evaporating the water of the brines:—

(1) Where direct heat from the fires is applied underneath the pans, and

(2) Where heat is supplied to the brine by steam through pipes running along the bottom and middle of the pan, or by use of a false bottom, enabling the steam to come in contact with the whole under surface.

In the first case, the pans have a depth of about 2 feet with a breadth of 20 feet and a length of 100 feet. The brine is kept at a depth of 18 inches, and heat, from coal or wood fires in fire-boxes at one end, is applied underneath the pan. The grade of salt produced by this method of pan evaporation varies according to the intensity of the heat. Fine-grained salt is produced nearest the fires, where the evaporation is most rapid; coarser grades of salt are produced where the evaporation is slower.

The advantage of steam heat supplied through pipes lies in the fact that the grade of salt produced in any one pan is uniform, since it is possible to regulate the heat so as to keep the brine at an even temperature throughout the whole pan. These pans are called grainers and are used quite extensively in Canadian plants to obtain the coarser grades of salt.

*Vacuum-pan Process.*—This process is coming into use more and more as a cheap, quick, and economical method of producing the finer grades of salt. In this process a specially constructed vacuum pan is employed. The essential features of the pan consist in a series of vertical tubes arranged with their upper ends connected with a vacuum chamber. The lower ends communicate with a chamber provided with a hopper-shaped bottom. The vertical tubes are so arranged that steam for the purpose of heating can be circulated around them. Brine is introduced into the chamber below and passes up into the tubes. The pressure in the vacuum chamber is usually about one-fifth atmospheric pressure, a condition which materially lowers the boiling point of the brine, and hastens evaporation, when heat is applied. As the water evaporates, the salt in solution is precipitated and falls into the conical collecting chamber below the tubes. In some cases, heat contained in the vapour from the evaporated brine is utilized in promoting evaporation in a second pan. In this second similar pan, where the temperature is not so high, the evaporation is slower, the crystals produced are larger, and the commercial salt is of a coarser grain.

The following is a list of the Companies producing salt in the Ontario district:—

Canadian Salt Company, Windsor, Ont.
Dominion Salt Company, Sarnia, Ont.
Elarton Salt Company, Parkhill, Ont.
Exeter Salt Company, Exeter, Ont.
Gray, Young & Sparling Salt Company, Wingham, Ont.
Ontario People's Salt and Soda Company, Kincardine, Ont.
North American Chemical Company, Goderich, Ont.
Parkhill Salt Company, Parkhill, Ont.
Stapleton Salt Company, Clinton, Ont.
Western Canada Flour Mills Company, Goderich, Ont.
Western Salt Company, Mooretown, Ont.

A new plant, nearing completion, is being erected at Sandwich by the Canadian Salt Company, at which it is proposed to prepare caustic soda and bleaching powder from the salt brine. This plant will be the first of its kind to operate in Canada, and its erection marks a new departure in the industry which opens up a large field for the utilization of the excess of brine produced. The method to be employed is to decompose the brine by electrolysis into sodium hydroxide and chlorine gas. The former is purified and crystallized, while the latter is passed over lime in large, lead-lined chambers producing bleaching powder ($CaOHCl$.)

WESTERN PROVINCES.

Several of the alkali lakes in the western prairie country were visited, but owing to the excessively wet season, these lakes, which in dry years have deposits of salts anywhere up to a foot in thickness, showed only a slight saline incrustation. This prevented samples being taken and the ascertaining whether the salts were present in commercially valuable quantities.

The production of salt in Canada is showing a gradual increase each year. As is shown by the following table, this increase, which is regulated by the demand, varies greatly from year to year.

| Year. | Quantity. | Value. | Increase. |
|---|---|---|---|
| | Tons. | $ | % |
| 1909 | 84,037 | 415,219 | 5·1 |
| 1910 | 84,092 | 409,624 | 0·1 |
| 1911 | 91,582 | 443,004 | 8·9 |

The percentages are calculated from the tonnage, and are based on the increase over the preceding year.

Only a very small quantity of salt is exported, the yearly average being from 150 to 250 tons.

Although the production of salt in Canada is increasing, it still supplies less than half the home consumption, the larger part being controlled by the product of the British Isles and British possessions. This salt is admitted duty free, as is also that imported from the United States for use in the fisheries.

A word might be said on the great opportunity which exists for the establishment of a soda industry. In 1909, imports of soda products in Canada were valued at $604,162, while in 1910 their value had increased to $767,846. With such unlimited deposits upon which to draw within easy access of a central distributing point for the whole of Canada, this industry should make very rapid progress. By establishing a plant at Sandwich for the production of caustic soda and bleaching powder, a start is already being made by the Canadian Salt Company, of Windsor.

# ON THE PHOSPHATE AND FELDSPAR DEPOSITS OF ONTARIO AND QUEBEC.

*Hugh S. de Schmid, M.E.*

I was engaged during the greater part of the season of 1911 in the compilation of the monograph on mica, the field work for which was undertaken during the previous summer. A great deal of information, however, bearing on the commercial uses of the mineral and its manufacture, still remained to be collected, the work entailed thereby not being completed until the beginning of September. Having handed in my report upon the above, I at once proceeded to the Lièvre River phosphate region, in order to collect data for the monograph upon this mineral, to be issued next year by the Mines Branch. I also visited the various feldspar mines in the above district, and secured all available data regarding the occurrence, exploitation, etc., of the mineral.

## STATUS OF THE PHOSPHATE INDUSTRY.

Practically all the phosphate mines in the Lièvre district have been idle since their closing down in the early nineties, this cessation of mining activity being caused by the discovery and exploitation of the enormous deposits of sedimentary phosphates in the southern United States, notably in Florida. The production of phosphate in this State commenced in 1888 with the dredging of river pebble, the output of this mineral reaching a maximum in 1893, when 122,820 tons were produced. Since 1893, the mining of hard rock phosphate and of land pebble phosphate has increased enormously, and has almost completely displaced the original industry. In 1910, the output of hard rock phosphate in Florida amounted to 438,347 long tons (a decrease of about 75,000 tons over the production of 1909), while the amount of land pebble raised reached the large total of 1,629,160 long tons—an increase of 363,000 tons over the output of the previous year. The total amount of phosphate rock raised in Florida alone in the year 1910, was thus 2,067,507 long tons. The price of hard rock phosphate averaged $6.96 per ton, and that of land pebble $3.43 per ton, f.o.b. at the mines. The hard phosphate rock has a maximum tri-basic calcium phosphate content of 85 per cent, while the average for the entire phosphate series (including sands, clays, etc.) is between 10 and 30 per cent. There were 37 companies engaged in phosphate mining in 1909 in this State, 20 operating in hard rock and 17 in land pebble.

In addition to the deposits in Florida, extensive phosphatic beds also exist in South Carolina and Tennessee, the former State in 1910 producing a total tonnage of land and river phosphate rock of 179,659, and the latter State 398,188, long tons.

In Idaho, Wyoming, Montana, Arkansas, and Utah, large deposits of phosphatic rock have been located and to some extent exploited, the total production of these States in 1910 being 10,734 long tons. Congress has, however, adopted a policy of establishing "phosphate reserves" in the last-named States; large areas have been withdrawn from public entry, and are, at the present time, awaiting the passing of some measure to govern their disposal. In Florida, also, some 37,000 acres of phosphate lands were withdrawn from entry, and the total area throughout the United States now withdrawn exceeds 2,500,000 acres.

The total phosphate production of the United States in 1910 was 2,654,988 long tons, of an average value of $4.11 per ton. These figures show an increase in tonnage of 324,836 tons over the production of 1909; the average unit value had, however, decreased $0.51.

**Marketed Production of Phosphate Rock in the United States, 1900-1910, in long tons.***

| Year. | Quantity. | Value. |
|---|---|---|
| | | $ |
| 1900 | 1,491,216 | 5,359,248 |
| 1901 | 1,483,723 | 5,316,403 |
| 1902 | 1,490,314 | 4,693,444 |
| 1903 | 1,581,576 | 5,319,294 |
| 1904 | 1,874,428 | 6,580,875 |
| 1905 | 1,947,190 | 6,763,403 |
| 1906 | 2,080,957 | 8,579,437 |
| 1907 | 2,265,343 | 10,653,558 |
| 1908 | 2,386,138 | 11,399,124 |
| 1909 | 2,330,152 | 10,772,120 |
| 1910 | 2,654,988 | 10,917,000 |
| Total | 21,586,025 | 86,353,906 |

* Advance chapter from Mineral Resources of the United States, 1910.

In 1910, the exports of phosphate rock from the United States amounted to 1,083,037 long tons, valued at $8,234,276. In addition to the United States (which country, at the present time, constitutes the principal source of supply, and also the greatest reserve of natural phosphates), Algeria, Belgium, France, Tunis, and Christmas island (Straits Settlements), also produce large quantities of phosphate rock. The combined production of these five countries in 1909, amounted to 2,036,479 long tons, equal to about seven-eighths of the output of the United States for the same period.

CANADIAN PRODUCTION.

Compared with the above-mentioned large productions of foreign countries, notably the United States, the output of phosphate from Canadian deposits during recent years sinks into insignificance. In 1910, the production was 1,319 tons, valued at $11,780, giving an average of $8.93 per ton. Practically the whole of the output is consumed in this country, and is shipped to Buckingham, Que., where it is used for the manufacture of fertilizers and phosphorus. There are only two firms—the Electric Reduction Company, and the Capelton Chemical and Fertilizer Company—engaged in the manufacture of the above, and the annual demand of these for Canadian apatite, owing to the large supply of cheaper American phosphate, falls short of the thousand ton mark. The fact that the average price asked for American phosphate is only $4.11, f.o.b., while that of Canadian apatite is $8.93 (or more than double the price of the American product), naturally prohibits any extensive demand for the latter mineral; the former proves cheaper even with freight charges added. The greater quantity of the apatite marketed is derived as a by-product from the mica mines, the mica and phosphate often occurring intimately associated. Frequently, also, what was originally exploited as a phosphate mine develops into a mica mine and vice versa—the sporadic and impersistent occurrence of the two minerals being often highly perplexing to operators. At a few scattered localities mining for phosphate alone is carried on in an intermittent fashion—a few hundred tons of mineral being produced annually. Pockets of phosphate are often encountered by mica miners, and, as the mica crystals not infrequently occur disseminated in the filling of such pockets, both minerals can, in such case, be won profitably at the same time. At most mica mines a small amount of phosphate can usually be seen, which has been saved during mining operations for the former mineral, and many of the dumps contain considerable quantities of apatite which it has not been considered worth while to save. The practice of operators is to allow the phosphate to accumulate during the summer months and to ship it away in the winter, when winter-roads afford a more direct and cheaper means of transport. Taking all factors into consideration, it can well be considered questionable whether phosphate mining in Canada can ever—even in the earliest and most profitable days of mining activity, when the mineral sold for $14 and $15 per ton—have proved a highly paying undertaking. When the so-called "phosphate boom," in the early eighties, drew attention to the extensive apatite deposits lying adjacent to the Lièvre river, Quebec, numerous companies were formed in Canada, the United States, England, and France, to exploit the ore-bodies. Large sums were subscribed, and a large amount of foreign capital was expended upon the properties, some of which employed as many as 150 to 200 men. The High Rock mine, one of the largest in the district, and situated on range VII of the township of West Portland, was equipped with a camp capable of accommodating 175 men, the buildings being laid out to form regular streets, while the machinery included thirteen boilers and two compressors. A tramway 2 miles long was built to convey the ore to the Lièvre river. The mine was first operated on a large scale about 1882, and mining was continued for some eleven years, until 1893 or 1894, when, the price of phosphate being between $7 and $8 less per ton than in 1886, consequent upon the competition of the Florida production, the mine closed down. All traces of the buildings, etc., have long since been removed or destroyed by fire, and there is little at the present day, save the extensive workings and dumps, to indicate that this mine was, some five and twenty years ago, one of the main centres of mining activity in the district. Here, as at the majority of the other dozen or so mines in the Lièvre River phosphate region, enormous bodies of high-grade (85 to 90 per cent tri-basic calcium phosphate) and almost pure apatite, containing but little mica or other mineral impurities, were met with. Despite the high grade of the ore, the high cost of extraction due to the large machinery plants installed in the majority of the mines, and also the heavy expense of transport—entailing sometimes a journey of several miles over bush roads with subsequent re-shipment at three or four points before the ore reached the consumer—combined to render the mining of the mineral an expensive and somewhat hazardous undertaking. It is said that the bottoms of many of the shafts in this district were in extensive bodies of high-grade mineral when the mines were closed down, and that the cessation of operations was due solely to the lower prices caused by foreign competition, and not to any diminution in the quantity of phosphate in sight. The year of greatest mining activity, as far as figures are available, was 1890, when the total phosphate production of Ontario and Quebec was given as 31,753 tons, valued at $361,045—an average of $11.37 per ton. The following table shows the annual output during the past twenty-five years:—

TABLE 2.

## Annual Production of Phosphate in Canada 1886-1910.

| Calendar Year. | Tons. | Value. | Average Value per ton. |
|---|---|---|---|
| | | $ | $ |
| 1886 | 20,495 | 304,338 | 14 85 |
| 1887 | 23,690 | 319,815 | 13 50 |
| 1888 | 22,485 | 242,285 | 10 77 |
| 1889 | 30,988 | 316,662 | 10 21 |
| 1890 | 31,753 | 361,045 | 11 37 |
| 1891 | 23,588 | 241,603 | 10 24 |
| 1892 | 11,932 | 157,424 | 13 20 |
| 1893 | 8,198 | 70,942 | 8 65 |
| 1894 | 6,861 | 41,166 | 6 00 |
| 1895 | 1,822 | 9,565 | 5 25 |
| 1896 | 570 | 3,420 | 6 00 |
| 1897 | 908 | 3,984 | 4 39 |
| 1898 | 733 | 3,665 | 5 00 |
| 1899 | 3,000 | 18,000 | 6 00 |
| 1900 | 1,415 | 7,105 | 5 02 |
| 1901 | 1,033 | 6,280 | 6 07 |
| 1902 | 856 | 4,953 | 5 79 |
| 1903 | 1,329 | 8,214 | 6 18 |
| 1904 | 817 | 4,590 | 5 62 |
| 1905 | 1,300 | 8,425 | 6 48 |
| 1906 | 850 | 6,375 | 7 50 |
| 1907 | 824 | 6,018 | 7 30 |
| 1908 | 1,596 | 14,794 | 9 26 |
| 1909 | 998 | 8,054 | 8 07 |
| 1910 | 1,478 | 12,578 | 8 51 |
| Total | 200,519 | 2,181,300 | 8 49 |

Several inquiries have been received recently at the Mines Branch from interested parties in Europe, relative to the opportunities for both mining and obtaining apatite in Canada. The prices offered by English consumers for the mineral ($9 to $10 per ton c.i.f. British ports) are considerably ($1.50 to $2.50) less than those being paid at Buckingham, Que.—only a few miles distant from the mines. As already remarked, few operators consider it worth while, at the present time, to extract apatite, and almost the entire demand is supplied by the mineral produced as a by-product from the mica mines.

The above remarks, referring to the conditions of the phosphate industry in the Quebec apatite district, apply equally to the mines in Ontario. The latter Province has never figured as a phosphate producer to anything like the same extent as Quebec, the largest output of apatite (based upon exports) amounting to 3,547 tons in 1889.

It seems hardly possible that, with the enormous deposits of sedimentary phosphates known to exist at many places in the world, and particularly in the neighbouring United States—deposits which can be readily and simply mined by such methods as dredging, hydraulicking, steam-shovel work, or ordinary quarrying—the apatite veins and pockets of the Laurentian series of Quebec and Ontario can ever hope to again become a profitable source of phosphate, and the objective of any extensive mining operations. The depth of the pits at the larger mines, varying from 100 to as much as 600 feet, and the present precarious state of the workings, which followed pockety bodies of phosphate having no definite shape or direction (such bodies having been robbed as far as was practicable in their entirety), would entail the expenditure of much capital, in order to put the mines into new working shape, before a ton of phosphate could be produced; while the expense of mining at such depths would most certainly prove prohibitive, without a decided and most unlooked-for increase in the price of the mineral.

STATUS OF THE FELDSPAR INDUSTRY.

The largest production of feldspar in any one year since the inception of the industry amounts to 16,948 tons, in 1906. The output of 1910 ranks next with 15,719 tons, and the average for the past eight years (1903-1910) is 12,827 tons. Almost the entire production is, at the present time, derived from the mines in the townships of Portland and Bedford, Ont., the Kingston Feldspar and Mining Company, of Kingston, Ont., being the principal producer. This Company has been mining steadily since 1903, employs an average force of 40 to 50 men, and can produce, if necessary, as high as 100 tons of high-grade spar per diem. The entire output goes to the Pennsylvania Feldspar Company, of Charlotte, N.Y. A considerable amount of quartz is won simultaneously with the spar, and is shipped to Welland, Ont., for use in the manufacture of ferro-silicon. A number of smaller mines exist in the same district, and have been operated intermittently during the past ten years; the majority of them were, however, idle when the district was visited in October last. The spar at all the mines in this district is a terra-cotta coloured orthoclase.

A deposit of bluish-white feldspar was opened up in 1911, by Mr. E. Smith, on lot 13, concession V, of the township of North Burgess, Ont. The rock partakes of the nature of a very coarse graphic granite, and the spar is said to be of good quality. The owner reports an output of 700 tons, shipped to Trenton, New Jersey.

On Bobs lake, in the township of Bedford, the Suroff Feldspar Mining and Milling Company are erecting a camp and plant, and propose commencing operations, both mining and grinding, in the near future.

In the Parry Sound district, on lot 4, concession IX, of the township of Conger, the Ojaipee Silica and Feldspar Company have carried out a little work for both feldspar and quartz, the latter being the preponderating mineral.

The production of feldspar in the Province of Quebec is practically limited to a small output of high-grade, white spar (microcline) used in dentistry, which brings as high as $35 to $40 per ton. This spar is derived from the Villeneuve mine, in the township of Villeneuve, about 25 miles north of Ottawa, and is won simultaneously with the mica for which the mine is operated. The latter mineral is no longer found in paying quantities, and the mine was shut down in September, 1911. Small deposits of similar spar, mixed more or less intimately with the other varieties of the mineral, known as orthoclase and albite, exist at several spots in the area immediately to the north of Ottawa. Such deposits (pegmatite dykes) have been worked intermittently during the past five-and-twenty years, either for spar alone, or for the mica which they contain, the spar being saved as a by-product. With the exception of a small deposit on lot 22, range VI, of the township of West Portland, opened in September last by Messrs. O'Brien and Fowler, for mica and spar, none of the feldspar properties in this region are at present being operated.

On the north shore of the St. Lawrence, at Quetachu-Manikuagan bay, an extensive deposit of good quality, white feldspar is reported by J. Obalski.[1] No work appears to have been carried out here since 1899, when a couple of hundred tons of spar were produced.

Outside of Ontario and Quebec, no economic deposits of feldspar appear to have been located in the Dominion, and the supply of the mineral is derived entirely from the above-mentioned mines.

The following table shows the production of feldspar in Canada from 1890 to 1910:—

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[1] Ann. Rep. Dept. Mines, Prov. Que., 1899.

## Annual Production of Feldspar in Canada, 1890-1910.

| Calendar Year. | Tons. | Value. | Calendar Year. | Tons. | Value. |
|---|---|---|---|---|---|
| | | $ | | | $ |
| 1890 | 700 | 3,500 | 1901 | 5,350 | 10,700 |
| 1891 | 685 | 3,425 | 1902 | 7,576 | 15,152 |
| 1892 | 175 | 525 | 1903 | 13,928 | 18,966 |
| 1893 | 575 | 4,525 | 1904 | 11,083 | 22,166 |
| 1894 | Nil. | Nil. | 1905 | 11,700 | 23,400 |
| 1895 | | *2,545 | 1906 | 16,948 | 40,890 |
| 1896 | 972 | *2,583 | 1907 | 12,584 | 29,819 |
| 1897 | 1,400 | 3,290 | 1908 | 7,877 | 21,099 |
| 1898 | 2,500 | 6,250 | 1909 | 12,783 | 40,383 |
| 1899 | 3,000 | 6,000 | 1910 | 15,809 | 47,667 |
| 1900 | 318 | 1,112 | | | |

* Exports.

As is evident from this and the following table, the demand for feldspar by consumers in the United States has shown little variation during recent years, and operators have not been led to materially increase their output. In the United States, the spar employed is mainly derived from pegmatite, or coarse granitic dykes, and is not nearly so pure as that from the Canadian mines and especially from those in the Kingston district, the product of the last-named mines being always certain of finding a ready market at the Ohio and New Jersey potteries. The price paid by United States consumers for the highest grade, or "No. 1 Canadian," is between $5 and $5.50 per long ton f.o.b. mills, while the output of the Maine, Connecticut, and Maryland quarries brings from $2.50 to $4.50 per long ton, the average price being about $4. A duty of 20 per cent ad valorem is imposed by the United States upon ground feldspar entering that country, while the crude mineral enters free.

## Production of Feldspar in the United States, 1906-1910, in short tons.*

| Year. | Crude. | | Ground. | | Total. | |
|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| | | $ | | $ | | $ |
| 1906 | 39,976 | 132,643 | 32,680 | 268,888 | 72,656 | 401,531 |
| 1907 | 31,080 | 101,816 | 60,719 | 457,128 | 91,799 | 558,944 |
| 1908 | 18,840 | 65,780 | 51,634 | 362,773 | 70,474 | 428,553 |
| 1909 | 25,506 | 70,210 | 51,033 | 354,392 | 76,539 | 424,602 |
| 1910 | 24,655 | 81,965 | 56,447 | 420,487 | 81,102 | 502,452 |

* Advance Chapter from Mineral Resources of the United States, 1910.

# I.

## THE DETERMINATION OF MOISTURE IN FUELS.

*Edgar Stansfield, M.Sc.*

*Introduction.*—In November, 1910, the writer, with the permission of Dr. Haanel, became a member of the sub-committee (of the Commission Internationale d'Analyses, connected with the Eighth International Congress of Applied Chemistry, New York, 1912) on "The Standardization of Methods of Determining Water in Coal and other Fuels and in Minerals." In the autumn of 1911, the chairman of the sub-committee, G. T. Holloway, of London, England, sent out identical specimens of six coals to a number of the members of the Committee with a request that they should determine the water in them by three or more different methods.

The following is the report of the work done and the suggestions made by the writer. The full report of the Committee, which will embody the results and recommendations of all its members both with regard to water in fuels and in minerals, will be presented to the International Congress of Applied Chemistry at its meeting in New York in September, 1912.

All the following tests, with the exception of those on peat, were made on the six samples of coal supplied for the purpose. The subject was considered from the point of view of a commercial laboratory, that is, methods were considered by which a number of samples could be treated at once and the errors inherent in such methods were investigated. No efforts were made to get a succession of concordant results (regardless of their actual accuracy) and methods that could only be applied to single samples under research conditions were not considered. The tests made are obviously far from complete, but it was hoped that they would supplement work done by other members of the Committee.

It is worthy of note that in Canada when this work was done, the relative humidity indoors is generally extremely low during the winter months, although in the summer it is very high.

*Apparatus Employed.*—The customary laboratory equipment was employed, except for the two drying ovens used, which were as follows:—

(1) An electric oven made by the International Instrument Company, of Cambridge, Mass., U.S.A. This oven is 12″ × 12″ × 12″ inside; air passes over electrically-heated coils below the oven, enters through holes in the walls and escapes through a vent in the top. A mercury thermostat regulator controls the resistance in the heating circuit and keeps the temperature of the oven constant within about 2° C., although the temperature is not uniform throughout the interior. It was found that when the oven thermometer, which was in a corner at the back with its bulb on a level with the middle shelf, registered 105° C., a thermometer with its bulb standing in a crucible of coal at the front of the bottom shelf registered 109° C., and one with its bulb in a crucible of coal at the front of the middle shelf registered 103° C. With one exception, duly noted, all coals dried in this oven were placed about the middle of the middle shelf where the temperature would average close to 104° C.

(2) A toluol oven described by R. L. Sian (Journ. Soc. Chem. Indust., Vol. XXX, No. 2, Jan. 31, 1911, p. 61) and made by Baird & Tatlock, of London. This oven is 12″ long by $2\frac{3}{8}$″ wide by $1\frac{1}{2}$″ high inside. The door is made airtight with

a rubber gasket, and the oven is arranged so that a current of gas, which is heated to the oven temperature by the toluol vapour before it enters the drying chamber, can be passed through. Experiments showed that, neglecting the extreme ends of the oven, the inside temperature was very steady at from 108°-109° C. Coals were put into this oven when it was cold and it usually took about ten minutes to reach full heat throughout; five minutes extra time was allowed in all experiments to compensate for this delay in heating. The air or gas passed through the oven was previously dried by means of a U tube filled with calcium chloride and a wash bottle of sulphuric acid. Nitrogen, and carbondioxide were first freed from traces of oxygen by passing them through a pipette filled with sticks of yellow phosphorus. The volume of the gas was measured by a meter after it left the oven.

*Experimental.*—The experiments made can be divided into two series; series I was begun on January 26, 1912, and series II on February 7.

In series I, a number of sample tubes, weighing bottles, etc., were first prepared and labelled; then one of the cans containing the coal samples was opened, for the first time, the contents thoroughly mixed with a spatula, and two sample tubes, 3″ × ½″ outside, were filled with the coal and at once corked. Ten other sample tubes 2″ × ½″ were similarly filled. Another portion of the sample was put into a special glass tube which was at once sealed in a blowpipe flame; and about a gram of the coal was introduced into a small weighing bottle, 2″ × 1″, that had been weighed empty a few minutes before. Four or five briquettes of the coal were made in a briquetting press and put into another small weighing bottle (this being omitted in the case of coal No. 1), and the sample can carefully closed again. The whole operation was completed in from ten to fifteen minutes, after which the 2″ × 1″ weighing bottle was at once reweighed. The relative humidity in the laboratory at the time was about 24 per cent. All six cans of coal were similarly treated, after which the six weighing bottles were placed unstoppered in a desiccator, containing about 125 c.c. of concentrated sulphuric acid. The desiccator was then exhausted by means of a water pump to a pressure of about 60 mm. of mercury.

The sample tubes employed were closed with corks that had been impregnated with paraffin wax; and were then stored until used, in large weighing bottles or in corked containers. When a test was to be made, a tube was weighed corked, about a gram of the coal poured out into a crucible, and the tube at once recorked and reweighed. The difference of weight gave the exact weight of coal taken. This method renders it possible to carefully weigh out a portion of coal without risk of its gaining or loosing moisture during the process; it is not possible, however, in this way to take an exact gram of the sample.

*Series II.*—Some of the results obtained in the experiments of series I could only be accounted for by the supposition that the moisture content of the sample tubes had changed before use. On February 7, the original sample cans were again opened, the contents well mixed, and from each sample about one gram of coal was put into each of six 2″ × ½″ sample tubes and into a weighed 2″ × 1″ weighing bottle, and all these were at once carefully weighed. The weighing bottles were placed over strong sulphuric acid in a desiccator which was exhausted to 60 mm. as before, and the six tubes of each sample were stored together in a large weighing bottle until used. These sample tubes were reweighed before use. The change in weight has been reported in each case, but all results have been corrected to the weight of coal in the tube immediately after filling. In order to be able to make the necessary calculations the entire contents of a tube had to be taken if this had changed in weight; and thus in series II, although the tubes were not completely filled, considerably more than one gram of coal was frequently taken; the use of smaller tubes would have been much better.

In both series, when an exhausted desiccator was to be opened, air was first allowed to pass in through a sulphuric acid wash bottle. The bottles were then stoppered, and allowed to stand for a few minutes in the balance case before they were weighed; two small vessels containing sulphuric acid being always kept in the balance case. The crucibles containing coal were cooled after heating in desiccators over strong sulphuric acid. Only two crucibles were placed in each desiccator, and they were weighed as soon as cool. Weighings were made as quickly as possible, and the crucible was covered during the process by a counterpoised watch glass.

The details of the separate experiments are as follows, the results are given in tabular form later.

*Series I, Experiment 1.*—Weighing bottles filled directly from the main coal sample on January 26, dried in exhausted desiccator over sulphuric acid, and reweighed every two or three days up to twelve days.

*Experiment 2.*—Coals dried for 1 hour in 25 c.c. porcelain crucibles on the bottom shelf of the electric oven; the temperature was not well regulated on this occasion, and would probably average about 110°-112° C. in the crucibles.

*Experiment 3.*—Coals dried for 1 hour in 15 c.c. porcelain crucibles on the middle shelf of the electric oven.

*Experiment 4.*—Like 3, except that 25 c.c. crucibles were used.

*Experiment 5.*—Coals dried for 1 hour in 20 c.c. porcelain capsules in toluol oven: 24 litres of dry air being meanwhile drawn through the oven.

*Experiment 6.*—Coals dried for 1 hour in 20 c.c. capsules in toluol oven: 66 litres of dry air being meanwhile drawn through.

*Experiment 7.*—Coals were dried in 25 c.c. porcelain crucibles over sulphuric acid in exhausted desiccator and weighed at intervals during a period of 9 days. The crucibles were then heated for 1 hour in the toluol oven in a stream of dry, purified carbon dioxide; 5 litres being passed through to displace the air before the oven was heated, and 11 litres afterwards. The crucibles were then cooled and weighed. Finally the crucibles were heated in the toluol oven for one hour, during which time 17 litres of dry air were drawn through.

If it is assumed that the nine days drying in the exhausted desiccator had completely removed the moisture from the coal, and that carbon dioxide is a neutral gas, then the change in weight during the first hour's heating was due to loss of volatile matter other than moisture, and during the second hour's heating to the oxidation of the coal—two changes which ordinarily go on together when coal is heated in air.

*Experiment 8.*—Coals were dried for 2 hours in 20 c.c. capsules in toluol oven, 73 litres of dry air being meanwhile drawn through.

*Experiment 9.*—Coals were dried for 2 hours in 15 c.c. crucibles in electric oven.

*Experiment 10.*—Coals were dried for 1 hour in 20 c.c. capsules in toluol oven; the air was displaced by dry, oxygen free, nitrogen before the oven was heated, and 25 litres of the same gas were passed through afterwards.

*Experiment 11.*—Coals were dried for 1 hour in 20 c.c. capsules in toluol oven in a stream of dry, oxygen free, carbon dioxide; 5 litres were passed through before the oven was heated and 17 litres afterwards.

*Experiment 12.*—Coals were dried for 2 hours in 20 c.c. capsules in toluol oven in a stream of dry, oxygen free, nitrogen; 5 litres being passed through before the oven was heated and 38 litres afterwards. After the capsules had been weighed, as usual, they were reheated for 1 hour as before, except that 39 litres of dry air were now drawn through.

*Series II, Experiment 13.*—Weighing bottles were filled directly from the main coal samples on February 7, dried in an exhausted desiccator over sulphuric acid, and reweighed every 2 or 3 days up to date.

*Experiment 14.*—Coals were dried for 1 hour in 15 c.c. crucibles in electric oven, cooled and weighed as usual, and then heated for a second hour under the same conditions.

*Experiment 15.*—Coals were dried for 1 hour in 20 c.c. capsules in the toluol oven in a stream of purified carbon dioxide; 5 litres were passed through before the oven was heated and 17 litres afterwards. The capsules were then cooled and weighed as usual. The heating, etc., was repeated for a second hour as before, except that 5 and 15 litres of carbon dioxide were passed through before and during the heating, respectively. Finally a third hour's heating was given, during which 34 litres of dry air were drawn through.

*Experiment 16.*—Coals were dried for 1 hour in 20 c.c. capsules in the toluol oven, a stream of 36 litres of dry air being drawn through. After cooling and weighing a second hour's heating was given, during which 21 litres of dry air were drawn through.

*Experiment 17.*—Coals were dried for 2 hours in 15 c.c. crucibles in electric oven.

*Experiment 18.*—Two tubes of each sample left over from those filled on February 7, were reweighed on February 14 and February 17.

## Description of Coal Samples.

The description of the coal samples supplied by the Chairman of the Committee is briefly as follows: the figures are extremely rough and were merely given by him as an indication of the type of coal.

SAMPLE NUMBER.

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| Moisture.. .. .. .. .. .. .. .. .. .. | 2 | 8 | 6 | 5 | 6 | 8 |
| Total volatile matter, excluding water. | 5 | 35 | 34 | *23 | 33 | 27 |
| Ash.. .. .. .. .. .. .. .. .. .. .. .. | 8 | 3½ | 4½ | 37 | 8½ | 10 |

* Excluding sulphur.

No. 1 is an anthracite from South Wales.

No. 2 is from the "10 yard" or "thick coal" seam of South Staffordshire (England) and in many respects resembles a lignite.

No. 3 is from the Killburn seam of Leicestershire (England) and is a coking coal.

No. 4 is a coal from South America; it is interesting in connexion with moisture determination on account of its high sulphur content (4·2% volatile, 8·2% non-volatile). No pyrites is visible or can be washed out, but the coal rapidly weathers and develops free sulphuric acid and ferrous sulphate.

No. 5 is ordinary bituminous coal from Leicestershire.

No. 6 is a somewhat less bituminous coal from the southeast of Scotland.

## SERIES I AND II.

### Coals dried in weighing bottles in Exhausted Desiccator.

Total percentage loss of weight of coals after successive periods of drying.

| Time elapsed. | | | 2 days. | 3 days. | 5 days. | 7 days. | 10 days. | 12 days. | 13 days. | 54 days. |
|---|---|---|---|---|---|---|---|---|---|---|
| Coal. | Experiment. | Weight of coal. | | | | | | | | |
| 1 ................. | 1 | 1·1227 | ... | 3·03 | 3·08 | 3·08 | 3·10 | 3·08 | .. | |
| | 13 | 1·1292 | 3·04 | ...... | 3·09 | 3·13 | 3·08 | ... | 3·09 | 3·14 |
| 2 ................. | 1 | 1·1752 | ..... | 9·78 | 10·03 | 10·10 | 10·17 | 10·17 | ..... | |
| | 13 | 0·9940 | 9·97 | ... | 10·08 | 10·13 | 10·16 | ...... | 10·26 | 10·45 |
| 3 ................. | 1 | 1·3791 | .... | 7·40 | 7·61 | 7·69 | 7·76 | 7·75 | ... | |
| | 13 | 1·3973 | 7·47 | ... | 7·56 | 7·61 | 7·65 | .... | 7·74 | 7·87 |
| 4 ................. | 1 | 1·3939 | ... | 5·02 | 5·34 | 5·47 | 5·57 | 5·60 | . | |
| | 13 | 1·2877 | 5·12 | .. | 5·29 | 5·37 | 5·45 | ..... | 5·66 | 6·31 |
| 5 ................. | 1 | 1·0179 | ... | 7·27 | 7·46 | 7·58 | 7·59 | 7·59 | .. | |
| | 13 | 0·7858 | 7·34 | . . | 7·46 | 7·48 | 7·51 | . | 7·60 | 7·74 |
| 6 ................. | 1 | 1·1906 | .... | 7·68 | 7·83 | 7·93 | 7·93 | 7·92 | ... | |
| | 13 | 1·0202 | 7·72 | .. | 7·80 | 7·81 | 7·83 | ... | 7·89 | 7·98 |
| Average ........... | 1 | 1·21 | .. | 6·70 | 6·89 | 6·98 | 7·02 | 7·02 | ..... | |
| | 13 | 1·10 | 6·78 | ..... | 6·88 | 6·92 | 6·95 | .... | 7·04 | 7·25 |

Samples taken from main supply on January 26, and February 7, respectively.

## SERIES I.

### Experiment 7.—Coals dried 9 Days in Desiccator then heated 1 hour in Carbon Dioxide and 1 hour in Air.

| — | Weight of coal taken from tubes on Jan. 31. | Loss of weight after 1 day's drying. | Total loss of weight after 2 day's drying. | Total loss of weight after 5 day's drying. | Total loss of weight after 9 day's drying. | After heating for 1 hour in toluol oven in an atmosphere of carbon dioxide. | | After further heating for 1 hour in toluol oven in an atmosphere of air. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Change of weight caused. | Total net loss of weight. | Change of weight caused. | Total net loss of weight. |
| Coal. | grams. | % | % | % | % | % | % | % | % |
| 1 | 1·2833 | 2·69 | 2·81 | 2·87 | 2·87 | +0·01 | 2·86 | −0·02 | 2·88 |
| 2 | 1·0696 | 9·70 | 9·94 | ........ | ........ | ........ | ........ | ........ | |
| 3 | 1·2474 | 7·26 | 7·49 | 7·65 | 7·70 | −0·05 | 7·75 | +0·18 | 7·57 |
| 4 | 1·3706 | 5·14 | 5·45 | 5·84 | 5·99 | −0·30 | 6·29 | +0·02 | 6·27 |
| 5 | 1·0271 | 7·09 | 7·41 | 7·49 | 7·58 | −0·09 | 7·67 | +0·19 | 7·48 |
| 6 | 1·2772 | 7·44 | 7·65 | 7·77 | 7·81 | −0·06 | 7·87 | +0·21 | 7·66 |
| Average | 1·21 | 6·55 | 6·79 | ........ | ........ | −0·10 | ........ | +0·12 | |

Interval changes as well as total changes expressed as percentages of original weight of sample.

SERIES I

## Coals dried in Electric Oven.

Percentage loss of weight of coals.

| | | | | |
|---|---|---|---|---|
| Number of experiment | 2 | 3 | 4 | 9 |
| Date of experiment | Jan. 27 | Jan. 29 | Jan. 29 | Feb. 3. |
| Time of heating | 1 hour.* | 1 hour. | 1 hour. | 2 hours. |
| Coal. | % | % | % | % |
| 1 | 3·15 | 2·83 | 2·83 | 2·79 |
| 2 | 10·18 | 9·92 | 9·98 | 9·85 |
| 3 | 7·69 | 7·33 | 7·32 | 7·24 |
| 4 | 6·26 | 6·00 | 6·03 | 6·01 |
| 5 | ? | 7·44 | 7·44 | 7·28 |
| 6 | 7·65 | 7·57 | 7·47 | 7·19 |
| Average | — | 6·85 | 6·85 | 6·73 |

* Coals heated on bottom shelf of oven.

SERIES I.

## Coals dried in Toluol Oven.

| Number of experiment.... | 5 | 6 | 8 | 10 | 11 | 12 | | |
|---|---|---|---|---|---|---|---|---|
| Date of experiment........ | Jan. 30 | Jan. 31 | Feb. 1. | Feb. 3. | Feb 5. | Feb. 6. | | |
| Time of heating. ........ | 1 hour. | 1 hour. | 2 hours. | 1 hour. | 1 hour. | 2 hours. | 1 hour. | |
| Gas in oven ............. | air. | air. | air. | nitrogen | carbon dioxide. | nitrogen | air. | |
| Litres of gas passed through. | 24 | 66 | 73 | 25 | 17 | 38 | 39 | |
| — | Loss of weight. | Loss of weight. | Loss of weight. | Loss of weight. | Loss of weight. | Loss of weight. | Change of weight* | Total net loss of weight. |
| Coal. | % | % | % | % | % | % | % | % |
| 1 ........................ | 2·97 | 2·82 | 2·79 | 2·70 | 2·76 | 2·40 | −0·05 | 2·35 |
| 2 ........................ | 9·77 | 9·96 | 9·59 | 10·01 | 9·69 | 10·26 | +0·19 | 10·07 |
| 3........................ | 7·31 | 7·55 | 7·08 | 7·53 | 7·49 | 7·65 | +0·15 | 7·50 |
| 4 ........................ | 6·01 | 6·05 | 5·95 | 6·30 | 5·87 | 6·21 | +0·03 | 6·18 |
| 5........................ | 7·15 | 7·49 | 7·02 | 7·64 | 7·07 | 7·23 | +0·09 | 7·14 |
| 6 ........................ | 7·71 | 7·64 | 7·31 | 7·64 | 7·27 | 7·19 | −0·11 | 7·08 |
| Average............ | 6·82 | 6·92 | 6·62 | 6·97 | 6·69 | 6·82 | +0·10 | 6·72 |

* Expressed as percentage of original weight.

## TABLE 5—SERIES II.

### Coals dried in Electric Oven.

| Number of experiment | 14 | | | | | 17. | | |
|---|---|---|---|---|---|---|---|---|
| Date of experiment | February 8. | | | | | February 12. | | |
| Time of heating | 1 hour. | | | 1 hour. | | 2 hours. | | |
| — | Weight of coal taken from tubes. | Change of weight of coal in tube before use. | Total net loss of weight after first heating. | Change in weight caused by second heating. | Total net loss of weight after second heating. | Weight of coal taken from tubes. | Change of weight of coal in tube before use. | Total net loss of weight after heating. |
| Coal. | grams. | % | % | % | % | grams. | % | % |
| 1 | 1·0907 | −0·03 | 3·01 | −0·06 | 2·95 | 1·1172 | −0·01 | 2·82 |
| 2 | 1·3038 | −0·02 | 10·08 | ....... | ...... | 1·4034 | −0·05 | 9·78 |
| 3 | 1·3140 | −0·02 | 7·54 | −0·05 | 7·49 | 1·3594 | −0·13 | 7·30 |
| 4 | 1·5981 | −0·02 | 5·98 | −0·04 | 6·02 | 1·3524 | −0·06 | 5·93 |
| 5 | 1·1663 | −0·02 | 7·33 | −0·09 | 7·42 | 1·2566 | −0·02 | 7·26 |
| 6 | 1·2746 | −0·02 | 7·44 | −0·08 | 7·52 | 1·2167 | −0·02 | 7·53 |
| Average | 1·29 | −0·01 | 6·90 | −0·02 | ...... | 1·28 | 0·00 | 6·77 |

All changes of weight calculated as percentage of original weight of coal as filled into tubes on Feb.

SERIES II

## Coals dried in Toluol Oven.

| No. of experiment | 15. | | | | | | | 16 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date of experiment.. | Feb. 8. | | | Feb. 9. | | Feb. 10. | | Feb. 12. | | | | |
| Time of heating..... | 1 hour. | | | 1 hour. | | 1 hour | | 1 hour. | | | 1 hour. | |
| Gas in oven....... | Carbon dioxide. | | | Carbon dioxide | | Air. | | Air. | | | Air. | |
| Gas passed through. | 17 Litres. | | | 15 Litres. | | 34 Litres | | 36 Litres. | | | 21 Litres. | |
| — | Weight of coal taken from tubes. | Change of weight of coal in tube before use. | Total net loss of weight of coal at end of first heating. | Change of weight caused by second heating. | Total net loss of weight of coal at end of second heating. | Change of weight caused by third heating. | Total net loss of weight of coal at end of third heating. | Weight of coal taken from tubes. | Change of weight of coal in tube before use. | Total net loss of weight of coal at end of first heating. | Change of weight caused by second heating. | Total net loss of weight of coal at end of second heating. |
| Coal. | grams | % | % | % | % | % | % | grams | % | % | % | % |
| 1 ........... | 1·2439 | −0·01 | 3·02 | −0·06 | 3·08 | +0·05 | 3·03 | 1·4049 | −0·02 | 3·06 | −0·09 | 3·15 |
| 2 ............... | 1·2665 | 0·00 | 10·28 | −0·08 | 10·36 | +0·16 | 10·20 | 1·4041 | −0·01 | 10·13 | +0·04 | 10·09 |
| 3 ........... | 1·1823 | −0·01 | 7·84 | −0·05 | 7·89 | +0·16 | 7·73 | 1·4488 | −0·19 | 7·47 | +0·07 | 7·40 |
| 4 ............... | 1·6490 | 0·00 | 6·19 | −0·13 | 6·32 | 0·00 | 6·32 | 1·6342 | −0·04 | 6·08 | −0·03 | 6·11 |
| 5 ........... | 1·0577 | +0·03 | 7·61 | ..... | ..... | +0·10 | ..... | 0·9998 | −0·69 | 7·35 | +0·07 | 7·28 |
| 6 ........... | 1·1942 | −0·07 | 7·83 | +0·01 | 7·82 | +0·13 | 7·69 | 1·2440 | +0·02 | 7·55 | +0·11 | 7·44 |
| Average......... | 1·27 | −0·01 | 7·13 | −0·06 | ... | +0·10 | ... | 1·36 | −0·16 | 6·94 | +0·03 | 6·91 |

SERIES II.

## Change in Weight of Tubes filled February 6.

| Mark on tube. | F. | E. | D. | C. | B. | | | | A. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days elapsed between filling and re-weighing tube. | 1. | 1. | 5. | 5. | 7. | 10. | 13. | 51. | 7 | 10. | 13. | 51. |
| Coal. | grams. | grams. | grams. | grams. | grams. | grams. | grams. | grams. | grams. | grams. | grams. | grams. |
| 1 | 0·0003 | 0·0001 | 0·0003 | +0·0001 | +0·0002 | −0·0001 | −0·0003 | −0·0044 | −0·0001 | −0·0005 | −0·0008 | 0·0047 |
| 2 | 0·0003 | 0·0000 | 0·0002 | +0·0007 | +0·0011 | +0·0012 | +0·0012 | −0·0025 | −0·0041 | −0·0059 | −0·0076 | 0·0241 |
| 3 | 0·0003 | 0·0001 | −0·0028 | 0·0018 | 0·0004 | +0·0003 | −0·0002 | −0·0043 | +0·0003 | −0·0001 | −0·0006 | 0·0054 |
| 4 | 0·0003 | 0·0000 | 0·0006 | +0·0008 | 0·0005 | 0·0065 | −0·0008 | −0·0044 | +0·0008 | +0·0012 | +0·0013 | 0·0010 |
| 5 | 0·0002 | +0·0003 | 0·0069 | 0·0002 | +0·0008 | +0·0008 | +0·0005 | −0·0022 | +0·0015 | +0·0005 | −0·0002 | 0·0076 |
| 6 | +0·0002 | −0·0008 | +00·002 | +0·0002 | 0·0008 | 0·0011 | −0·0020 | −0·0092 | 0·0000 | −0·0002 | −0·0008 | 0·0062 |

Average weight of coal in tubes emptied was 1·50 grams.

CONCLUSIONS AND SUGGESTIONS.

*Air Drying of Coal.*—The method used by the writer in the past, and which has given him satisfaction, consists in exposing coal, crushed to ¼", in shallow trays in an air-tight box in which are also a number of trays containing calcium chloride solution of 1·30 specific gravity.[1] Under these conditions nearly all wet coals, with the exception of lignites, lose moisture for about a week, after which they begin to slowly gain in weight owing to absorption of oxygen. The trays are weighed every day or two until an increase in weight is noticed, and the maximum loss of weight is taken as the moisture lost on air drying. The coal is then ground in a ball mill, and the moisture found in the ground coal reported as the moisture in air dry coal. Other analyses of the coal were made on a separate sample, and not on the coal exposed to oxidation by the air drying process. A slow current of air, bubbled through the calcium chloride solution and then circulated through the drying chamber, would doubtless accelerate the drying. The above solution will moisten, or dry, air to about 60 per cent humidity.

*Grinding of Coal Samples.*—The writer heartily endorses the recommendation that a ball mill should be employed.

*Storage of Sample before Analyses.*—The problem is to find a method of storing samples, such that not only can the moisture in the sample as prepared be accurately determined, but that successive portions can be taken for other analyses that shall contain the same moisture as the portion in which moisture has already been determined. If small sample tubes, such as were employed in these experiments, preserved their contents unchanged, a number of tubes filled with the original sample would satisfy the conditions of storage as outlined above. The experiments made, however, were very disappointing and some of the results are distinctly puzzling. It is at first sight hard to see how, with similar tubes containing samples of the same coal, and kept in the same container at the same time, some can gain in weight while others lose. It should, however, be considered that air contains about 23 per cent by weight of oxygen, but that, even if it enters the tubes only one-fourth saturated and leaves saturated with water vapour at 20° C., it can only remove about 1 per cent of its weight of water. If then, the diffusion of air through a cork is extremely slow, the absorption of oxygen by the coal in the tube may easily be twenty times as great as the loss of moisture. On the other hand, where, owing to the use of an inferior cork, the diffusion of air is more rapid, the moisture loss may become serious and yet the coal be unable to absorb oxygen, little, if any, more rapidly than it did before, in spite of the great increase in the supply of that gas. Although the use of rubber stoppers for the tubes might largely obviate the above difficulty, the only really safe method would appear to consist in filling a sufficient number of small glass tubes with the sample as soon as it is prepared, and to seal them off in a blowpipe flame, a separate tube being used for each determination made. When its contents were required for use, the end would be cut off a tube, a glass cap slipped over the open end, the tube and cap weighed, a suitable amount of coal poured out in a crucible or other vessel, and the tube reweighed with its cap on. If only a few determinations are to be made, and if these can be begun at once, the difficulty is not serious. But where complete proximate and ultimate analyses, and determinations of calorific value have to be made, possibly on several samples at once, delay is inevitable in all but large laboratories, and precautions against change must be taken. The percentage change in a comparatively large sample in a bottle might not be so large over a certain period as in the small samples in tubes. If, however, as is stated by N. W.

[1] "An investigation of the Coals of Canada," Report 83, Mines Branch, Department of Mines, Canada, Vol. II, p. 130.

Lord (United States Geol. Survey, Prof. Paper 48, p. 192), since the heavier particles tend to accumulate towards the bottom of the bottle, it is necessary to turn the whole of the contents of a bottle out on a sheet of paper and to mix it up well every time a portion is taken for analysis, the difference in moisture content between the first and last portions taken for analysis may easily be quite considerable. Furthermore, the method in which one gram of a coal sample is weighed out in a counterpoised scoop, is often very unsatisfactory on account of obvious gain or loss of weight of the sample during the operation.

*Determination of Moisture.*—Drying the sample over sulphuric acid in an exhausted desiccator appears to be the best method, but this is very slow for ordinary use. Some samples may be completely desiccated in 24 hours, especially if only one sample is put into a desiccator and if the coal is exposed in a very thin layer; for such a purpose a very low, wide weighing bottle might be made. Ten days appeared the minimum time necessary in the above experiments,[1] and the coals differed markedly in their rate of drying. Coal No. 4 was notably slow, but that is not a normal coal and hardly needs to be considered. If this method is adopted, a minimum limit should be set as the permissible strength of sulphuric acid used. It is obviously impossible to use fresh acid for every determination, but how frequently ought it to be renewed?

Hot drying is far quicker than the above, but two notable errors are introduced, the first being the loss of volatile matter other than moisture, and the second the oxidation of the coal. The writer intended to thoroughly investigate these two points, but was hardly able to do more than make a beginning. The tables given indicate that these errors are not negligible. They may sometimes largely neutralize each other, since most, if not all, coals first gain in weight by oxidation under these conditions, but it is not safe to assume that they will always do so. One solution of the difficulty is to determine the moisture directly by collecting and weighing it, instead of indirectly from the loss in weight of the coal; this is rather a difficult operation and each sample would have to be treated separately. Oxidation can be avoided by heating the coal in a neutral gas such as nitrogen, but this is a troublesome operation as nitrogen cannot be easily prepared on a large scale in the laboratory. Carbon dioxide can be more readily prepared, or may be obtained in cylinders: it is probably a satisfactory substitute for nitrogen, although E. Richters has stated in a paper (Dingler's Poly. Journ., Vol. 195, 1870, p. 315) that coal absorbs carbon dioxide with the greatest readiness at ordinary temperatures.

A method might be devised which would combine the advantages of the vacuum and the heating methods, without the more serious disadvantages of either. A double chamber desiccator could be constructed, in one chamber of which the coal sample or samples would be heated by means of an electric heater or a current of hot water to a definite temperature, which need not be as high as 100° C., and in the other chamber the usual sulphuric acid could be kept cool. If this desiccator was suitably designed so as to permit of free air circulation between the two chambers, it would, when well exhausted, probably thoroughly dry coal samples in a few hours without notable oxidation. Reduced pressure would, of course, increase the tendency for volatile matter to be given off. Whether this would be a serious matter or not could only be settled by experiment.

The writer has had no experience with the calcium carbide method for the determination of moisture.

*Reporting of Results.*—After a consideration of the above results and discussion, it is hardly necessary to emphasize the absurdity of reporting coal analyses to the

[1] Experiment 13 was carried on for a further period of 41 days after this report was written, the results, which are included in Table I, show that a marked loss in weight takes place even after 13 days drying.

hundredth of one per cent. Sulphur, nitrogen, and possibly hydrogen are the only constituents commonly determined in which the second decimal figure is at all reliable, and, quite apart from accuracy, it is only for the hydrogen that this second figure has any practical value. The writer hopes that the Committee will see fit to discourage the reporting of a second decimal figure for the results of any determinations except those of hydrogen, and in special research work where small differences are being looked for.

NOTE ON THE DRYING OF PEAT.

When a tray of crushed peat is dried in an oven at 105° C. until no further loss of weight occurs, it is generally easy to determine when the peat is dry by the characteristic odour which it gives out and which pervades the whole room. This smell is probably due to hydrocarbons evolved, and the question arose as to whether the peat was materially altered by drying. A number of experiments on this point have shown that at any rate, within the limits of experimental errors, the calorific value of the peat was not changed by such treatment.

The following series of experiments will show the character of the results obtained: a single damp peat briquette, made at the Government Peat Bog, Alfred, Ontario, was taken and a number of cuts were made through it with a saw. The sawdust was screened and all that passed through a 20-mesh screen was taken for the experiments. Three portions were taken from this sample—one was dried in the oven, a second was dried in a desiccator, and the third was briquetted for calorimeter determinations. Sixty-one small briquettes were made, weighing 7·87 grams altogether.

(*a*) Sample dried at 110° C.:—

| | | | |
|---|---|---|---|
| 9·3 g. taken, heated for 4 hours, | | loss = 41·0 | per cent. |
| " " 9 " | total | " = 41·14 | " |
| " " 13 " | " | " = 41·23 | " |

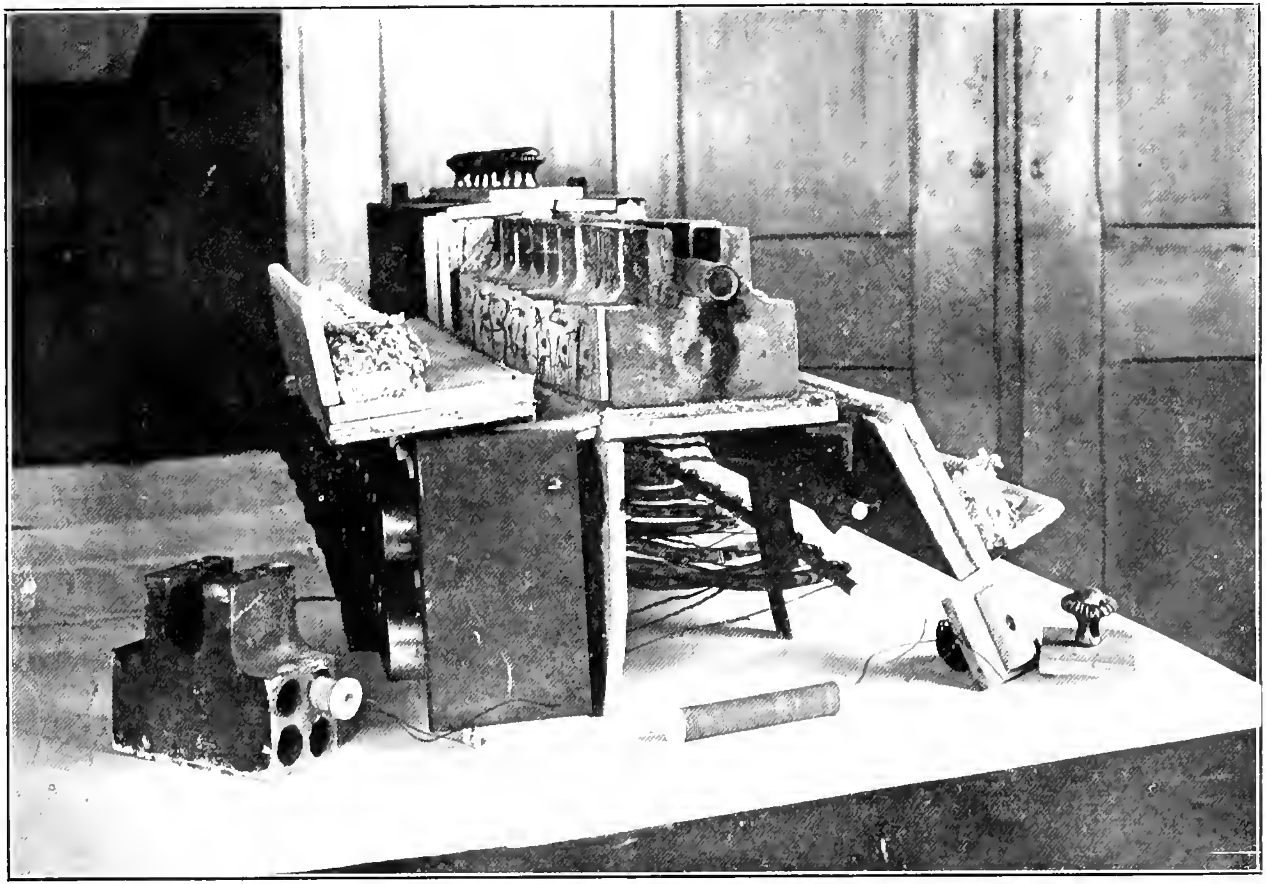
(*b*) Sample dried over sulphuric acid in vacuum desiccator:—

| | | | |
|---|---|---|---|
| 8·7 g. taken, dried for 4 days, | | loss = 40·16 | per cent. |
| " " 7 " | total | " = 40·60 | " |
| " " 13 " | " | " = 40·78 | " |

Therefore, over the above periods, hot drying gave a result 0·45 per cent higher than did vacuum drying.

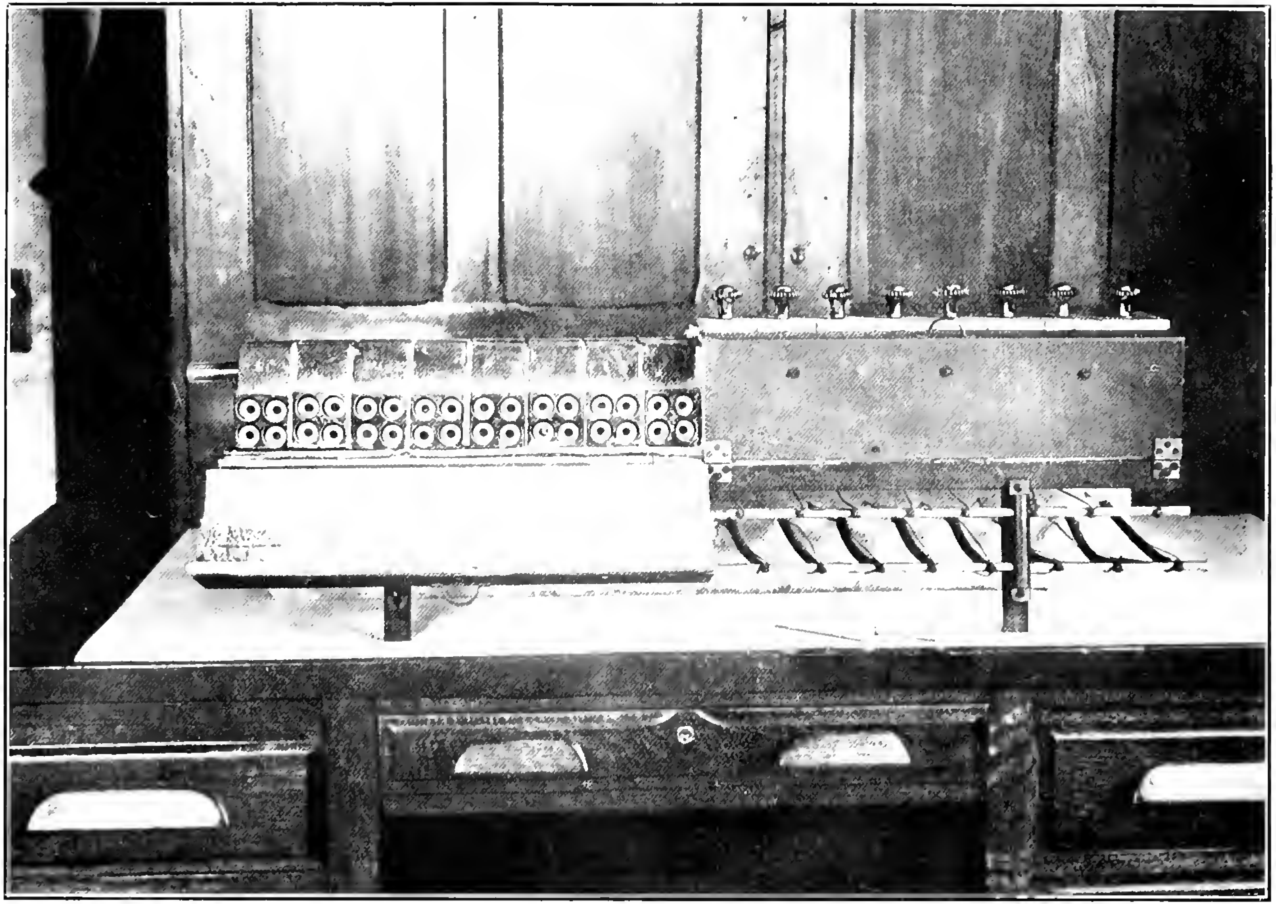
(*c*) Sample burned in calorimeter.

Two determinations of calorific value were made on the briquettes as prepared; the briquettes for these determinations being weighed as soon as made, but not burned until the following day. They would meanwhile have lost moisture, and the results were calculated on their weight when made. A third determination was made two days later when the briquettes had lost 36·03 per cent moisture in a vacuum desiccator. The remaining briquettes were then heated for 4 hours at 110° C., as a result of which a total of 40·42 per cent moisture was driven off, and a fourth determination was then made. The briquettes still remaining lost 0·14 per cent of their original weight when heated for a further 5 hours in the oven, that is, a total of 40·56 per cent of moisture was determined. The original peat sample probably lost some of its moisture whilst it was being briquetted, which would account for this result being slightly lower than that found above. The results were as follows:—

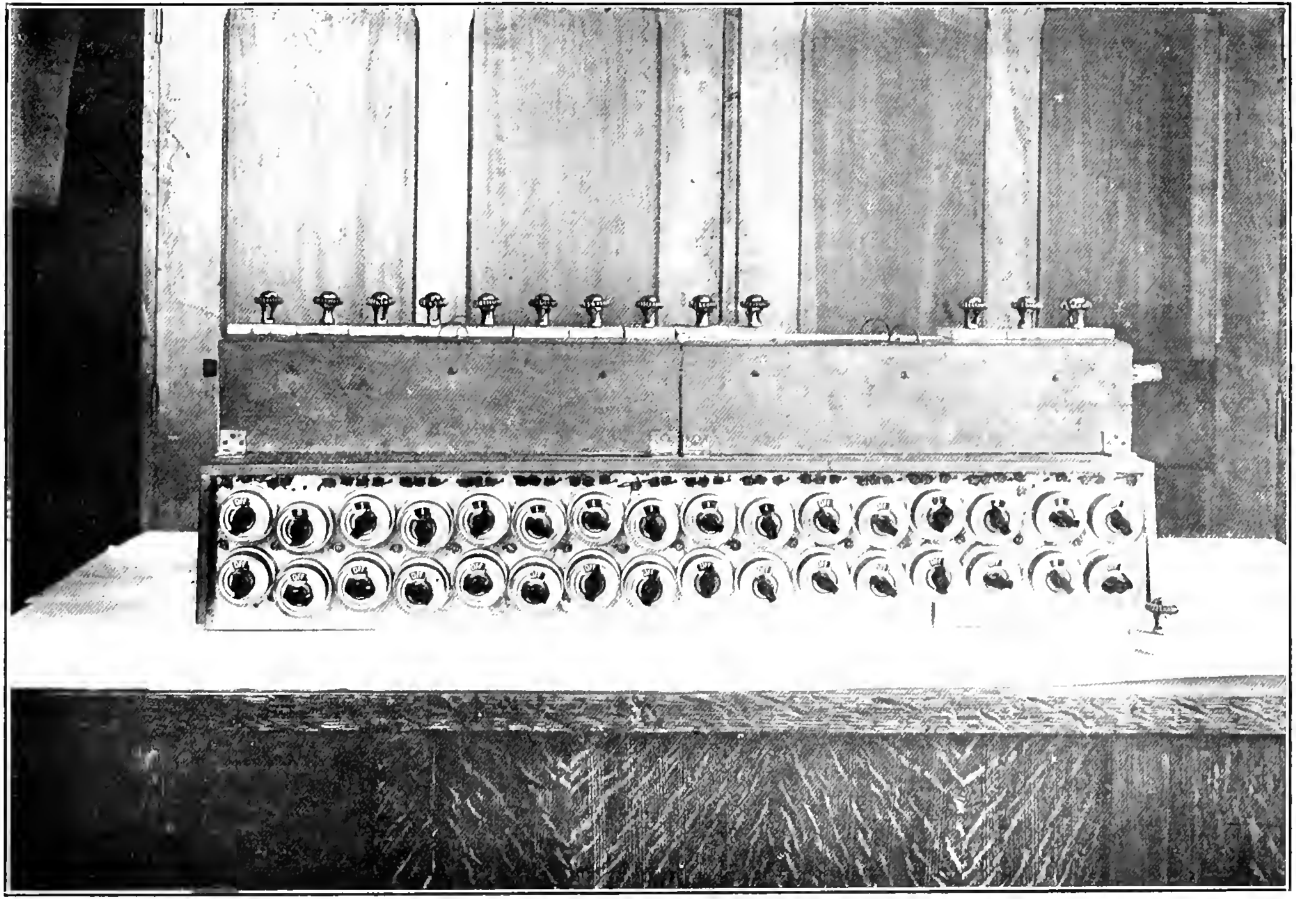


Electric tube furnace---end view.

Plate VI.

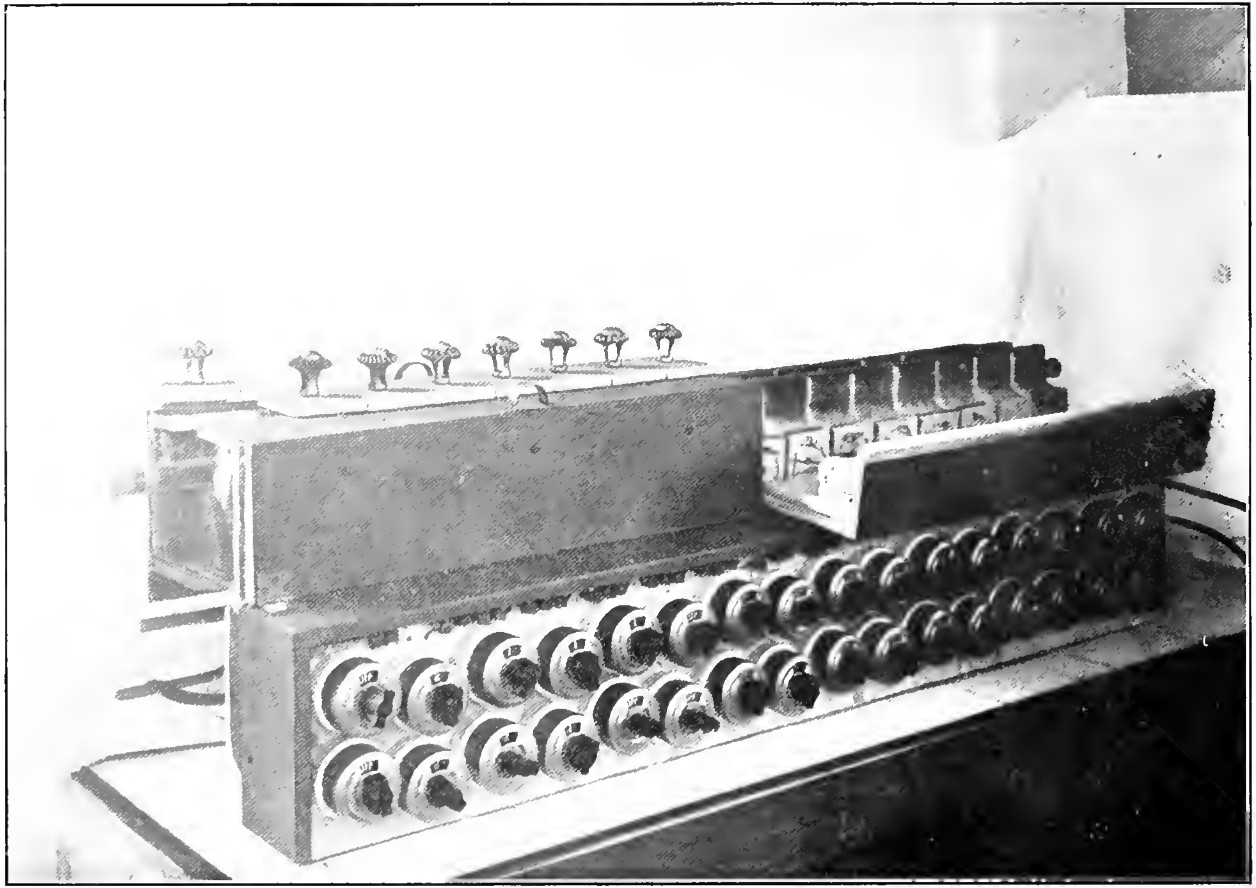


Electric tube furnace---back view.



Electric tube furnace---front view.

Plate VIII.



Electric tube furnace---set up for use on tiled table.

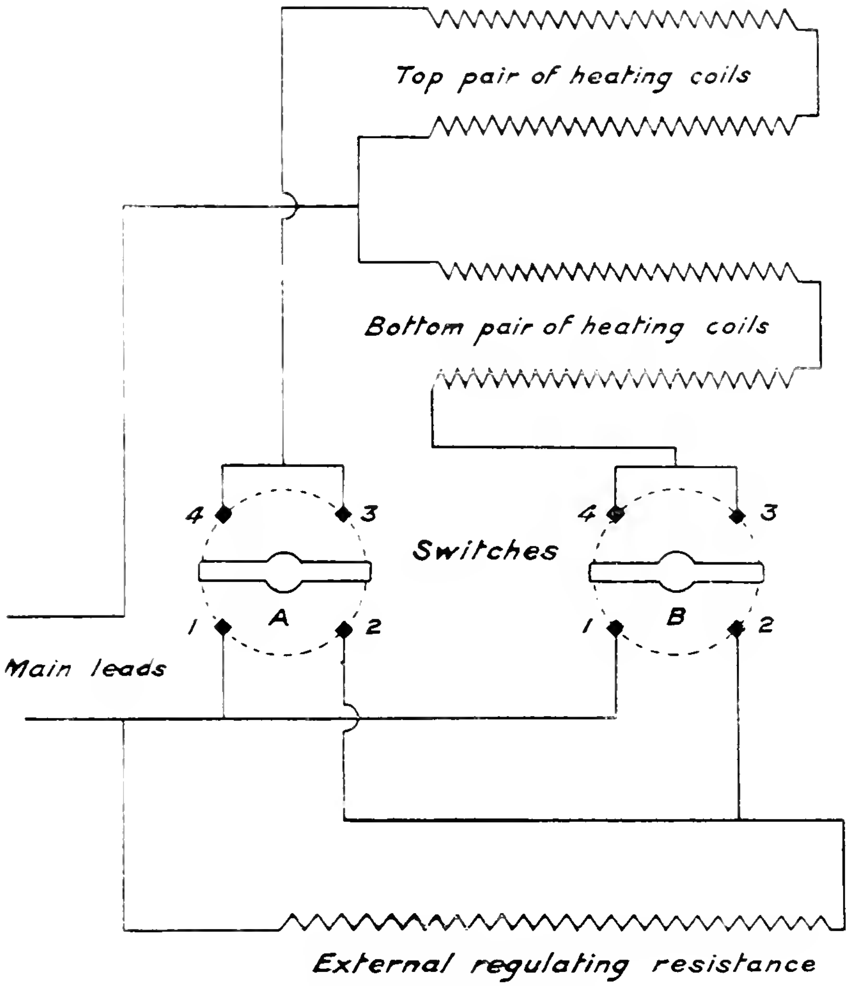



Fig. 6. Wiring diagram for Electric Furnace.

| Determination. | Water in briquettes when weighed. | Calorific value as determined. | Calorific value corrected to dry peat. |
|---|---|---|---|
| | % | | Cals. per gram. |
| (1) ............ .. ....... | 40·56 | 3133 | 5270 |
| (2) ............. ....... .. | 40·56 | 3137 | 5277 |
| (3).... .... . ....... ..... | 7·08 | 4928 | 5304 |
| (4) ....... .......... . ... | 0·24 | 5261 | 5274 |

The third determination is a trifle high, but the other three agree better than would be expected from a consideration of the probable errors of experiment.

II.

## REPORT OF TESTS ON PYRENE.

Sample received about September 1, 1911, from the Whyte Railway Signal Company, Limited, of Toronto. Sample consisted of a quart tin, containing a liquid, labelled "Pyrene ........, Ontario May-Oatway Fire Alarms, Limited, Toronto."

The liquid was brown in colour with a not unpleasant, ethereal odour, somewhat resembling that of chloroform; exposed to the air, it rapidly evaporates, leaving behind a brown, resinous residue.

It was not soluble in water, but readily dissolved in alcohol or ether.

A chemical examination showed that it contained carbon, chlorine, and a trace of hydrogen.

Upon distilling a portion of the sample, it was found that it began to boil at 66° C. (151° F.). The boiling point of the liquid rose gradually, but about 95 per cent distilled over below the temperature of boiling water. It was not found possible to separate the liquid into two or more different constituents, even after twice redistilling fractionally, as the boiling point of the liquid rose without any marked jumps from about 66° C. (151° F.) to 80° C. (176° F.). The specific gravity of the distillate also rose at the same time. Pyrene has a specific gravity of 1·56; the first fraction taken, namely, that boiling between 66° and 71° C., had a specific gravity of 1·525, whilst the largest fraction taken, namely, that between 74° and 80° C., had a specific gravity of 1·589. On continuing the distillation of the small residue left which had a boiling point above 80° C., the temperature rapidly rose to about 150° C. (300° F.), when the residue began to decompose with the evolution of choking fumes of hydrogen chloride (hydrochloric acid gas).

From the above and other tests, it was concluded that pyrene consists mainly of carbon tetrachloride (which boils at 76° C. and has a specific gravity of 1·591), together with other compounds of a similar character.

No injurious effects of any kind were observed from smelling pyrene; although tests were being carried out on it in a small laboratory during a period of several days, and, as already stated, it is a readily volatile liquid. If pyrene is thrown on a hot fire, however, fumes of hydrochloric acid are produced, as described above; these fumes, although choking and irritating, are not actively poisonous.

The value of pyrene as a fire extinguisher appears to lie in the fact that it neither burns nor supports combustion, moreover, as it readily volatilizes at low temperatures, if thrown on a fire, it will rapidly vaporize, forming a heavy vapour which, by displacing the air, will prevent the continuation of combustion. It will not materially cool the fire zone, so that if the fire were in a draughty place, the vapours would soon be blown away and the fire continue almost unchecked.

Assuming that pyrene were entirely carbon tetrachloride, one imperial quart of it would weigh about four pounds. If heated to the temperature of boiling water under normal barometric conditions, this would form a vapour about five and one-half times as heavy as air under the same conditions, which would occupy a volume of about $12\frac{1}{2}$ cubic feet. Any decomposition of the liquid to form hydrogen chloride would increase the volume of gas produced, but, as stated above, it does not appear probable that more than 5 per cent, at the outside, decomposes when heated.

## III.

## AN ELECTRICALLY HEATED TUBE FURNACE, SUITABLE FOR MAKING ULTIMATE ORGANIC ANALYSES.

A tube furnace, for ultimate organic analyses, and such as is commonly known as a combustion furnace, should fulfill the following conditions: the temperature should be under full control at any point throughout its length; the furnace should be arranged so that it may be possible to inspect at any time any part of the tube which is being heated; and also, if required for the analyses of easily volatile material, such as coal, the furnace should be at least 32 inches long. Many types of gas-heated furnaces are made which satisfy the above requirements, but the writer was unable to find any description of a satisfactory, electrically heated furnace of this kind. He, therefore, designed the furnace described below, which was subsequently built by the Dominion Electric Company of Ottawa.

In the gas-heated combustion furnace there are frequently as many as twenty-four burners arranged along the length of the furnace, each of which burners can be separately controlled. In the electric furnace referred to above there are sixteen heating sections, each separately controlled: it would neither have been easy, nor did it seem desirable, to have a greater number of smaller sections.

The heating resistance for each section consists of four coils of a nickel-chromium wire known as nichrome. Each heating coil contains about 14 feet of No. 22 gauge wire wound on a threaded fireclay bobbin $4\frac{1}{4}''$ long and $\frac{5}{8}''$ diameter, and having a flange at each end of almost $\frac{7}{8}''$ diameter. These heaters, of which spare ones are illustrated in Plates V and VI, were employed because they are a commercial article, being manufactured in large numbers by the Dominion Electric Company for use in their various electrically heated devices.

Each section of the furnace consists essentially of an iron casting about 2″ wide, $4\frac{3}{8}''$ from back to front, and $3\frac{7}{8}''$ high. A slot in the top of the casting forms a part of the bed which supports the tube while it is being heated. This slot is sufficiently large to receive any tube up to $\frac{7}{8}''$ diameter. Four holes, each of $\frac{7}{8}''$ diameter, pass from front to back of the casting and serve as receptacles for four of the heaters described above. A spare casting is shown on the left in Plate V. Plates V, VI, and VIII show the manner in which sixteen of these castings are bolted together with layers of asbestos between them, to form the complete furnace.

The iron castings rest on asbestos on a stand about 6″ high. They are also completely surrounded with asbestos, except at the two ends (which are never required to be more than warm) and over the trough in which the tube to be heated is placed. This trough can, however, be covered with a number of small lids made of asbestos board, and which lids can easily be lifted when it is desired to inspect the tube at any point. In order that the furnace may be cooled, at either end, between two experiments, the asbestos cover for the sides and top is made in four parts, two in front and two behind. These covers are so hinged that each may be separately turned quite clear of the furnace proper. The packing of asbestos board, sheet, and rope in each part, is fastened to a sheet of iron, bent at right angles, which has a handle on the top and is connected by hinges at the bottom to the frame work of the furnace. Plates V, VI, and VIII show the furnace with one end thus opened out to cool; Plate VII shows the furnace entirely closed for heating, except that three of the lids over the trough are not in place. The overall dimensions of the furnace are —length, 36″; height, 13½″; thickness from back to front, 12″.

The electrical connexions are shown diagramatically in Fig. 6. The furnace is designed for use with either alternating or direct current at 110 volts, the current being supplied to the two aluminium bus bars which run the length of the furnace behind. In each section the top pair of heaters are connected in series and controlled by a two-way switch; the bottom pair are similarly connected and separately controlled by another two-way switch. Underneath each section there is a regulating resistance, consisting of an exposed coil of nichrome wire. This resistance can be connected in series with either or with both pair of heaters, thus reducing the current which passes through them. Thus, in Fig. 6, when the switch A is turned so as to connect points 1 and 3, full current passes through the top pair of heaters, whilst when the switch is turned to connect points 2 and 4 a reduced current passes through. Switch B similarly controls the bottom pair of heaters. The switches are of the indicating type, so that it is possible to see at once, as is shown in Plate VII, exactly what current is being used for each section. The switches are mounted on an asbestos board, supported several inches in front of the furnace proper, to prevent them from getting too hot.

The resistance of a pair of heaters is approximately 35 ohms and that of the external regulating resistance is 10 ohms. Thus the following five different currents can be passed through any section:—

| | |
|---|---|
| Both pairs of heaters full current.............................. | 6·3 amperes. |
| One pair full current, the other pair reduced current.......... | 5·6 " |
| Both pairs reduced current................. .................. | 4·0 " |
| One pair full current, the other pair no current............. | 3·15 " |
| One pair reduced current, the other pair no current.......... | 2·45 " |

The above currents are calculated for 110 volts across the bus bars. The resistance of the nichrome wire was not found to change noticeably with change of temperature. It is possible to pass about 100 amperes through the furnace, but in an ordinary combustion experiment it is never necessary to employ more than about 50 amperes.

In actual use the furnace has been found to work very satisfactorily. When commencing a combustion, the operator can turn full current on to the sections under the copper oxide in his tube and go to the balance room to make the necessary weighings, leaving the furnace entirely without attention for about half an hour. At the expiration of this period the tube will be hot enough to proceed with the combustion. If the current is now reduced to the possible minimum (2½ amperes) in all sections, with the exception of one at each end, of the heated length, the temperature is maintained almost without change. The subsequent rapid heating of the front end of the tube, and the very gradual heating of that portion of the tube in which the substance being analysed is situated, can also be readily controlled. The most serious disadvantage yet noticed is the time the furnace takes to cool; it does not seem possible to reduce the temperature of one end of the furnace, from a red heat to a temperature at which the tube can be touched by the hand without inconvenience, in less than about two hours.

The furnace has not yet been used for a sufficient length of time to enable any statement to be made with regard to its probable life, although previous experience with the type of heater employed has been satisfactory. Up to the present time no heaters have burnt out, but in such an event any one of them could easily be replaced in a few minutes at only a slight cost. The resistance wire on the bobbin is so close to the iron to be heated by it that there is comparatively little risk of local overheating of the wire, and at the same time the flanges at the end of the bobbins hold the latter in place and prevent the wire coming into actual contact with the iron. The electrical connexions are situated in as cool a position as possible.

A hard glass tube heated in this furnace appears to be less damaged than when heated to the same temperature in an ordinary gas-heated furnace, and the risk of breaking the tube through too sudden heating or cooling is reduced to a minimum.

# I.

## REPORT ON THE EXPLOSION OF AN EXPLOSIVE AT SAND POINT, ONTARIO.

*J. G. S. Hudson.*

On April 27, 1911, an explosion of explosives took place at the explosives factory operated by Dominion Explosives, Limited, at Sand Point, near Arnprior, in the Province of Ontario.

This explosion, which occurred in the drying-house at 1.20 p.m., resulted in the death of four employes, namely:—

Horace McMullen,
Joseph Mills,
Donald Bennet.
William Brooks.

An explosion of explosives, of which an account appeared in the Summary Report of the Mines Branch for 1910, had also occurred in the same factory on July 11, 1910, and had resulted in the death of three men.

Following the explosion of April 27, 1911, an inquest on the death of the men killed was held at Sand Point, on May 2. On that occasion the Coroner's Court consisted of—

Dr. Armstrong, Coroner.
J. B. Metcalf, Esq., Crown Attorney.
G. F. Henderson, Esq., K.C., and J. E. Thompson, Esq., appearing for Dominion Explosives, Limited.
Mr. Foy, representing relatives of the deceased.
Miss Isabella Dewar, stenographer.

The evidence submitted was of a very exhaustive character. Every detail which had any bearing on the process of manufacture, the discipline as carried out at the works, and the precautions taken for the prevention of accidents, was inquired into by Mr. Metcalf, the Crown Attorney for the county of Renfrew.

After the explosion of July, 1910, no explosives were manufactured at this factory until the month of January, 1911. Meanwhile the management of the Company reconstructed the whole plant. In this rearrangement, and in order to safeguard building and lives of employes against possible future explosions, special attention was paid to the distances separating the various buildings in which manufacturing was carried on.

The process of manufacturing the explosive known as "Blaster's Friend"—the product of the Dominion Explosives Company—is fully explained in the Summary Report of the Mines Branch for 1910. The evidence of Mr. Machette, the superintendent, may, however, be taken as describing generally the formulæ used in the manufacture of this explosive.

The base of the explosive known as "Blaster's Friend," is Cassava flour—a residue from the manufacture of tapioca. This flour is treated with a mixture composed of sulphuric and nitric acids, together with nitrate of soda and machine oil. After the flour has been subjected to this treatment, it is washed in a solution of ammonia made up in the proportion of twenty pounds of ammonia to three hundred and sixty pounds of water, this solution being used to neutralize the acid previously taken up. The mixture is then put into a centrifugal whizzing machine in order to extract as much water as possible, after which the pulp is conveyed to the drying-house.

In this drying-house the damp pulp is spread on screens, which are then placed in a closet through which a continuous circulation of air is allowed to flow. This air has a temperature of 100° F. at the entrance of the ductet and of 90° F. where it enters the drying-house. It was in this building that the explosion, which resulted in the death of the four men named above, occurred.

It is apparent from the evidence that on each occasion when explosions have occurred, namely, on July 11, 1910, and on April 27, 1911, the explosion was generated in the drying-house. It was brought out in the evidence that the air being circulated through the drying-house had to be maintained at a temperature of 100° F. as a maximum which would give 90° F. at the end of the ductet. But it was also stated by the superintendent of the works—Mr. Machette—that he had seen the temperature recorded up as high as 120°-130° F., and when asked directly by the Crown Attorney whether he considered that temperature dangerous—replied that he did not.

Mr. Ogden, the chemist, in his evidence states that he had repeatedly heated samples of the wet pulp taken from the drying-house, to a temperature of 212° F. for a period of an hour or an hour and a half. "That I have done repeatedly with the powder, but it never showed signs of decomposing, and to put it to an extreme test after this (accident) happened, I took some of the powder as it stood in the mixing-house right after it had come from the dry-house and heated it for about seven hours at the boiling point of water, 212 degrees, and there was no apparent decomposition of the powder—it was still in apparently the same condition, that was at 212." Mr. Ogden then explained a physical test applied in the laboratory of the works.

*Question by Crown Attorney to Mr. Ogden:*

"Now, have you been able to cause an explosion of this powder at the dry-house stage—of course, we were always concerned with that—by anything short of fire? I know the doubt that's on your mind and I promise you to come to that in a moment. Perhaps I had better come to it first. Tell me, tell the jury about your test with the anvil and hammer. You took a very small amount of this powder first of all, and put it on an anvil and struck it with a hammer, and first tell me the result.

*Answer by Mr. Ogden.*

"With a very small quantity, hitting it a hard blow with the hammer on the anvil, there would be——"

Q. Well, now, just what did happen?

A. By Ogden, There would be a crack, a detonation.

Q. An explosion?

A. An explosion?

Q. You could detect an explosion?

A. Yes. When Mr. Lumsden took a large amount sufficient to form a cushion between the hammer and the anvil, probably a quarter of an inch, and it wouldn't explode, that little cushion on the anvil wouldn't set it off, but a very small layer on the anvil would, that would set it off. In fact, apparently the other extreme seemed to be the fault of the powder, that it required a slightly stronger cap to set it off."

It was also shown in the evidence that a man named Sproule was reported to have had a match in his possession while at the works, but on cross-examination this possession of a match was denied.

*Cross-examination by Mr. Metcalf, Crown Attorney:*

Q. "Were you searched that morning at the office?

A. No, sir.

Q. Are the men not searched every time when they go in?

A. No.

Q. Don't you report every morning at the office, before you go to work?

A. We go to the office and take everything off that we have on.

Q. Well, did you do that, Mr. Sproule?

A. Yes, sir.

Q. You did that?

A. Yes, sir.

Q. And are you prepared to swear positively that you had no sulphur match about your person?

A. Yes, sir.

Q. At the time that Bennett saw you and spoke to you in front of the mixing-house?

A. Yes, sir.

Q. That there was no sulphur on that match whatever—when had it been discarded?

A. When, I don't know.

Q. Well, had it been broken off; I mean before you went to the works?

A. Oh, yes, sure.

Q. Do you swear to that?

A. Yes, sure.

Q. So that the discarded head didn't and couldn't fall on one square inch of the ground of the factory?

A. No, sir.

Q. That's all I want to know. You swear to that?

A. Yes, sir."

As is so often the case in an explosion of an explosive during the process of manufacture, very little information is available, regarding the exact conditions and the actual cause of the explosion. It was shown by the evidence that the Dominion Explosives Company had in their employ an explosives chemist whose duty it was to analyse the ingredients composing the explosive known as the "Blaster's Friend," and that on several occasions he had applied a "heat test" to the compound at certain stages of manufacture. It was also shown that he had applied physical tests for percussion. While these tests might be carried out under the chemist in charge, and under the personal supervision of the superintendent of the works, yet it must be apparent that these tests, carried out in the laboratory of the factory and by employes of the Company, could not in any way compare with the chemical and physical tests to which an explosive would be subjected in a testing station such as that provided for under the Explosives Act for Canada and administered by the officers of the Explosives Division of the Mines Branch.

Owing to the fact that no Explosives Act for Canada has as yet been enacted, and since they thus have no legal status, members of the staff of the Mines Branch attending inquests such as the above are placed in a difficult position. Thus, we are repeatedly asked by the Coroner and by the jurymen why certain conditions exist, and we are requested to express a more direct opinion as to the exact cause of these accidents. The only answer that we can give is that we are unable to do either; that there is no law on our statute books whereby a manufacturer of an explosive is under any obligation whatever to give any information as to the composition of his explosive; that until an Explosive Act is passed by the Federal Government of Canada, we have not the authority to examine either chemically or physically explosives manufactured, imported, stored, or used in Canada.

Such a condition as this does not exist under any other modern progressive government and should not exist in Canada.

The Jury, after hearing all the available witnesses, rendered the following verdict, namely:—

"We find that William Brooks came to his death on April 27, on the premises of the Dominion Explosives, Limited, near Sand Point, with whom he was employed, as a result of an explosion in the building known as the dry-house, but from what cause the explosion occurred we are unable from the evidence submitted to determine.

"For the better protection of human life and property and to minimize the danger of a recurrence of such a catastrophe we recommend:

1st. "That until such times as the public road bordering on their premises be changed to the south side of the Canadian Pacific railway, the Dominion Explosives, Limited, be prohibited from operating their plant or to manufacture the explosives known as the 'Blaster's Friend.'

2nd. "That in the event of the Dominion Explosives, Limited, being permitted to resume operations, we recommend that greater precautions be taken by all the employees, including the Superintendent.

3rd. "That all employees be searched for matches and other dangerous articles every day before being allowed to work.

4th. "That direct and instant communication be established between the dry-house and the building where heat is generated for said dry-house, that the overseer in charge of the works be made a responsible agent for the Dominion Explosives, Limited, for the safety of their employees."

After this explosion occurred the President of the Dominion Explosives Company employed Mr. Leo Guttmann, of Queen's University, and Professor George Munro, of the George Washington University, to report on the processes employed in the manufacture of their explosive. These reports were of a confidential nature and not available for publication.

## II.

## REPORT ON THE EXPLOSION OF AN EXPLOSIVE AT BELŒIL, QUE.

On Saturday, September 23, 1911, an explosion of explosives occurred at an explosives factory, operated by the Canadian Explosives Company, at Belœil, Quebec. As a result of this explosion, one man was killed outright, while four other employes were seriously injured.

The men seriously injured by this explosion are in the hospital, and their injuries may prove fatal.

The names and ages of the men killed or injured are as follows, namely:—

William St. George, age 28, died.
Maurice Menard, age 18, badly burned.
Casmir Williams, age 39, slightly burned.
Alphonse Duquette, age 22, painfully burned.
Arsene Williams, age 21, painfully burned.

I have been informed that three of the above-named men have succumbed since the day of the accident to their injuries.

The accident occurred in one of the explosives factories operated by the Canadian Explosives Company, Limited, Head Office, 4 Hospital Street, Montreal.

This Company has lately taken over under its management the explosives factories of the Hamilton Powder Company, of the Standard and Western Explosives Companies, and of the Ontario Powder Company.

The factory in which the explosion occurred, was formerly operated by the Hamilton Powder Company, and is one of the oldest and largest plants owned by the Canadian Explosives Company. It is situated on the Richelieu river, near the village of Belœil, in the Province of Quebec, and is in close proximity to the railway line of the Grand Trunk from Montreal to Lévis.

The explosion occurred in one of the packing-houses of the plant.

These packing or punch-houses are used for the purpose of holding the machines which pack the explosive, after it has been mixed, into the paper cartons which, when complete, are designated as cartridges, being of specified diameter and length to meet the explosives trade requirements.

The explosive is conveyed from the mixing-house to the packing-house in wood-fibre buckets, containing such quantities of explosive as may be conveniently handled with the least degree of danger.

When the explosive has been received from the mixing-house, it is placed in a machine, operating a series of shuttles, designed to fill the paper cartons with explosive, evenly and with a uniform degree of compactness.

These packing or punching machines employed in explosives factories are usually of three types, namely, hand operated, those operated by power from belt transmission, and a large shuttle type of large capacity and power.

The explosion occurred in a packing-house, in which the machines were of the belt-driven type. Following a universal custom pursued in explosives factories, at the end of the days' work all parts of the machines and interior of the buildings are cleaned up, so that no loose explosive is left lying round which might constitute a danger.

The men who were killed and injured by the explosion at Belœil on Saturday afternoon were employed doing this work, consequently only a comparatively small quantity of explosive was in the building when the explosion occurred. From the information furnished by the Assistant Superintendent of the works, I gather the following account of the explosion:—

On Saturday afternoon the supply of explosive being conveyed from the mixing to the packing-house was stopped to allow the men working in the packing-house to finish putting into paper cartons the quantity of explosive already received. When this quantity of explosive should have been made up into cartridges, the usual cleaning up of the machine and interior of the building was to have been proceeded with. On account of the day being Saturday, an extra length of time is allowed for this work, as the machines and buildings have to stand over Sunday. Additional supervision and care are taken on this account in preparation for the commencement of work on Monday morning.

As far as can be estimated the quantity of explosive in the building would not exceed 150 pounds in weight.

Apparently a fire originated, possibly due to the friction of a rapidly-moving belt, but this can only be surmised, since, as unfortunately happens in the majority of accidents in explosive factories, the men who might give positive evidence of what took place are either killed or fatally injured.

From the available evidence given by some of the men, who were able to tell the manager of the works their version of the occurrence, it appears that they noticed a fire in the building, and endeavoured to the best of their ability to extinguish it. Coming to the conclusion, however, that it was beyond their power to do so, these men tried to make their escape from the zone of danger, and ran out of the building

The fact that they were but a short distance away when the explosion did take place, proves that they fought the fire and remained at their posts until the very last moment.

The explosion completely wrecked the building, practically nothing being left.

The men were injured by burns and shock, as, when they were found, their clothing was burning, and it took some time to extinguish the flames.

After visiting the scene of the explosion, I made inquiries as to where the inquest (if any), relative to the death of William St. George, was to be held. I was informed that the Coroner at Montreal had made an investigation, and that the evidence given by Mr. Wilson, the Works Manager, was so explicit that the jury rendered their verdict without further inquiry.

I may state that the explosives plant operated by the Canadian Explosives Company at Belœil is affiliated with the works of the Nobel Explosives Company of Great Britain. The methods of manufacturing explosives are based on the practice as carried out at the Ardeer factories, which constitute one of the largest explosives establishments in Great Britain, and are licensed under the Act regulating the manufacture of explosives in that country.

During my several visits to the factory at Belœil, I have, through the courtesy of the manager, had an opportunity of observing the care with which explosives and ingredients thereof are handled at this factory.

The information contained in this report has also been obtained through the courtesy of the manager, as, owing to the fact that the Explosives Bill had not yet been passed, I had no authority to require the information. In fact, I was forbidden to take photographs inside of the factory grounds.

## III.

## REPORT ON THE EXPLOSION OF AN EXPLOSIVE AT RIGAUD, QUE.

On October 19, 1911, an explosion of explosives occurred at the explosives factory of Curtis and Harvey of Canada, Limited. This factory is located between the town of Rigaud and Graham landing, on the Ottawa river. It is in close proximity to the Ottawa-Montreal short line of the Canadian Pacific railway, between Rigaud and Lavigne station. This factory was, until within the last year, operated by the Northern Explosives Company. In December, however, that Company entered into an arrangement with Messrs. Curtis and Harvey, of London, England, whereby the management of this plant was to be taken over. This arrangement was made in order to give to Messrs. Curtis and Harvey the control of an explosive plant already established in this country, and from which they might supply their long established and increasing explosives trade in Canada.

On acquiring this plant and property, Messrs. Curtis and Harvey notified the Explosives Division of the Mines Branch that they were aware of the fact that an Explosives Bill, to regulate the Manufacture, Importation, Storage, and Testing of Explosives in Canada, had been prepared, and was to be laid before the House by the Minister of Mines during the current session of Parliament. In view of the fact that the Explosives Act for Canada, in many of its salient features, would be based upon the findings of the Explosives Act of Great Britain, the management of Curtis and Harvey of Canada deemed it advisable, in the rearrangement of such buildings as then existed, and also in the contemplated construction of new buildings within their factory site, that the Tables of Distances, as authorized by the Explosives Department of the British Home Office, should be adopted.

In carrying out this policy, the Company were necessarily placed for the time being under considerable financial loss, their output of explosives being curtailed, until new buildings and improved methods of manufacture could be established.

The adoption of this policy by Messrs. Curtis and Harvey, a firm long established in the explosives trade, must be regarded as satisfactory evidence of their approval of the proposed establishment of the Explosives Act of Canada.

The topography of the site, on which the plant of the Company is situated, offers certain natural advantages for the location of an explosives factory. Thus, for example, by placing many of the danger buildings in close proximity to the hill sides, advantage has been taken of the undulating character of the ground. In case of an explosion in factory danger buildings or in magazines, the protection of natural mounds is in this way obtained. Consequently, buildings containing explosives or their ingredients, which, being wholly or partially mixed, are in a more or less dangerous state as to sensitiveness to percussion, friction, or concussion, are afforded very material protection from flying debris. This fact was strikingly demonstrated when on October 19, 1911, a quantity of 60 per cent dynamite, estimated as being equivalent to one ton, exploded in the Company's mixing-house. The accompanying photographs (Plates IX to XVI), taken on the occasion of the writer's investigation, indicate the value of such protection to buildings even when situated in close proximity to the explosion.

Moreover, on the site of the danger buildings there is also a considerable amount of thick underbrush and numerous closely-growing trees. The effects of the rush of air, propelled by the explosion in the mixing-house, is illustrated in photograph Plate XIII, in which trees of considerable size and diameter are shown as having been uprooted.

In the manufacture of their explosives, the management of Curtis and Harvey exercise due care, the works manager, chemist, and foremen being men of experience in this business. The apparatus, implements, and receptacles used in the several processes of manufacture are also of the best and most improved type. The same care is seen in the fact that floors and interiors of buildings are lined with rubberoid, that doors of danger buildings open outward, in the use of wooden mixing shovels, rakes with rubber-tipped teeth, and wood-fibre tubs protected with rubber buffers for conveying the ingredients of explosives, and in a general absence of iron in implements used.

Well-defined and explicit rules and regulations are posted up in the buildings and in conspicuous places for the guidance of the employes.

### INVESTIGATION OF ACCIDENT.

On Tuesday afternoon (October 19, 1911), I was called up on the long-distance telephone from Montreal, and informed by Mr. J. J. Riley, the General Manager of Curtis and Harvey of Canada, that an explosion of explosives had occurred in the mixing-house of their plant at Rigaud, Que., and that as far as could be ascertained at the time, four men had lost their lives. I mention this fact since this was the first instance in which the Department had been officially notified of an explosion of an explosive in a factory in Canada. In accordance with instructions, I proceeded by the first train on Wednesday morning to Rigaud, where the bodies of the men who were killed by the explosion on the day previous were being viewed by the Coroner and jurymen. After viewing the remains, the inquest was adjourned until the following week. I then proceeded in company with Mr. Louis Guyon, Chief Inspector of Industrial Establishments and Public Buildings, Montreal, and inspected the site on which the building known as the mixing-house had stood previous to the explosion.

On arriving at the plant we were informed by the management that, with the exception of the nitrating house, which on account of the spilled nitro-glycerine had to be protected, the buildings and appliances were in the same condition as they were immediately after the explosion. We were further given to understand that the management, officials, and workmen were at our disposal, that they would willingly answer any question which we might desire to ask, relating to the explosion or cause thereof, and that I was at liberty to take photographs.

Plans showing the location of the buildings, together with detailed plans of the buildings themselves, were on view at the office for our information. The manager, works manager, and foreman accompanied us on our inspection, explaining fully the several methods of conveying the ingredients of the explosives from one building to another, and also the precautions taken to minimize the danger of an explosion in the mixing-house.

The works manager informed me that he had visited this mixing-house a short time previous to the explosion and that he had not detected any disarrangement of any apparatus. He further stated that no unusual occurrences had arisen in the ordinary working methods whereby the accident could be accounted for, adding that he was extremely anxious to obtain any clue which would lead to a satisfactory solution of what might have occurred, not only on account of its immediate bearing on this accident, but that the management might be in a position to guard against similar occurrences in the future.

On the morning on which the explosion occurred, at seven minutes before 12 o'clock, provided the usual works practice was being adhered to, Napoleon Castonguay and Eugene Seguin should have been inside the mixing-house, while A. Sevigny and Wilfred Malette should have been on the outside. As, however, all of the above-named employes were killed instantly, their relative positions will never be determined. Two other employes, Emile Faubert and Elsezar Thauville, who were working at a distance from the mixing-house when the explosion occurred, were slightly injured by the flying debris.

They were not in a position to give any definite or conclusive evidence as to what really happened in the mixing-house when the explosion occurred.

The man who was employed in the nitrating house (*see* plan for relative location) states that he is positive he heard a slight explosion previous to the heavier one which showed such disruptive force, and he evidently knew that a much heavier explosion would follow. Being a man of considerable experience, he, therefore, adopted a wise precaution, and on hearing the first explosion, immediately "drowned" his charge of 1,200 pounds of glycerine, which was at the time in the nitrater. It might be inferred from the evidence of the man who was in the nitrating house, that in handling the ingredients which made up the estimated quantity of 2,000 pounds of 60 per cent dynamite which exploded, a small portion of the explosives mixture, from some cause at present unknown, exploded with sufficient force to detonate the larger quantity of explosive contained in the mixing-house. It was the explosion of this larger quantity that caused the loss of life and the damage to buildings.

Mr. McMahon, the Coroner for the district of Montreal, held an inquest on the bodies of the men who were killed by the explosion. At this inquest, Mr. J. J. Riley, the General Manager, Mr. Barnes, the works manager, and eighteen employes of the Company gave evidence. Mr. L. Guyon, the Inspector of Industrial Establishments in the Province of Quebec, also attended and gave evidence.

At the inquest, Mr. Riley gave the following statement, as quoted in the *Montreal Star*, of October 20, 1911:—

"Mr. James Riley, manager of the firm, declared in his evidence that since the Company began business at Rigaud, its plant and premises had never either been visited or inspected by any Government Inspector or other official." In connexion with this statement, reference should be made to the fact that until the Explosives Act for Canada is passed, no one has the authority or power to inspect this class of factory. Mr. Guyon, the Inspector of Industrial Establishments for the Province of

Quebec, informed the writer that his assistant inspectors objected most strenuously to going into explosives factories. I am, moreover, of the opinion that they are right in their contentions and that, if they are not familiar with this hazardous class of work, they have no more necessity for going into explosives factories than the general public.

Commenting on this accident, the *Montreal Star*, in its issue of October 20, 1911, editorially remarks: "In such investigations as that which must be made into yesterday's explosion at Rigaud, the public has more than an indirect interest. Explosives factories at their best are a menace to those whose business calls them within a very considerable radius of the plant itself, as well as to the workmen actually employed there. It is well to have it made clear after such an incident whether or not everything has been done to make an explosion improbable in the first place, and to minimize its consequences, should one occur, in the second place.

"There have been enough of such accidents in the vicinity of Montreal during the last few years to make the subject one of considerable interest. The verdict of the jury stated that the accident must have been caused by the carelessness of one of the victims, also that there was no crime to be suspected in the present case."

On several similar occasions in the past, I have drawn attention to the unsatisfactory conditions under which any officer of the staff of the Mines Branch attends investigations and inquests such as the above.

1st. Not having a legal status as inspector, it is only through the courtesy of the Coroner that he can appear as a representative of the Mines Branch.

2nd. He has no official knowledge of the conditions as they exist at the factory before the explosion, and is, therefore, not in a position to give an opinion as to what caused the explosion, nor what precautions might have been taken for its prevention.

Within the last eighteen months, I have investigated five explosions of explosives, each one being attended with fatal consequences and resulting in all in 25 persons being killed. Yet to-day there are no statutes nor any regulations for the efficient inspection of such manufactories, nor any authority for collecting information relative to the accidents or manufacture of explosives in Canada.

## MAPS AND DRAWINGS MADE DURING 1911.

*H. E. Baine, Chief Draughtsman.*

**L. H. Cole.**—Map of Cobalt, Gowganda, Shiningtree, and Porcupine Districts—6¾ miles to 1 inch.

**B. F. Haanel.**—Plan of ground floor, Fuel Testing Plant, Section of Gas Producer.

**B. F. Haanel.**—Three plans Producer Gas Engine, 15 charts.

**A. C. Lane, Ph.D.**—Map of Geology of Point Mamainse, Ontario, to accompany Bulletin No. 6, Diamond Drilling at Point Mamainse—4,000 feet to 1 inch.

**A. W. G. Wilson.**—Map of the Great Lakes Region, to accompany report on Pyrites
Twenty-eight drawings of furnaces, etc., for plates.

**Hugh de Schmid.**—Map showing Principal Mica Occurrences in the Dominion of Canada—100 miles = 1 inch.
Map, showing location of the Principal Mines and Occurrences in the Ontario Mica Area—3·95 miles.
Map, showing location of the Principal Mines and Occurrences in the Quebec Mica Area—3·95 miles.
Nineteen Maps showing Mica Occurrences in the different Townships of Ontario and Quebec.
Six drawings for cuts and plates.

**H. Fréchette.**—Map of Southwest Part of Torbrook Iron-bearing District, Annapolis county, Nova Scotia—400 feet = 1 inch.

**Dr. J. B. Porter.**—General Map of Canada showing Coal Fields, 100 miles to 1 inch.
General Map of Coal Fields in Yukon Territory—32 statute miles = 1 inch.
General Map of Coal Fields in British Columbia—35 miles = 1 inch.
Map of Coal Fields in Manitoba, Alberta, and Saskatchewan—35 miles = 1 inch.
Map of Coal Fields in Nova Scotia—12 miles = 1 inch.

**E. Lindeman.**—Map of No. 3 Mine, Lot 7, Concessions V and VI, Township of McKim, Sudbury district, Ontario—scale 100 feet = 1 inch.
Magnetometric Map, Austin Brook—400 feet = 1 inch.
Geological Map, Austin Brook—400 feet = 1 inch.
Index Map, showing Iron-bearing Area at Austin Brook.
Section of Diamond Drill-holes at Austin Brook.
*Not published.* Map, Bow Lake Iron Ore Deposits, Faraday township, Hastings county, Ontario—200 feet = 1 inch.
Magnetometric Map, Carlow Sheet, Hastings county, Ontario—200 feet = 1 inch.
Magnetometric Map, Bagot township, Renfrew county, Ontario—200 feet = 1 inch.

**Geo. C. Mackenzie.**—Map of Dominion of Canada, showing the Magnetic Iron Sand Deposits—100 miles = 1 inch.

Index Map, Magnetic Iron Sand Deposits in relation to Natashkwan harbour and Great Natashkwan river, Quebec—40 chains = 1 inch.

Map, Natashkwan Iron Sand Deposits, Saguenay county, Quebec—250 feet = 1 inch.

Eight drawings for plates and cuts.

**A. Anrep Jr.**—Plans of Holland Peat Bog, Ontario.
" Fort Francis Peat Bog, Ontario.
" Julius Peat Bog, Manitoba.
" Transmission Peat Bog, Manitoba.
" Boggy Creek Peat Bog, Manitoba.
" Mud Lake Peat Bog, Manitoba.
" Corduroy Peat Bog, Manitoba.
" Lac du Bonnet Peat Bog, Manitoba.
" Rice Lake Peat Bog, Manitoba.
" Litter Bog, Manitoba.

## LIST OF REPORTS, BULLETINS, ETC., PUBLISHED DURING 1911.

*S. Groves, Editor, Department of Mines.*

69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses (Second Edition)—by Fritz Cirkel, M.E. Published March 30, 1911.

82. Bulletin No. 5: Magnetic Concentration Experiments with Iron Ores of the Bristol Mines, Que.; Iron Ores of the Bathurst Mines, N.B.; A Copper Nickel Ore, from Nairn, Ont.—by G. C. Mackenzie, B.Sc. Published February 10, 1911.

83. An Investigation of the Coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others—
    - Vol. I—Coals: sampling, crushing, washing, mechanical purification, and coking trials.
    - Vol. II—Coals: steam boiler, producer, and gas engine trials, also chemical laboratory work.

84. Gypsum Deposits of the Maritime Provinces—by W. F. Jennison, M.E. Published November 15, 1911.

88. Annual Report of the Division of Mineral Resources and Statistics on the Mineral Production of Canada, during the calendar year 1909—by John McLeish, B.A. Published April 29, 1911.

89. Proceedings of Conference on Proposed Legislation on the Manufacture, Importation, and Testing of Explosives; Held, House of Commons, September 23 and September 30, 1910. Published September 28, 1911.

92. Investigation of the Explosives Industry in the Dominion of Canada, 1910—by Capt. Arthur Desborough. Published: First Edition, February 10; Second Edition, June 14; Third Edition, October 4, 1911.

93. Molybdenum Ores of Canada—by Prof. T. L. Walker, Ph.D. Published November 15, 1911.

102. Preliminary Report on the Mineral Production of Canada for the calendar year 1910—by J. McLeish, B.A. Published February 28, 1911.

103. Mines Branch Summary Report, 1910. Published November 15, 1911.

104. Catalogue of Publications of Mines Branch, from 1902 to 1911: containing Tables of Contents, and List of Maps, etc. Published March 28, 1912.

110. Bulletin No. 7: Western Portion of Torbrook iron ore deposits, Annapolis county, N.S.—by Howells Fréchette, M.Sc. Published February 5, 1912.

111. Diamond Drilling at Point Mamainse, Ont.—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph.D. Published June 24, 1912.

114. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, 1910—by J. McLeish. Published December 28, 1911.

115. Production of Iron and Steel in Canada during the calendar year 1910—by J. McLeish. Published December 22, 1911.

116. Production of Coal and Coke in Canada during the calender year 1910—by J. McLeish. Published December 22, 1911.

117. General Summary of the Mineral Production in Canada during the calender year 1910—by J. McLeish. Published December 22, 1911.

118. Mica: Its Occurrences, Exploitation, and Uses—by Hugh S. de Schmid. Published July 10, 1912.

143. Annual Report on the Mineral Production of Canada during the calendar year 1910—by John McLeish. Published May 15, 1912.

150. Preliminary report on the Mineral Production of Canada, during the calendar year 1911—by John McLeish. Published June 1, 1912.

## ACCOUNTANT'S STATEMENT.

### MINES BRANCH.

### Statement of Appropriation and Expenditure by Mines Branch for the year ending March 31, 1911.

| | Appropriation. | Expenditure. |
|---|---|---|
| Amounts voted by parliament | $189,762 50 | |
| Receipts— | | |
| For sales of peat | 2,435 25 | |
| " assays and analyses | 528 25 | |
| Civil list salaries | | $ 37,098 71 |
| Machinery, labour, etc., peat bog, Alfred | | 8,313 93 |
| Fuel testing plant, Ottawa | | 9,480 86 |
| Concentrating laboratory | | 5,647 82 |
| Metallurgical investigations | | 5,706 00 |
| Investigations *re* explosives | | 5,560 69 |
| Publication of reports | | 5,371 88 |
| " maps | | 3,934 41 |
| Printing, stationery, books, mapping material | | 2,925 61 |
| Wages, outside service | | 2,614 57 |
| Investigations *re* iron ore deposits | | 2,551 75 |
| Monograph on building stones | | 2,160 42 |
| Monograph on molybdenum | | 1,818 70 |
| Investigations, peat and coals | | 1,944 34 |
| Instruments and repairs | | 1,997 10 |
| Investigations of copper deposits | | 1,396 02 |
| Chemical laboratory | | 1,864 42 |
| Investigations of ore deposits | | 1,030 28 |
| Miscellaneous | | 840 30 |
| Monograph on mica | | 496 60 |
| Mineral statistics | | 253 65 |
| Travelling expenses | | 222 30 |
| Investigations *re* gas producers | | 198 60 |
| Balance unexpended and lapsed | | 89,297 01 |
| | $192,726 00 | $192,726 00 |

| Summary. | Vote. | Expenditure. | Unexpended Balance. |
|---|---|---|---|
| Civil government salaries | $ 39,362 50 | $ 37,098 71 | $ 2,263 79 |
| Investigations of ore deposits, economic minerals, etc. | 41,000 00 | 27,106 56 | 16,893 44 |
| Printing, apparatus, chemical laboratories' expenses, books, etc. | 34,500 00 | 19,573 07 | 14,926 93 |
| Operation of peat bog, Alfred, $8,313.93; less sales of peat, $2,435.25 | 6,000 00 | 5,878 68 | 121 32 |
| Investigation of metallurgical problems of economic importance | 5,900 00 | 5,706 00 | 194 00 |
| Investigation of the manufacture, etc., of explosives in Canada | 10,000 00 | 5,102 44 | 4,897 56 |
| Zinc investigations per Bill No. 182 | 50,000 00 | ...... | 50,000 00 |
| | $189,762 50 | $100,465 46 | $89,297 01 |

Appropriation, 1909-10.
Balance unaccounted for by J. E. Woodman, $100.

(Signed) **Jno. Marshall.**

## APPENDIX I.

EUGENE HAANEL, Ph.D.,
Director of Mines.

SIR,—I beg to submit herewith, the annual preliminary report on the mineral production of Canada in 1911, including a table showing the revised statistics of production in 1910.

The figures of production for 1911, while subject to revision, are based upon direct returns from mines and smelters operators and are fairly complete.

Special acknowledgments are due to those operators who have promptly furnished reports of their operations during the year.

When complete returns shall have been received the usual annual report will be prepared containing in greater detail the final statistics as well as information relating to exploration, development, prices, markets, imports, and exports, etc.

I am, sir, your obedient servant,

(Signed) John McLeish.

Division of Mineral Resources and Statistics,
February 27, 1912.

## PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, 1911.

*(Statistics subject to revision.)*

The mining industry during the years 1909 and 1910 showed such substantial progress and large increase in output that it is not surprising a slight falling off should be shown in 1911, particularly when it is remembered that the long continued strike of coal miners in Alberta and the Crowsnest district of British Columbia not only seriously reduced the coal output, but also, because of the closing down of the Granby smelter on account of the coke shortage, caused a lower production of copper, silver, and gold than would have otherwise been obtained.

The preliminary statistics herewith published, based upon direct returns from mine and smelter operators but subject to final revision, show the total value of the production in 1911 to have been $102,291,686, a falling off of $4,531,937, or 4 per cent, when compared with the production of $106,823,623 in 1910.

The production of the more important metals and minerals is shown in the following tabulated statement in which the figures are given for the two years, 1910 and 1911, in comparative form, and the increase or decrease in value shown. Tabulated statements for both years, in greater detail, will be found on subsequent pages of this pamphlet:—

| | | 1910. | | 1911. | | Increase (+) or decrease (−) in value. |
|---|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. | |
| | | | $ | | $ | $ |
| Copper | Lbs. | 55,692,369 | 7,094,094 | 55,848,665 | 6,911,831 | − 182,263 |
| Gold | Ozs. | 493,707 | 10,205,835 | ........ | 9,762,096 | − 443,739 |
| Pig iron | Tons | 800,797 | 11,245,622 | 917,535 | 12,306,860 | + 1,061,238 |
| Lead | Lbs. | 32,987,508 | 1,216,249 | 23,525,050 | 818,672 | − 397,577 |
| Nickel | " | 37,271,033 | 11,181,310 | 34,098,744 | 10,229,623 | − 951,687 |
| Silver | Ozs. | 32,869,264 | 17,580,455 | 32,740,748 | 17,452,128 | − 128,327 |
| Other metallic products | | | 510,081 | ........ | 409,674 | − 100,407 |
| Total | | | 59,033,646 | ........ | 57,890,884 | − 1,142,762 |
| Less pig iron credited to imported ores | | 695,891 | 9,594,773 | 875,349 | 11,693,456 | + 2,098,683 |
| Total metallic | | | 49,438,873 | ........ | 46,197,428 | − 3,241,445 |
| Asbestos and asbestic | Tons | 102,215 | 2,573,603 | 126,914 | 2,943,107 | + 369,504 |
| Coal | " | 12,909,152 | 30,909,779 | 11,291,553 | 26,378,477 | − 4,531,302 |
| Gypsum | " | 525,246 | 934,446 | 505,457 | 978,863 | + 44,417 |
| Natural gas | | | 1,346,471 | ........ | 1,820,923 | + 474,452 |
| Petroleum | Bls. | 315,895 | 388,550 | 291,092 | 357,073 | − 31,477 |
| Salt | Tons | 84,092 | 409,624 | 91,582 | 443,004 | + 33,380 |
| Cement | Bls. | 4,753,975 | 6,412,215 | 5,635,950 | 7,571,299 | + 1,159,084 |
| Clay products | | | 7,629,956 | ........ | 8,317,709 | + 687,753 |
| Lime | Bus. | 5,848,146 | 1,137,079 | 7,227,310 | 1,493,119 | + 356,040 |
| Stone | | | 3,650,019 | ........ | 3,680,371 | + 30,352 |
| Miscellaneous non-metallic | | | 1,993,008 | ........ | 2,110,313 | + 117,305 |
| Total non-metallic | | | 57,384,750 | ........ | 56,094,258 | − 1,290,492 |
| Grand total | | | 106,823,623 | ........ | 102,291,686 | − 4,531,937 |

The subdivision of the mineral production in 1910 and 1911 by provinces was approximately as follows:—

| Provinces. | 1910. | | 1911. | |
|---|---|---|---|---|
| | Value of Production. | Per cent of Total. | Value of Production. | Per cent of Total. |
| | $ | % | $ | % |
| Nova Scotia | 14,195,730 | 13·29 | 15,354,928 | 15·01 |
| New Brunswick | 581,942 | 0·54 | 611,597 | 0·60 |
| Quebec | 8,270,136 | 7·74 | 9,087,698 | 8·88 |
| Ontario | 43,538,078 | 40·76 | 42,672,904 | 41·72 |
| Manitoba | 1,500,359 | 1·40 | 1,684,677 | 1·65 |
| Saskatchewan | 498,122 | 0·47 | 618,379 | 0·60 |
| Alberta | 8,996,210 | 8·42 | 6,404,110 | 6·26 |
| British Columbia | 24,478,572 | 22·92 | 21,237,801 | 20·76 |
| North West Territories | 4,764,474 | 4·46 | 4,619,592 | 4·52 |
| Dominion | 106,823,623 | 100·00 | 102,291,686 | 100·00 |

Of the total production in 1911 a value of $46,197,428 or 45 per cent is credited to metals and $56,094,258 to non-metallic products. Practically all of the metals with the exception of pig iron show a falling off in production in so far as value is concerned. In the case of copper, however, there was an increased output of the metal although the average price per pound was slightly lower than in 1910. The increase in pig iron production was quite considerable although this is chiefly attributable to imported ore.

Amongst the non-metallic products increases are shown in the production of arsenic, asbestos, feldspar, graphite, natural gas, pyrites, salt, and in nearly all of the structural materials, including cement, clay products, stone, lime, etc.

Outside of the metallic products the principal decreases are in coal and petroleum; the falling off in value of coal production alone being practically equivalent to the total net decrease for the year.

There is comparatively little change in the relative importance of the Provinces as mineral producers—Ontario contributed nearly 42 per cent of the total in 1911; British Columbia nearly 21 per cent; Nova Scotia 15 per cent; Quebec nearly 9 per cent and Alberta 6 per cent. The order in 1910 was the same except that Alberta slightly exceeded Quebec in production.

The Provinces showing an increased output for the year are Nova Scotia, New Brunswick, Quebec, Manitoba, and Saskatchewan; those showing a falling off being Ontario, Alberta, and British Columbia.

In Nova Scotia the coal industry was particularly active and to that and the clay and stone industries is the increase in this Province to be chiefly ascribed. There was a slight increase in New Brunswick. In Ontario the net result was a decrease of about $1,000,000, being chiefly in copper, nickel, and petroleum; on the other hand there were substantial increases in nearly all of the other products of which a great variety is obtained in this Province. Manitoba produces gypsum, clay, and stone products; and Saskatchewan coal and clays.

The difficulties incident to coal mining operations in Alberta and British Columbia have already been noted and these have been the chief cause of falling off in production in these Provinces. In British Columbia notwithstanding the coke shortage and the consequent closing down of the Granby smelter for a portion of the year there was still a slight increase in the copper production although the output of silver, lead, and zinc was less than in 1910.

# THE MINERAL PRODUCTION OF CANADA IN 1911.

*(Subject to revision.)*

| Product. | | Quantity. | Value. |
|---|---|---|---|
| METALLIC. | | | $ |
| Copper, value at 12·376 cents per pound | Lbs. | 55,848,665 | 6,911,831 |
| Gold | | .... .. .... | 9,762,096 |
| Pig iron from Canadian ore | Tons. | 42,186 | 613,404 |
| Iron ore sold for export | " | 39,162 | 86,812 |
| Lead, value at 3·48 cents per pound | Lbs. | 23,525,070 | 818,672 |
| Nickel, value at 30 cents per pound | " | 34,098,744 | 10,229,623 |
| Silver, value at 53·304 cents per oz | Ozs. | 32,740,748 | 17,452,128 |
| Cobalt and nickel oxides | | | 221,790 |
| Zinc ore | | 2,590 | 101,072 |
| Total | | | 46,197,428 |
| NON-METALLIC. | | | |
| Actinolite | Tons. | 67 | 736 |
| Arsenic, white | " | 2,097 | 76,237 |
| Asbestos | " | 100,893 | 2,922,062 |
| Asbestic | " | 26,021 | 21,045 |
| Chromite | " | 27 | 351 |
| Coal | " | 11,291,553 | 26,378,477 |
| Corundum | " | 1,472 | 161,873 |
| Feldspar | " | 17,718 | 51,924 |
| Fluorspar | " | 34 | 238 |
| Graphite | " | 1,269 | 69,576 |
| Grindstones | " | 5,312 | 49,942 |
| Gypsum | " | 505,457 | 978,863 |
| Manganese | " | 5½ | 300 |
| Magnesite | " | 991 | 5,531 |
| Mica | " | .... .... ... | 119,863 |
| Mineral pigments— | | | |
| Barytes | " | 50 | 400 |
| Ochres | " | 3,622 | 28,333 |
| Mineral water | | | 223,758 |
| Natural gas | | | 1,820,923 |
| Peat | Tons. | 1,463 | 3,817 |
| Petroleum, value at $1·22⅔ per barrel | Bls. | 291,092 | 357,073 |
| Phosphate | Tons. | 558 | 4,928 |
| Pyrites | " | 82,666 | 365,820 |
| Quartz | " | 60,526 | 83,865 |
| Salt | " | 91,582 | 443,004 |
| Talc | " | 7,300 | 22,100 |
| Tripolite | " | 20 | 122 |
| Total | | | 34,191,161 |

## THE MINERAL PRODUCTION OF CANADA IN 1911—*Concluded.*

*(Subject to revision.)*

| Product. | | Quantity. | Value. |
|---|---|---|---|
| STRUCTURAL MATERIALS AND CLAY PRODUCTS. | | | $ |
| Cement, Portland | Bls. | 5,635,950 | 7,571,299 |
| Clay products— | | | |
| Brick, common, pressed, paving | | ...... | 6,521,558 |
| Sewer-pipe | | ...... | 799,756 |
| Fireclay, drain tile, pottery, etc. | | ...... | 996,395 |
| Lime | Bus. | 7,227,310 | 1,493,119 |
| Sand and gravel (exports) | Tons. | 573,494 | 408,110 |
| Sand-lime brick | | ...... | 424,241 |
| Slate | Sq. | 1,833 | 8,248 |
| Stone— | | | |
| Granite | | ...... | 880,309 |
| Limestone | | ...... | 2,282,146 |
| Marble | | ...... | 140,903 |
| Sandstone | | ...... | 377,013 |
| Total structural materials and clay products | | ...... | 21,903,097 |
| All other non-metallic | | ...... | 34,191,161 |
| Total value, metallic | | ...... | 46,197,428 |
| Total value, 1911 | | ...... | 102,291,686 |

The average monthly prices of the metals in cents per pound for several years past are shown herewith.

| — | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. |
| Copper, New York | 20·004 | 13·208 | 12·982 | 12·738 | 12·376 |
| Lead " | 5·325 | 4·200 | 4·273 | 4·446 | 4·420 |
| " London | 4·143 | 2·935 | 2·839 | 2·807 | 3·035 |
| " Montreal * | ... | ... | ... | ... | 3·480 |
| Nickel, New York | 45·000 | 43·000 | 40·000 | 40·000 | 40·000 |
| Silver " | 65·327 | 52·864 | 51·503 | 53·486 | 53·304 |
| Spelter " | 5·962 | 4·720 | 5·503 | 5·520 | 5·758 |
| Tin " | 38·166 | 29·465 | 29·725 | 34·123 | 42·281 |

* Quotations furnished by Messrs. Thomas Robertson & Company, Montreal, Que.

## Smelter Production.

General statistics of smelter production have been collected by this Branch since 1908. Complete returns have been received for the year 1911 with the exception of one or two plants recently established for the treatment of Ontario silver cobalt ores. It should also be explained that the accompanying statistics include the treatment of a small quantity of imported ores in the British Columbia smelters.

The total quantity of ores treated in 1911 was 2,192,727 tons as compared with 2,683,714 tons treated in 1910.

The ores treated may be conveniently classified as follows:—

| — | 1909. | 1910. | 1911. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Nickel-copper ores | 462,336 | 628,947 | 610,834 |
| Silver-cobalt-nickel-arsenic ores | 8,384 | 9,466 | 8,504 |
| Lead and other ores treated in lead furnaces | 54,539 | 57,549 | 55,408 |
| Copper-gold-silver ores | 1,850,889 | 1,987,752 | 1,517,981 |
| Total | 2,376,148 | 2,683,714 | 2,192,727 |

The closing down of the Granby smelter due to coke shortage was the principal cause of the falling off in copper-gold ores treated.

The products obtained in Canada from the treatment of these ores include: refined lead produced at Trail, B.C., and fine gold, fine silver, copper sulphate, and antimony produced from the residues of the lead refinery; silver bullion, white arsenic, nickel oxide, and cobalt oxide produced in Ontario from the Cobalt District ores. In addition to these refined products, blister copper, copper matte, and nickel copper matte are produced and exported for refining outside of Canada.

The aggregate results of these smelting and refining operations for the years 1910 and 1911 are briefly summarized in the following table:—

SMELTER AND REFINERY PRODUCTION IN CANADA, 1910 AND 1911.

| — | | 1910. | | 1911. | |
|---|---|---|---|---|---|
| | | Refined products. | Metals contained in matte, blister, and base bullion. | Refined products. | Metals contained in matte, blister, and base bullion. |
| Antimony | Lbs. | | | 30 | |
| Gold | Ozs. | 13,298 | 197,181 | 15,270 | 175,189 |
| Silver | " | 16,373,799 | 2,136,414 | 17,711,077 | 612,401 |
| Lead | Lbs. | 32,987,508 | | 23,525,050 | |
| Copper | " | | 56,149,299 | | 47,788,131 |
| Copper sulphate | " | 163,228 | | 197,187 | |
| Nickel | " | | 37,587,676 | | 34,098,744 |
| Cobalt and nickel oxides | " | 13,508 | | 15,174 | |
| Mixed oxides of cobalt and nickel | " | 108,178 | | 127,224 | |
| White arsenic | " | 3,003,467 | | 4,194,209 | |

Smelter products shipped outside of Canada for refining were: blister copper carrying gold and silver values 10,710 tons in 1911, as compared with 13,918 tons in 1910; copper matte carrying gold and silver values 11,320 tons in 1911, as against 11,519 tons in 1910; Bessemer nickel copper matte carrying small gold and silver values as well as metals of the platinum group 32,607 tons in 1911, as compared with 35,033 tons in 1910.

## Gold.

The gold production in 1911 is estimated as approximately $9,762,096 which, compared with the 1910 production $10,205,835, shows a falling off of $443,739. The Yukon placer production in 1911 is estimated at $4,580,000 as against $4,550,000 in 1910, the total exports on which royalty was paid during the calender year, according to the records of the Interior Department, being 277,430·97 ounces in 1911 and 275,472·51 ounces in 1910. The British Columbia production in 1911 was $4,989,524, of which the placer production, as estimated by the Provincial Mineralogist, was $468,000, smelter recoveries and bullion obtained from milling ores being valued at $4,521,524.

The production in Nova Scotia is estimated at $142,000, all from milling ores. In Quebec there was a small recovery from alluvial workings and a small content in the pyrite ores shipped, the total value of production being $12,443. Returns so far received from Ontario show a production of $37,929.

The exports of gold-bearing dust, nuggets, gold in ore, etc., in 1911 were valued at $7,493,523.

Gold was imported during 1911 in bars, blocks, ingots, etc., to the value of $924,233.

## Silver.

The silver production of Canada which has been very rapidly increasing during the past few years will probably show but little change in 1911.

Returns so far received appear to indicate a falling off of about 128,516 ounces. The total production of the year is estimated at 32,740,748 ounces valued at $17,452,128, of which 30,761,690 ounces were from Ontario, 1,910,323 ounces from British Columbia, 50,300 ounces from the Yukon, and 18,435 ounces from Quebec.

The production in Ontario was slightly greater than that of the previous year and in British Columbia a falling off of nearly half a million ounces is shown.

For British Columbia the figures represent the recovery as silver bullion or silver contained in smelter products, while for Ontario the figures represent the total silver content of ore and concentrates shipped less five per cent allowed for smelter losses, together with bullion shipments.

The total shipments of ore and concentrates from the Cobalt district and adjacent mines were about 16,234 tons, containing approximately 28,317,198 ounces in addition, to which 3,334,052 ounces were shipped as bullion. The average silver content of ore and concentrates shipped was thus about 1,744 ounces or $929.62 per ton, as compared with an average of 867 ounces in 1910 and 840 ounces in 1909. The 1911 shipments were chiefly high grade ore averaging over 3,400 ounces and concentrates averaging over 850 ounces.

The shipments in 1910 were 28,684 tons of ore containing 23,797,111 ounces of silver or an average of 830 ounces per ton; 6,943 tons of concentrates containing 7,111,579 ounces or an average of 1,024 ounces per ton, and bullion containing 1,003,111 fine ounces.

The exports of silver in ore etc., as reported by the Customs Department, were 31,216,725 ounces, valued at $15,807,366. There was also an importation of silver in bars, blocks, sheets, etc., valued at $847,645.

The price of refined silver in New York varied between a minimum of 51⅝ cents per ounce in February, and a maximum of 56⅜ cents in November, the average monthly price being 53·304 as compared with an average montbly price of 53·486 in 1910.

## Copper.

There is practically no production of refined copper in Canada, and the production is represented by the copper content of smelter products, matte, and blister copper produced, together with the amount of copper contained in ores exported estimated as recoverable.

The total production on this basis in 1911 was 55,848,665 pounds, valued at $6,911,831, as compared with 55,692,369 pounds valued at $7,094,094 in 1910, an increase in quantity of 156,296 pounds, but a falling off in total value owing to the slightly lower price of copper in 1911.

The total copper content of ores shipped in 1911 was approximately 67,282,590 pounds, being 3,123,189 pounds from Quebec, 21,402,221 pounds from Ontario, and 42,757,180 pounds from British Columbia. This record is of special interest as illustrating the distinction between ore content and smelter recoveries.

Of the production or smelter recovery in 1911, Quebec Province is credited with 2,436,190 pounds as against 877,347 pounds in 1910. This is altogether from pyrite ores, which are mined primarily for their sulphur contents. Ontario's production in 1911 was 17,932,263 pounds, as compared with 19,259,016 pounds in 1910, all being from the nickel-copper ores of the Sudbury district.

The production in British Columbia, notwithstanding the failure of the domestic coke supply due to strikes in the coal mines of the Crowsnest Pass district and the consequent shutting down of the Granby smelter for nearly five months, shows a slight increase, being estimated at 35,480,212 pounds in 1911 as against 35,270,006 pounds in 1910.

The British Columbia Copper Company operated with larger output, using imported coke and production from Coast mines, particularly the Britannia and Marble Bay, was specially active. The increased production from these mines more than balanced the falling off at Granby.

The New York price of electrolytic copper varied during the year between the limits of 11·85 cents and 14·05 cents per pound, the average being 12·376. During December the price ranged from 13 to 14 cents. The average monthly price in 1910 was 12·738 cents.

The total exports of copper contained in ore, matte, and blister, etc., according to Customs Department returns, were 55,287,710 pounds, valued at $5,467,725, which agrees fairly closely with the record of production.

The total imports of copper in 1911 were valued at $4,936,459 and included crude and manufactured copper to the extent of 35,155,550 pounds valued at $4,632,452; copper sulphate 2,191,899 pounds, valued at $88,419, and other copper manufactures valued at $215,588.

## Lead.

The total production of pig and manufactured lead in 1911 was 23,525,050 pounds, valued at $818,672 or an average of 3·48 cents per pound, the average wholesale or producer's price of pig lead in Montreal for the year. There was also a small production of lead concentrate from Calumet Island, Que., the shipments being about 45 tons.

The production of lead in 1910 was 32,987,508 pounds, thus showing a considerable falling off in 1911. The decrease is probably chiefly due to the diminished tonnage from the St. Eugene mine in East Kootenay and the idleness of some of the more important mines of the Slocan following the destruction of the Kaslo and Slocan railway by forest fires in 1910. The Bear Lake branch of the Canadian Pacific railway now under construction will provide shipment facilities for these properties.

The Sandon and Silverton camps would seem to promise an increased tonnage of silver-lead ores in the near future.

The exports of lead in ore in 1911 are reported as 32 tons and of pig lead only 36 tons, as compared with exports of 23 tons and 3,856 tons respectively in 1910.

The total value of the imports of lead and lead products in 1911 was $1,049,276 including 13,135 tons in the form of pig lead, bars, sheets, tea lead, etc., valued at $706,020; manufactures of lead, valued at $108,012; litharge and lead pigments having an equivalent lead content of approximately 2,395 tons, valued at $235,244.

The total value of the imports of lead and lead products in 1910 was $833,743 and with the exception of manufactures, valued at $107,688, represented an equivalent lead content of 10,544 tons.

The average monthly price of lead in Montreal during 1911 was 3·48 cents per pound and in Toronto 3·53 cents. These are producer's prices for lead in car lots as per quotations kindly furnished by Messrs. Thos. Robertson & Company. The average monthly price of lead in New York during the year was 4·42 cents and in London £13·970 per long ton, equivalent to 3·035 cents per pound.

The amount of bounty paid during the twelve months ending December 31, 1911, on account of lead production, was $219,557.70, as compared with payments of $318,308.28 in 1910.

## Nickel.

The mining and smelting of nickel copper ores in the Sudbury district of Ontario was carried on actively throughout the year, and although the production was slightly less than in 1910, it was still very much larger than in any previous year. Active operations were as usual carried on by the Mond Nickel Company at Victoria mines and the Canadian Copper Company at Copper Cliff, Creighton, Crean Hill, etc., while the Dominion Nickel Company continued to develop their property at Norman station.

The ore is first roasted and then smelted and converted to a Bessemer matte containing from 77 to 82 per cent of the combined metals, copper and nickel, the matte being shipped to the United States and Great Britain for refining. A portion of the matte is now used for the production of the alloy monel metal which is obtained directly from the matte without the intermediate refining of either nickel or copper.

The total production of matte in 1911 was 32,607 tons, valued at the smelters at $4,945,593, a decrease of 2,426 tons or 6·9 per cent from the production of 1910. The metallic contents were, copper 17,932,263 pounds, and nickel, 34,098,744 pounds.

The aggregate results of the operations on the Sudbury District nickel-copper ores during the past four years were as follows in tons of 2,000 pounds:—

| | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|
| Ore mined | 409,551 | 451,892 | 652,392 | 612,511 |
| " smelted | 360,180 | 462,336 | 628,947 | 610,834 |
| Bessemer matte produced | 21,197 | 25,845 | 35,033 | 32,607 |
| Copper content of matte | 7,503 | 7,873 | 9,630 | 8,966 |
| Nickle " " | 9,572 | 13,141 | 18,625 | 17,049 |
| Spot value of matte shipped | $2,930,989 | $3,913,017 | $5,380,064 | $4,945,592 |
| | Pounds. | Pounds. | Pounds. | Pounds. |
| Exports to Great Britain | 2,554,486 | 3,843,763 | 5,335,331 | 5,023,393 |
| " United States | 16,865,407 | 21,772,635 | 30,679,451 | 27,596,578 |
| | 19,419,893 | 25,616,398 | 36,014,782 | 32,619,971 |

The price of refined nickel in New York remained practically constant throughout the year—quotations in the *Engineering and Mining Journal* being large lots, contract business. 40 to 45 cents per pound during the first four months and 40 to 50 cents from May to December. Retail spot from 50 cents for 500 pound lots up to 55 cents for 200 pound lots. The price for electrolytic is 5 cents higher.

The imports of nickel anodes in 1911 were valued at $34,199, as compared with $23,317 in 1910.

## Iron.

IRON ORE.—The total shipments of iron ore in 1911 are reported as 210,344 tons, valued at $522,319. These may be classified as magnetite 72,945 tons, and hematite 137,399 tons.

In 1910 the total shipments were 259,418 tons comprising: magnetite 127,768 tons; hematite 130,380 tons, and bog ore 1,270 tons.

Exports of iron ore from Canada during 1911 are recorded by the Customs Department as 37,686 tons, valued at $133,411. The exports were chiefly from Bathurst, New Brunswick.

The shipments from the Wabana mines, Newfoundland, in 1911, by the two Canadian companies operating there, were 1,181,463 short tons, of which 765,184 tons were shipped to Sydney and 416,279 tons to the United States and Europe.

PIG IRON.—The total production of pig iron in Canadian blast furnaces in 1911 was 917,535 tons of 2,000 pounds, valued at approximately $12,306,860, as compared with 800,797 tons, valued at $11,245,622, in 1910.

Of the total output in 1911, 20,758 tons were made with charcoal as fuel and 896,777 tons with coke. The classification of the production according to the purpose for which it was intended was as follows:—

Bessemer, 208,626 tons; basic, 464,220 tons; foundry and miscellaneous, 244,686 tons.

The amount of Canadian ore used during 1911 was 67,434 tons; imported ore, 1,628,368 tons; mill cinder, etc., 30,298 tons.

The amount of coke used during the year was 1,121,321 tons, comprising 543,933 tons from Canadian coal and 577,388 tons imported coke or coke made from imported coal. There were also used 1,190,459 bushels of charcoal.

Limestone flux was used to the extent of 625,216 tons.

In connexion with blast furnace operations there were employed 1,778 men, and $1,097,355 were paid in wages.

The total daily capacity of 18 completed furnaces was according to returns received 3,630 tons, and the number of furnaces in blast December 31, 1911, was 12.

The production of pig iron by Provinces in 1910 and 1911 was as follows:—

PRODUCTION OF PIG IRON BY PROVINCES, 1910 AND 1911.

| Provinces. | 1910. | | | 1911. | | |
|---|---|---|---|---|---|---|
| | Tons. | Value. | Value per Ton. | Tons. | Value. | Value per Ton. |
| | | $ | $ | | $ | $ |
| Nova Scotia | 350,287 | 4,203,444 | 12 00 | 390,242 | 4,682,904 | 12 00 |
| Quebec | 3,237 | 85,255 | 26 34 | 658 | 17,282 | 26 34 |
| Ontario | 447,273 | 6,956,923 | 15 55 | 526,635 | 7,606,674 | 14 44 |
| Total | 800,797 | 11,245,622 | 14 04 | 917,535 | 12,306,860 | 13 41 |

The exports of pig iron during the year are reported as 5,870 tons, valued at $271,968, an average of $46.33 per ton. Probably the greater part of this is ferro-silicon and ferro-phosphorus, produced at Welland and Buckingham, respectively.

There were imported during the year 208,487 tons of pig iron, valued at $2,610,989, and 17,226 tons of ferro-manganese, etc., valued at $429,465.

STEEL.—The production of steel ingots and castings in 1910 is reported as 876,215 tons of 2,000 pounds, of which 861,493 tons were ingots and 14,722 tons castings.

The production in 1910 was 822,284 tons, including 803,600 tons of ingots and 18,684 tons of castings.

The production of open-hearth and Bessemer steel has been for four years as follows:—

PRODUCTION OF STEEL, 1908, 1909, 1910, 1911.

| — | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. |
| *Ingots*—Open-hearth (basic) | 443,442 | 535,988 | 580,932 | 651,676 |
| Bessemer (acid) | 135,557 | 203,715 | 222,668 | 209,817 |
| *Castings*—Open-hearth | 9,051 | 14,013 | 18,085 | 13,982 |
| Other steels | 715 | 1,003 | 599 | 740 |
| Total | 588,763 | 754,719 | 822,284 | 876,215 |

## Asbestos.

For a number of years past the annual output of asbestos has exceeded the sales. In 1911, however, the sales have been greatly increased but at considerably reduced prices. Returns received for the year 1911 show a total output of 96,299 tons, as compared with 100,430 tons in 1910. The sales in 1911 are, however, reported as 100,893 tons, valued at $2,922,062 or an average of $28.96 per ton, as compared with 77,508 tons valued at $2,555,974, or an average of $32.98 per ton in 1910, an increase of 23,385 tons or 30 per cent in quantity but only $366,088, or 14 per cent in total value. Stocks on hand at December 31, 1911, are reported as 34,568 tons, valued at $1,509,100, as compared with 41,903 tons, valued at $1,943,171, on December 31, 1910.

The average number of men employed in mines and mills during 1911, was 2,707 at a wage cost of $1,231,896.

The total quantity of asbestos rock sent to mills is reported as 1,484,691 tons, which, with a mill production of 91,237 tons, shows an average estimated recovery of about 6·14 per cent.

The following tabulated statement shows the output and sales during 1911 and the stock on hand at the end of the year:—

| — | Output. | Sales. | | | Stock on hand. Dec. 31. | |
|---|---|---|---|---|---|---|
| | Tons. | Tons. | Value. | Per ton. | Tons. | Value. |
| | | | $ | $ | | $ |
| Crude No. 1 | 1,467·9 | 1,301·4 | 342,855 | 263 45 | 1,256 | 327,508 |
| " 2 | 3,594·5 | 3,562·7 | 402,107 | 112 86 | 3,222·7 | 404,198 |
| Mill stock No. 1 | 20,376 | 18,315 | 916,678 | 50 05 | 8,471 | 380,570 |
| " 2 | 39,289 | 47,326 | 991,370 | 20 95 | 17,794 | 365,457 |
| " 3 | 31,572 | 30,388 | 269,052 | 8 85 | 3,824 | 31,367 |
| Total asbestos | 96,299·4 | 100,893·1 | 2,922,062 | 28 96 | 34,567·7 | 1,509,100 |
| Asbestic | .... | 26,021 | 21,045 | 81 | .... | |

In the absence of a uniform classification of asbestos of different grades the above subdivisions have been adopted purely on a valuation basis; crude No. 1 comprising material valued at $200 and upwards, and crude No. 2 under $200; mill stock No. 1 includes stock valued at from $30 to $100; No. 2 from $15 to $30; No. 3 under $15.

Output, sales, and stocks in 1910 were as follows:—

| — | Output. | Sales. | | | Stock on hand. Dec. 31. | |
|---|---|---|---|---|---|---|
| | Tons. | Tons. | Value. | Per ton. | Tons. | Value. |
| | | | $ | $ | | $ |
| Crude No. 1 | 2,181 | 1,817 | 471,675 | 259 58 | 1,702 | 446,675 |
| " 2 | 3,268 | 1,923 | 192,833 | 100 28 | 3,219 | 440,571 |
| Mill stock No. 1 | 16,720 | 13,480 | 735,244 | 54 54 | 6,978 | 398,895 |
| " 2 | 56,395 | 43,414 | 1,013,251 | 23 34 | 26,613 | 628,528 |
| " 3 | 21,866 | 16,874 | 142,971 | 8 47 | 3.391 | 29,177 |
| Total asbestos | 100,430 | 77,508 | 2,555,974 | 32 98 | 41,903 | 1,943,846 |
| Asbestic | .... | 24,707 | 17,629 | 0 71 | .... | |

Exports of asbestos during the twelve months ending December 31, 1911, are reported by the Customs Department as 75,120 tons, valued at $2,067,259, comprising: 62,551 tons, valued at $1,732,541, to the United States; 7,511 tons, valued at $192,993, to Great Britain: 1,841 tons, valued at $62,757, to Belgium: 2,596 tons, valued at $52,047, to France; 361 tons, valued at $20,494, to Germany: and 260 tons, valued at $6,447, to other countries.

The imports of manufactures of asbestos during the same period are reported as valued at $319,815.

## Coal and Coke.

The long continued strike which took place in the coal mines of southern Alberta and eastern British Columbia, was responsible for a considerable falling off in the coal production of Canada in 1911.

The total coal production during the past year, comprising sales and shipments, colliery consumption, and coal used in making coke, is estimated at 11,291,553 tons of 2,000 pounds, valued at $26,378,477. This is a decrease of 1,617,599 tons or nearly 12·53 per cent from the production of 1910, which was 12,909,152 tons, valued at $30,909,779.

There was an increase of 562,978 tons in the Nova Scotia production, that of New Brunswick remained practically stationery, while an increase of about 23,097 tons is shown in Saskatchewan.

In Alberta, the decrease was about 1,396,412 tons or 48 per cent, and British Columbia also shows a falling off of 794,243 tons or nearly 24 per cent.

The production by provinces was approximately as follows, the figures for 1909 and 1910 being also given:—

| Province. | 1909. | | 1910. | | 1911. | |
|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| | | $ | | $ | | $ |
| Nova Scotia | 5,652,089 | 11,354,643 | 6,431,142 | 12,919,705 | 6,994,120 | 14,050,687 |
| British Columbia | 2,606,127 | 8,144,147 | 3,330,745 | 10,408,580 | 2,536,502 | 7,926,569 |
| Alberta | 1,994,741 | 4,838,109 | 2,894,469 | 7,065,736 | 1,498,057 | 3,933,958 |
| Saskatchewan | 1,02,125 | 296,339 | 181,156 | 293,923 | 204,253 | 342,921 |
| New Brunswick | 49,029 | 98,496 | 55,455 | 110,910 | 55,781 | 111,562 |
| Yukon Territory | 7,364 | 49,502 | 16,185 | 110,92[illegible] | 2,840 | 12,780 |
| Total | 10,501,477 | 24,781,236 | 12,909,152 | 30,909,779 | 11,291,553 | 26,378,47 |

The exports of coal in 1911 were 1,500,639 tons, valued at $4,357,074, as compared with exports of 2,377,049 tons in 1910, valued at $6,077,350, a decrease in exports of 876,410 tons.

Imports of coal during the year include bituminous 8,905,815 tons, valued at $18,407,603; slack 1,632,500 tons, valued at $2,090,796, and anthracite 4,020,577 tons, valued at $18,794,192, or a total of 14,558,892 tons, valued at $39,292,591.

The imports of coal in 1910 were: bituminous, 5,966,466 tons; slack, 1,365,281 tons, and anthracite, 3,266,235 tons, or a total of 9,872,924 tons.

COKE.—The total production of oven coke in 1911 was 847,402 tons, valued at $2,340,674, as compared with the production of 902,715 tons, valued at $3,462,872, in 1910. The total quantity of coal charged to ovens was 1,228,700 short tons.

By provinces the production was: Nova Scotia, 469,305 tons: Ontario, 259,554 tons (made from imported coal): Alberta, 36,216 tons, and British Columbia, 82,327 tons. All the coke produced was used in Canada with the exception of 9,290 tons sold for export to the United States.

The quantity of coke imported during the calendar year was 751,389 tons, valued at $1,843,248, as compared with imports of 737,088 tons, valued at $1,908,725, in 1910.

## Petroleum and Natural Gas.

A further falling off is shown in the output of petroleum, the production in 1911 being 291,092 barrels or 10,188,219 gallons, valued at $357,073, as compared with 315,895 barrels or 11,056,337 gallons, valued at $388,550, in 1910. The average price per barrel at Petrolia in 1911 was $1.22$\frac{2}{3}$, and in 1910, $1.23.

These statistics of production have been furnished by the Trade and Commerce Department and represent the quantities of oil on which bounty was paid, the total payments being $152,823.29 in 1911 and $165,845.06 in 1910.

The production in Ontario by districts as furnished by the Supervisor of Petroleum Bounties was, in 1911, as follows, in barrels: Lambton, 184,459; Tilbury and Romney, 48,708; Bothwell, 35,244; Dutton, 6,732; and Onondaga, 13,501. In 1910 the production by districts was: Lambton, 205,456; Tilbury and Romney, 63,058; Bothwell, 36,998; Leamington, 141; Dutton, 7,752; and Onondaga, 1,005.

The production in New Brunswick in 1911 was 2,461 barrels, as against 1,485 barrels in 1910.

Exports of refined oil in 1911 were 489 gallons, valued at $73. There was also an export of naphtha and gasoline of 23,959 gallons, valued at $4,427.

The imports of petroleum and petroleum products again show a very large increase. The total imports of petroleum oils, crude and refined, in 1911, were 116,892,689 gallons, valued at $6,009,730, in addition to 1,959,787 pounds of wax and candles, valued at $106,424. The oil imports included crude oil 71,637,533 gallons, valued at $2,187,952; refined and illuminating oils 13,690,962 gallons, valued at $722,403; gasoline 23,338,773 gallons, valued at $1,976,052 lubricating oils 5,308,917 gallons, valued at $806,452; and other petroleum products 2,916,504 gallons, valued at $316,891.

The total imports in 1910 were 84,629,334 gallons of petroleum oils, crude and refined, valued at $4,826,763, and 1,362,235 pounds of wax and candles, valued at $80,106.

A large increase is shown in the production of natural gas in 1911, the total value being reported as $1,820,923, of which $96,665 was the production in Alberta and $1,724,258 in Ontario. These values represent as closely as can be ascertained the value received by the owners of the wells for gas produced and sold or used and do not necessarily represent what the consumers have to pay for the gas, since in many cases the gas is resold once or twice by pipe line companies before reaching the consumer.

The total quantity of gas used in Ontario was about 9,869 million feet and in Alberta probably over 611 million feet.

The production of natural gas in 1910 was valued at $1,346,471, and represented about 7,952 million feet.

## Cement.

Complete statistics have been received from the manufacturers of cement covering their production and shipments during the year 1911. These returns show that the total quantity of cement made during the year, including both Portland and slag cement, was 5,677,539 barrels, as compared with 4,396,282 barrels in 1910, an increase of 1,281,257 barrels, or 29 per cent.

The total quantity of Canadian Portland cement sold during the year was 5,635,950 barrels, as compared with 4,753,975 barrels in 1910, an increase of 881,975 barrels, or 18·5 per cent.

The total consumption of Portland cement in 1911, including Canadian and imported cement and neglecting an export of Canadian cement, valued at $4,067, was 6,297,866 barrels, as compared with 5,103,285 barrels in 1910, or an increase of 1,194,581 barrels, or 23·4 per cent.

Detailed statistics of production during the past four years are shown as follows:—

| — | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|
| | Barrels. | Barrels. | Barrels. | Barrels. |
| Portland cement sold | 2,665,289 | 4,067,709 | 4,753,975 | 5,635,950 |
| " manufactured | 3,495,961 | 4,146,708 | 4,396,282 | 5,677,539 |
| Stock on hand January 1 | 383,349 | 1,098,239 | 1,189,731 | 844,741 |
| " December 31 | 1,214,021 | 1,177,238 | 832,038 | 903,590 |
| Value of cement sold | $3,709,063 | $5,345,802 | $6,412,215 | $7,571,299 |
| Wages paid | $1,275,638 | $1,266,128 | $1,409,715 | $2,103,838 |
| Men employed | 3,029 | 2,498 | 2,220 | 3,010 |

The average price per barrel at the works in both 1910 and 1911 was $1.34, as compared with an average price of $1.31 in 1909 and $1.39 in 1908.

The imports of Portland cement during the twelve months ending December 31, 1911, were 2,316,707 cwt., valued at $834,879. This is equivalent to 661,916 barrels of 350 pounds at an average price per barrel of $1.26. The imports in 1910 were 349,310 barrels, valued at $468,046, or an average price per barrel of $1.34.

The imports from Great Britain during 1911 were 190,506 barrels, valued at $210,839; from the United States 441,317 barrels, valued at $575,768; from Belgium 2,683 barrels, valued at $2,019; from Hong Kong 22,059 barrels, valued at $38,292; and from other countries 5,351 barrels, valued at $7,962.

Following is an estimate of the Canadian consumption of Portland cement for the past five years:—

| Calendar Years. | Canadian. | | Imported. | | Total. |
|---|---|---|---|---|---|
| | Barrels. | Per cent. | Barrels. | Per cent. | Barrels. |
| 1907 | 2,436,093 | 78 | 672,630 | 22 | 3,108,723 |
| 1908 | 2,665,289 | 85 | 469,049 | 15 | 3,134,338 |
| 1909 | 4,067,709 | 97 | 142,194 | 3 | 4 209,903 |
| 1910 | 4,753,975 | 93 | 349,310 | 7 | 5,103,285 |
| 1911 | 5,635,950 | 89·5 | 661,916 | 10·5 | 6,297,866 |

## EXPORTS OF PRODUCTS OF THE MINE AND MANUFACTURES OF MINE PRODUCTS, YEAR 1911.

*(Compiled from Trade and Navigation Monthly Statements.)*

| Products. | | Quantity. | Value. |
|---|---|---|---|
| | | | $ |
| Arsenic | Lbs. | 4,125,558 | 81,761 |
| Asbestos | Tons | 75,120 | 2,067,259 |
| Coal | „ | 1,500,639 | 4,357,074 |
| Feldspar | „ | 16,150 | 56,085 |
| Gold | | | 7,493,523 |
| Gypsum | Tons. | 362,102 | 425,161 |
| Copper, fine in ore, etc | Lbs. | 55,208,054 | 5,459,770 |
| „ black or coarse and in pigs | „ | 79,656 | 7,955 |
| Lead, in ore, etc | „ | 65,100 | 1,826 |
| „ pig, etc | „ | 71,961 | 2,806 |
| Nickel, in ore, etc | „ | 32,619,971 | 3,676,396 |
| Platinum | Ozs. | 39 | 1,961 |
| Silver | „ | 31,216,725 | 15,807,366 |
| Mica | Lbs. | 693,940 | 242,548 |
| Mineral pigments | „ | 3,999,925 | 27,070 |
| Mineral water | Gals. | 26,495 | 12,952 |
| Oil, refined | „ | 489 | 73 |
| Ores— | | | |
| Antimony | Tons. | 57 | 4,946 |
| Corundum | „ | 742 | 77,777 |
| Iron | „ | 37,686 | 133,411 |
| Manganese | „ | 4 | 225 |
| Other ores | „ | 6,919 | 375,695 |
| Phosphate | „ | 3 | 100 |
| Plumbago | Cwt. | 16,263 | 43,249 |
| Pyrites | Tons. | 32,102 | 120,585 |
| Salt | Lbs. | 454,600 | 5,055 |
| Sand and gravel | Tons. | 573,494 | 408,110 |
| Stone, ornamental | „ | 168 | 1,796 |
| „ building | „ | 83,767 | 25,103 |
| „ for manufacture of grindstones | „ | 15 | 22 |
| Other products of the mine | | | 204,028 |
| Total mine products | | | 41,121,688 |
| Manufactures— | | | |
| Agricultural implements— | | | |
| Mowing machines | No. | 22,859 | 778,274 |
| Reapers | „ | 9,385 | 574,315 |
| Harvesters | „ | 14,355 | 1,432,911 |
| Ploughs | „ | 20,437 | 508,095 |
| Harrows | „ | 5,412 | 95,904 |
| Hay rakes | „ | 11,085 | 317,842 |
| Seeders | „ | 174 | 13,795 |
| Threshing machines | „ | 339 | 92,442 |
| Cultivators | „ | 5,923 | 138,377 |
| All other | | | 1,533,728 |
| Parts of | | | 796,246 |
| Bricks | M | 394 | 3,977 |
| Cement | | | 4,067 |
| Clay, manufactures of | | | 2,071 |
| Coke | Tons. | 9,852 | 39,823 |
| Acetate of lime | Lbs. | 7,428,157 | 117,904 |
| Calcium carbide | „ | 4,888,975 | 142,402 |
| Phosphorus | „ | 524,370 | 76,608 |
| Earthenware and all manufactures of | | | 6,101 |
| Grindstones, manufactured | | | 29,184 |
| Gypsum and plaster ground | | | 4,429 |
| Iron and steel— | | | |
| Stoves | No. | 1,176 | 20,626 |
| Gas buoys and parts of | | | 68,485 |
| Castings, N.E.S. | | | 33,441 |
| Pig iron | Tons. | 5,870 | 271,968 |

## EXPORTS OF PRODUCTS OF THE MINE AND MANUFACTURES OF MINE PRODUCTS, YEAR 1911—*Concluded.*

*(Compiled from Trade and Navigation Monthly Statements.)*

| Products. | | Quantity. | Value. |
|---|---|---|---|
| | | | $ |
| Iron and steel — *Concluded.* | | | |
| Machinery (Linotype machines) | | | 12,239 |
| " N.E.S. | | | 431,493 |
| Sewing machines | No. | 18,519 | 218,075 |
| Typewriters | " | 4,771 | 318,935 |
| Scrap iron and steel | Cwt. | 84,153 | 54,618 |
| Hardware, tools, etc | | | 94,513 |
| " N.E.S. | | | 44,199 |
| Steel and manufactures of | | | 769,692 |
| Lime | | | 39,536 |
| Aluminium in bars | Cwt. | 49,901 | 747,587 |
| " Manufactures of | | | 1,555 |
| Metals, N.O.P. | | | 175,716 |
| Naptha and gasoline | Gals. | 23,959 | 4,427 |
| Plumbago, manufactures of | | | 33,956 |
| Stone, ornamental | | | 980 |
| " building | | | 456 |
| Tar | | | 56,669 |
| Tin, manufactures of | | | 30,176 |
| Automobiles | No. | 1,509 | 1,184,506 |
| " parts of | | | 45,798 |
| Bicycles | No. | 90 | 5,936 |
| " parts of. | | | 50,828 |
| Total manufactures | | | 11,424,905 |
| Grand Total | | | 52,546,593 |

## ANNUAL MINERAL PRODUCTION IN CANADA SINCE 1886.

| Year. | Value of Production. | Value per Capita. | Year. | Value of Production. | Value per Capita. |
|---|---|---|---|---|---|
| | $ | $ cts | | $ | $ cts. |
| 1886 | 10,221,255 | 2 23 | 1899 | 49,234,005 | 9 27 |
| 1887 | 10,321,331 | 2 23 | 1900 | 64,420,877 | 12 04 |
| 1888 | 12,518,894 | 2 67 | 1901 | 65,797,911 | 12 16 |
| 1889 | 14,013,113 | 2 96 | 1902 | 63,231,836 | 11 36 |
| 1890 | 16,763,353 | 3 50 | 1903 | 61,740,513 | 10 83 |
| 1891 | 18,976,616 | 3 92 | 1904 | 60,082,771 | 10 27 |
| 1892 | 16,623,415 | 3 39 | 1905 | 69,078,999 | 11 49 |
| 1893 | 20,035,082 | 4 04 | 1906 | 79,286,697 | 12 81 |
| 1894 | 19,931,158 | 3 98 | 1907 | 86,865,202 | 13 75 |
| 1895 | 20,505,917 | 4 05 | 1908 | 85,557,101 | 13 16 |
| 1896 | 22,474,256 | 4 38 | 1909 | 91,831,441 | 13 70 |
| 1897 | 28,485,023 | 5 49 | 1910 | 106,823,623 | 14 93 |
| 1898 | 38,412,431 | 7 32 | 1911 | 102,291,686 | 14 20 |

## THE MINERAL PRODUCTION OF CANADA IN 1910.

*(Revised.)*

| No. | Product. | | 1910. Quantity. | Value. (a). | Per cent of total. |
|---|---|---|---|---|---|
| | *Metallic.* | | | $ | % |
| 1 | Antimony ore | Tons* | 364 | 13,906 | |
| 2 | " refined | Lbs. | | | |
| 3 | Cobalt (i) | " | | 51,986 | |
| 4 | Copper (b) | " | 55,692,369 | 7,094,094 | 6·64 |
| 5 | Gold | Ozs. | 493,707 | 10,205,835 | 9·55 |
| 6 | Pig iron from Canadian ore (c) | Tons. | 104,906 | 1,650,849 | 1·54 |
| 7 | Iron ore (exports) | " | 114,449 | 324,186 | 0·30 |
| 8 | Lead (d) | Lbs. | 32,987,508 | 1,216,249 | 1·13 |
| 9 | Nickel (e) | " | 37,271,033 | 11,181,310 | 10·46 |
| 10 | Silver (f) | Ozs. | 32,869,264 | 17,580,455 | 16·45 |
| 11 | Zinc ore | Tons. | 5,063 | 120,003 | 0·11 |
| | Total | | | 49,438,873 | 46·28 |
| | *Non-Metallic.* | | | | |
| 12 | Actinolite | Tons. | 30 | 330 | |
| 13 | Arsenic | " | 2,049 | 81,044 | |
| 14 | Asbestos | " | 77,508 | 2,555,974 | 2·39 |
| 15 | Asbestic | " | 24,707 | 17,629 | |
| 16 | Chromite | " | 299 | 3,734 | |
| 17 | Coal | " | 12,909,152 | 30,909,779 | 28·93 |
| 18 | Corundum | " | 1,870 | 198,680 | 0·18 |
| 19 | Feldspar | " | 15,809 | 47,667 | |
| 20 | Fluorspar | " | 2 | 15 | |
| 21 | Graphite | " | 1,392 | 74,087 | |
| 22 | " artificial | " | 1,221 | | |
| 23 | Grindstones | " | 3,973 | 47,196 | |
| 24 | Gypsum | " | 525,246 | 934,446 | 0·87 |
| 25 | Magnesite | " | 323 | 2,160 | |
| 26 | Mica | " | | 190,385 | 0·17 |
| | Mineral pigments— | | | | |
| 27 | Barytes | " | 0 | 0 | |
| 28 | Ochres | " | 4,813 | 33,185 | |
| 29 | Mineral water | | | 199,563 | 0·18 |
| 30 | Natural gas (g) | | | 1,346,471 | 1·26 |
| 31 | Peat | Tons. | 841 | 2,604 | |
| 32 | Petroleum (h) | Bls. | 315,895 | 388,550 | 0·36 |
| 33 | Phosphate | Tons. | 1,478 | 12,578 | |
| 34 | Pyrites | " | 53,870 | 187,064 | 0·17 |
| 35 | Quartz | " | 88,205 | 91,951 | |
| 36 | Salt | " | 84,092 | 409,624 | 0·38 |
| 37 | Talc | " | 7,112 | 22,308 | |
| 38 | Tripolite | " | 22 | 134 | |
| | Total | | | 37,757,158 | 35·34 |

N.B.—Footnotes on p. 173.

## THE MINERAL PRODUCTION OF CANADA IN 1910—*Concluded.*

*(Revised.)*

| No. | Product. | | 1910. | |
|---|---|---|---|---|
| | | Quantity. | Value. (a). | Per cent of total. |
| | *Structural Materials and Clay Products.* | | $ | % |
| 39 | Cement, Portland ... Bls. | 4,753,975 | 6,412,215 | 6·00 |
| | Clay products— | | | |
| 40 | Brick, common ... No. | 627,715,319 | 5,105,354 | 4·77 |
| 41 | Brick, pressed ... " | 67,895,034 | 807,284 | 0·75 |
| 42 | Brick, paving ... " | 4,214,917 | 78,980 | |
| 43 | Brick, moulded and ornamental ... | 703,345 | 16,092 | |
| 44 | Fireclay, and fireclay products ... | ... | 50,215 | |
| 45 | Fireproofing and architectural terra-cotta ... | ... | 176,979 | 0·16 |
| 46 | Pottery ... | ... | 250,924 | 0·23 |
| 47 | Sewer-pipe ... | ... | 774,110 | 0·72 |
| 48 | Tile, drain ... No. | 24,562,648 | 370,008 | 0·34 |
| 49 | Lime ... Bus. | 5,848,146 | 1,137,079 | 1·06 |
| 50 | Sand-lime brick ... No. | 44,593,541 | 371,857 | 0·34 |
| 51 | Sand and gravel (exports) ... Tons. | 624,824 | 407,974 | 0·38 |
| 52 | Slate ... Squares. | 3,959 | 18,492 | |
| | Stone— | | | |
| 53 | Granite ... | ... | 739,516 | 0·69 |
| 54 | Limestone ... | ... | 2,249,576 | 2·10 |
| 55 | Marble ... | ... | 158,779 | 0·14 |
| 56 | Sandstone ... | ... | 502,148 | 0·47 |
| | Total ... | ... | 19,627,592 | 18·37 |
| | Grand total ... | ... | 106,823,623 | 100·00 |

* Short tons throughout.

(a) The metals copper, lead, nickel, and silver are for statistical and comparative purposes valued at the final average value of the refined metal. Pig iron is valued at the furnace, and non-metallic products at the mine or point of shipment.

(b) Copper content of smelter products and estimated recoveries from ores exported at 12·738 cents per pound.

(c) The total production of pig iron in Canada in 1910 was 800,797 tons valued at $11,245,622, of which 695,891 tons valued at $9,594,773 are credited to imported ores.

(d) Refined lead and lead contained in base bullion exported at 3·687 cents in 1910, the average price in Toronto.

(e) Nickel content of matte produced valued at 30 cents. (Increasing quantities of nickel-copper matte are now being used in making monel metal which is sold at a price much below that of refined nickel). The value of the nickel contained in matte, as returned by the operators, was about 10 cents per pound.

(f) Estimated recoverable silver at 53·486 cents.

(g) Gross returns for sale of gas.

(h) Quantity on which bounty was paid and valued at $1.23.

(i) Value received by shippers of silver cobalt ores for cobalt content.

## APPENDIX II.

### ON EXPLOSIVES.

(*a*)

INTRODUCTION.

In the Summary Report for 1910 there appeared an extended reference dealing with measures already initiated by the Mines Branch looking toward the establishment of Federal supervision over the manufacture, importation, transportation, storage, and testing of explosives in Canada.

It had been deemed advisable that, prior to taking definite action regarding so important a matter, the best possible expert advice should be obtained. Consequently, through the courtesy of the Home Office, Captain Arthur Desborough, H.M. Inspector of Explosives, was permitted to visit Canada and to act in an advisory capacity to the Dominion Government. In order to make himself thoroughly conversant with Canadian conditions, Capt. Desborough travelled throughout the country, inspected the various factories where explosives are manufactured, and finally submitted a report summing up his conclusions regarding the explosives industry of Canada. Subsequently a conference was held in the House of Commons at Ottawa on September 23 and 30, 1910. At this conference, which was attended by representatives of the Mines Branch and of the manufacturers of explosives throughout Canada, the practical effects that the proposed legislation would have on the explosives industry as at present established in this country, was thoroughly discussed with Captain Desborough himself.

Complete official statements relative to the Explosives Act have, therefore, been already issued by the Mines Branch. These statements have set forth, not only the complete text of the Explosives Act itself, but also the report by Captain Desborough and a complete account of the conference held at Ottawa to consider the proposed legislation. Considering, however, the wide-spread interest which the question has aroused among manufacturers and users of explosives throughout Canada, it has been deemed advisable to reproduce in the present publication not only the report of Captain Desborough, but also a statement of the various clauses of the Explosives Act itself.

*Reprint.*

### REPORT ON THE EXPLOSIVES INDUSTRY IN THE DOMINION OF CANADA.

*Captain Arthur Desborough, H.M., Inspector of Explosives.*

OTTAWA, October, 1, 1910.

To Dr. EUGENE HAANEL,
Director of Mines, Ottawa.

SIR,—I have the honour to submit the following report on my investigation of the explosives industry in the Dominion of Canada.

Before offering any criticisms or recommendations, I propose to state briefly the more important principles upon which the British regulations are based; these general principles being, in many cases, equally applicable to the regulation of the industry in the Dominion.

(1) *Authorization of Explosives.*—No explosive may be manufactured in or imported into the United Kingdom for sale until it has been subjected to examination by the chemical advisers of the Explosives Department. It is the duty of these gentlemen to satisfy themselves that the explosive is not unduly sensitive to friction or percussion, and that it also possesses a reasonable degree of chemical stability. Explosives which are found to be of the requisite standard are included in the list of authorized explosives as soon as a license is obtained to allow of their being manufactured or imported.

(2) *Manufacture of Explosives.*—No explosives may be manufactured except in an authorized place. A person, therefore, who wishes to manufacture explosives has to obtain a license. By the terms of his license he is only permitted to erect buildings of a specified construction, on the sites shown on a plan attached to his license. The maximum number of work-persons, and the maximum quantity of explosives allowed to be present in each building are specified, as is also the nature of the operations proposed to be carried on in the buildings. The factory buildings are required to be at certain distances from one another, and certain distances must also be observed from buildings and works outside the factory. The distances are determined by the quantity of explosives allowed to be present in the building. A table showing quantities of explosives and distances was drawn up some years ago from data obtained by noting the damage caused by explosions of known quantities of explosive; suitable interpolations were made to render the application of the table practical. Since the adoption of this system of distances, no member of the general public has been killed, and no dwelling house has sustained any serious structural damage by an explosion in any factory. From recent explosions it appears that the distances are hardly adequate where the explosive involved consists of nitro-glycerine unmixed with other ingredients.

Generally speaking, the buildings in which operations of manufacture are carried out are required to be of light construction, having close joined wooden floors and being lined with wood or other suitable material. I will refer to magazine construction under the head of storage.

No responsibility is taken by the Explosives Department regarding the machinery employed, but in the event of any particular type of machine proving to be dangerous, the question of its discontinuance is taken up with the occupier of the factory.

The maximum number of work people allowed to be present in a building is determined by the nature of the operations carried out in the particular building, and, as a rule, varies from two to six. This number is exclusive of the men employed to convey explosives or ingredients to or from the building and who are essentially non-producers.

I may add that the death rate among the employes has been for a considerable number of years well below 1 per 1,000.

*Storage of Explosives.*—Magazine licenses are issued by the Home Office for the storage of explosives. As in the case of factory licenses, the terms require that the building should maintain certain distances from the buildings and works depending on the quantity of explosives allowed to be kept. Only half the specified distance need be maintained if the building is screened by substantial earth banks, and if satisfactory screening is afforded by the natural features of the ground the distances are sometimes diminished by 75 per cent. Magazines are almost invariably constructed of substantial masonry or brickwork, as it is considered that if the explosive is of good quality the only dangers to be feared are those which will arise from outside the building. The only objection to this form of construction is, that should an explosion occur in a building not surrounded by earth banks considerable damage may be caused by the projection of heavy debris. In the past thirty years, three magazines have been destroyed by explosions and in no case were any lives lost or surrounding property seriously damaged.

Licenses for the storage of limited quantities (2 tons of gunpowder or 1 ton of high explosive) are granted by the local authorities, if specified conditions as to construction and distances are observed.

*Home Office Licenses.*—Both factory and magazine licenses are prepared in draft by the applicant in consultation with the Explosives Department. When the draft has been agreed upon, the applicant is given permission by the Secretary of State to lay the draft before the local authority, in whose jurisdiction the proposed buildings are situated, in order to receive their assent. If the local authority give their assent, the draft license is confirmed. If, however, they refuse their assent, an inquiry is held by an officer of the Explosives Department, and the Secretary of State, on receipt of the report, either upholds the local authority or inserts additional terms to cover their objections, or over-rides their decision.

*Transportation.*—Accidents in transportation are practically unknown and this may be fairly ascribed to the quality of the explosives, the specified method of packing, and the care in handling the traffic. The method of packing and general regulations as to transportation are prescribed in Orders of Secretary of State made under the Act. Railway companies, canal companies, and harbour authorities have, however, to make by-laws regarding the transportation, loading, and unloading of explosives. These by-laws have to receive the sanction of the Board of Trade before they are operative.

*Importation.*—Only authorized explosives may be imported for sale. A person desiring to import explosives has to obtain an importation license from the Home Office. Before a license is granted he is required to show that he has an authorized place of storage at his disposal. Generally the importer owns licensed magazines, but if not he obtains a certificate from an occupier of a licensed magazine, that sufficient storage accommodation is available for the importation. When the importation is effected, the customs officers take samples which are forwarded for examination and the explosive is deposited in the specified magazines. If the samples are reported on as coming up to the required standard, the explosive is placed at the disposal of the importer. Otherwise, further samples are obtained (if the importer so desires), or the explosive is definitely condemned as being unfit for distribution. In certain doubtful cases the explosive is released, on the importer guaranteeing that it will all be used up in a limited time.

*Use of Explosives.*—The use of explosives is not governed by the Explosives Act. The use in mines and quarries is regulated by general rules contained in the Mines and Quarries Acts, and by special rules made under those Acts. A Bill was introduced into Parliament last year giving the Secretary of State power to make regulations regarding the use of explosives in construction works, but, owing to the large amount of other legislation before the House, the Bill was dropped.

*Home Office Testing Station.*—The station was established in 1897 under a section of the Coal Mines Regulation Act, 1896, and the work carried on there must not be confused with the purely chemical work of the chemical advisers of the Explosives Department. The station is used for testing explosives for use in coal mines where danger is to be feared from fire-damp, or coal dust. The test consists in firing charges from a cannon into a chamber filled with an explosive atmosphere of air and coal gas.

The details of the test are about to be considerably modified and for this purpose a new apparatus is being erected in the north of England. Only authorized explosives may be submitted to the test and the names of those which have passed this test and the conditions under which they may be used are published from time to time in an Order of the Secretary of State. These explosives are known as Permitted Explosives.

## Explosives Industry in the Dominion.

I have had the opportunity of visiting the majority of the more important factories. As was to be expected, the standard of precautionary measures against accidents varied considerably. Any criticism I may make must not be considered as being directed against any particular factory, as I purposely avoided making a detailed inspection of any one plant, feeling that with the very limited time at my disposal, the utmost I could do would be to obtain a general impression as to the conditions under which explosives were manufactured.

As regards the quality of the explosives, I will defer comment until I discuss the question of use, as the only information I have obtained was gained in course of conversation with the users of explosives.

Most of the factories appear to suffer from the defect of having been started in a small way and then added to as the business expanded. Had the probability of expansion been recognized at the commencement, there is little doubt but that the buildings would have been placed in more suitable positions and overcrowding thus avoided. In some instances the quantities in the buildings were considerably greater than the distances from other buildings would allow. This was sometimes due to the fact that explosive which had been operated on was allowed to remain in a building while a second batch was being operated on and a third was being brought into the building. As a general principle, a batch of explosives should be removed from a building as soon as it has been operated on: if the building in which the next operation is to take place is not available, it should be placed in an expense magazine situated at a suitable distance. The chief danger of explosion must of necessity be with the explosive which is being operated on; it is, therefore, unwise, to say the least of it, to expose a second or third batch to the certainty of communicated explosion. In other cases the excessive quantities were due to overcrowding of the factory buildings.

The actual operations of manufacturing nitro-glycerine appear to be generally carried out in one building, owing to climatic conditions, and this entails the accumulation of large quantities, sometimes amounting to over five tons, in one building. The majority of the factories have only one nitrating plant, and I think manufacturers should consider whether it would not be advisable to install a second plant, which could be used alternatively, and thus prevent such large accumulations in one building. An explosion in a nitrating plant must put a factory out of action for some considerable time, unless there is a duplicate plant available.

In some factories there were too many cartridge packing machines in one building. The objection to this practice does not lie in the number of machines but in the large number of men who must be present in the buildings to attend to the machines. In one instance, all the machines in the factory were under one roof, and no less than 15 men were present. Apart from humanitarian objections to the exposing of so many lives to one risk, I am strongly of opinion that it is economically unwise to concentrate all the cartridge packing in one building. I understand that in one factory last year 11 lives were lost, due to explosions which occurred in the packing house. This number exceeds the annual average number of deaths in all the explosives factories in Great Britain. Generally speaking, there appears to be a tendency to allow unnecessary articles to accumulate in danger buildings. The object of the manufacturer should be to reduce the number of movable implements to the minimum. When it is remembered that a thin layer of most explosives can be exploded by a blow from a comparatively light weight falling a distance of a few feet, the importance of this point will be realized. I may mention in this connexion that I have more than once witnessed the experiment of a thin layer of gunpowder spread on a wooden floor being ignited by a glancing blow from a wooden broom stick.

The presence of iron hammers and other tools is also objectionable. When they are required, they should only be used by a responsible person and should be removed as soon as they are no longer wanted.

Greater care should be exercised to prevent grit getting into the explosive and also to prevent explosive from lodging in crevices in the walls and floors of buildings. The iron framework of machines should be painted to prevent the detachment of rust, which is otherwise almost certain to find its way into the explosive.

I do not think that manufacturers pay sufficient attention to details, and it is only by studying details that it is possible to make the manufacture of explosives relatively safe. Apart from the risk of spontaneous decomposition, which may arise on rare occasions during the manufacture of nitro-glycerine, there is the risk of spontaneous decomposition from explosive dust settling on heating pipes and being left there, and from accumulations of explosive in cracks and crevices. With reasonable precaution these latter risks should be practically non-existent. The heating pipes should be so placed that they are readily accessible to inspection and the walls should be lined with a suitable material; the floor, if not close joined, should also be covered. I understand that rubberoid has been employed both as a lining for the walls and a floor covering by several manufacturers, with excellent results.

Another risk to be guarded against is the ignition of a thin film of explosive by a blow. As I have already stated, as few movable articles as possible should be present in a building. When it is remembered that most explosives when heated are much more sensitive to friction or percussion, special precautions should be taken in drying houses to eliminate this risk, and I think that the explosive should be allowed to cool down to the normal temperature before it is handled or the drying racks removed.

Grit mixed with explosive renders it far more sensitive; precautions should, therefore, be taken to prevent its introduction either by the work persons themselves, or by its adhering to boxes and packages brought into the building. It is impossible to prevent a certain amount of grit entering a building, and this grit will, of necessity, be mostly present on the floors of the buildings; it is important, therefore, to minimize the quantity of explosive spilt on the floor and also to have the floors swept periodically.

In buildings in which explosion is likely to be preceded by fire it is especially necessary to provide adequate means of escape for the work people, and care should be taken that the exits are not blocked by boxes or packages.

Sufficient forethought does not seem to be paid to the wiring of the electric light system. Apart from the dangers of ordinary wear and tear, there is always the risk that the concussion caused by an explosion in a neighbouring building may so dislocate the wiring as to cause a fire.

## Storage of Explosives.

I have not had the opportunity of visiting many magazines. In most instances the distances maintained from other buildings were inadequate, owing to the large quantities stored. I cannot help thinking that it would be wiser to erect a greater number of buildings and to store in each smaller quantities of from 25 to 50 tons.

In some instances I found packages of damaged explosive which had been returned by the users. Damaged explosive should be destroyed, as, if left in a magazine, it is liable to be overlooked and if of the nitro-compound class may ignite spontaneously.

## Transportation of Explosives.

My attention was drawn to two instances of the transportation of explosives by water, which I think are deserving of comment. In one case, after over 100 tons of dynamite had been loaded into a vessel, a number of cans of gasoline were placed on top of the explosive. Highly inflammable and volatile liquids, such as gasoline, should not be transported with explosive. In another instance, cargoes of explosive were habitually conveyed in a gasoline launch. I do not think it can be claimed that gasoline launches have reached such a state of perfection that the possibility of fire can even be regarded as remote. If such a launch caught fire in a crowded harbour, the result would be disastrous.

## Use of Explosives.

In the course of conversation with the users of explosives I have frequently been told that the quality of the explosives manufactured in the Dominion leaves much to be desired. It was asserted that no two charges fired in similar circumstances would do the same amount of work. Except so far as shot firing in coal mines is concerned, I do not think this unevenness of explosive can be said to be a positive danger, apart from the production of an unnecessarily large volume of deleterious gases from an over-charged shot. In the case of coal mines, where there is risk of igniting gas or dust, the danger is very appreciable. A miner will always gauge the weight of his charge by the weakest shot he has fired and the tendency will always be to overcharge. The gases produced from the surplus of explosive not having any work to do will not cool down rapidly, and should they come in contact with fire-damp or coal dust in suspension would probably cause an ignition. It is imperative, therefore, that steps should be taken to ensure an even quality of explosive for use in coal mines.

A thin film of explosive on the exterior of a cartridge, a state of affairs which I frequently noticed in the buildings in which cartridges were being packed into boxes, can hardly be conducive to safety in ramming. In the absence of specific information as to the accidents which occur from the use of explosives, I do not feel that it is possible for me to offer any further comments.

It will not be out of place, however, to give a word of warning as to the misleading effects of demonstrations of the safety of explosives. These experiments generally consist in burning a cartridge in the open or throwing a small quantity on to a fire. Such experiments can generally be performed with blasting explosives without risk. The behaviour of the explosive when confined in a bore hole or when ignited in bulk so that a certain amount of pressure is generated would be a much more reasonable test, but such experiments would not suit the demonstrator as they would be much more likely to result in an explosion. I may instance the case of many of the ammonium nitrate explosives, which are very difficult to ignite in the open, and when thrown on a red hot sheet of iron merely melt, but which in the confinement of a shot hole have been found, under certain conditions, to burn fairly readily until sufficient pressure is set up to cause the unburnt portion to explode.

It cannot be pressed too strongly upon the user of explosives that the function of an explosive is to explode, and that, no matter what assertions are made by an interested person as to the safety of his explosive, all explosives should be regarded as dangerous.

## Recommendations.

In the following pages I have acted on the assumption that the Dominion Government has the power to legislate on these matters.

It is not possible for me to mention in detail all the points which I think should be included in the draft bill which is in course of preparation. I propose, therefore, under the above heading, to discuss shortly some of the more important provisions which should be included in the proposed legislation and also to offer some suggestions on matters which, though they do not come directly within the scope of the bill, are of sufficient importance to warrant my commenting on them.

The following are the essential points which I propose to discuss:—

1. Authorization of explosives.
2. Licensing of factories.
3. Control of storage not otherwise provided for.
4. Control of transportation not otherwise provided for.
5. Control of importation.
6. Inspection and sampling.
7. Establishment of chemical laboratory and testing station.
8. Investigation of accidents in factories.
9. Investigation of accidents in storage, transportation, and use.
10. Appointment of staff.

(1) *Authorization of Explosives.*—I think the system in Great Britain should be adopted. It will undoubtedly improve the quality of the explosives manufactured in the Dominion and should thereby have a tendency to diminish accidents in use; it must not be expected, however, that fool-proof explosives will ever be produced. It will also prevent the user being at the mercy of the enthusiastic inventor who persuades him to try a new explosive which has probably been invented many years previously and then discarded on account of its danger or unsuitability.

(2) *Licensing of Factories.*—Factories should be licensed on the principle of limiting the amount of explosive allowed to be present in a building, in accordance with the distances that the building can maintain from the other buildings in the factory, and buildings and works outside the factory. Limitations should also be assigned as to types of construction adopted, the number of work persons allowed to be present, and the nature of the operations to be carried on in the various buildings. If these points are enforced in a reasonable manner, I do not think that manufacturers will find their trade unduly hampered.

As regards existing factories, I do not think the occupiers should be required to immediately conform to the new system, but that a definite time limit should be assigned, so as to admit of the change being made gradually. If, however, there happen to be particular buildings in a factory which constitute a very definite menace to the public safety by reason of their proximity to a city, I think the occupier should be required either to remove the building forthwith, or to reduce the quantity of explosive in the building, so as to diminish the danger zone. It is not possible to lay down a hard and fast rule and each case should be considered separately and treated on its merits.

(3) *Control of Storage.*—The special points to which attention should be paid are the situation, quantity of explosive, and construction. The first and second should be governed by the table of distances. As regards the third, two somewhat antagonistic features have to be considered. First, the building should be protected from dangers from without, such as rifle bullets, and should have security against unlawful entry and fire. Second, in the event of an explosion occurring the projection of heavy debris should be minimized; this feature is probably of greater importance in the Dominion than it is in Great Britain, owing to the fact of the large number of frame

dwelling houses which are to be found here, whilst they are almost non-existent in the latter country.

The ideal construction for a magazine would be to have a relatively lightly constructed building, surrounded by substantial earth banks, but it is difficult to make this type reasonably secure against unlawful entry and other dangers from without. It must always be remembered, however, that with the system of the authorization of explosives there should be little risk of the explosive igniting spontaneously, and as no operation should be carried on in a magazine the principal danger of explosion comes from causes outside the building. The results of some experiments carried out in Germany were recently published and the conclusion arrived at by the experimenters was, that a certain type of reinforced concrete gave the best result. It was found that with the particular form of construction very little debris was projected when an explosion occurred in the building, as the concrete was so pulverized that the fragments did not carry any great distance. If funds are available, it would be of considerable value to have experiments carried out on similar lines with buildings constructed to suit Canadian requirements.

In Great Britain there is a statutory requirement that every magazine should be fitted with an efficient lightning conductor; there are, however, no suggestions given as to what constitutes such a conductor. As I understand that parts of this country are frequently visited by severe electrical storms, I think the question of protecting magazines from lightning should be considered. I would venture to suggest that the scientific staff of some of the Universities and representatives of the explosives manufacturers should be invited to co-operate with your Department to inquire into the most efficient and economical system of securing the necessary protection. There is a system of storage in Great Britain, which I have not met with in the Dominion, but which might be found of use where the climatic conditions will admit of it. In the rivers Thames and Mersey vessels are moored at places specially selected by the Harbour Authorities, and these vessels are licensed by the Home Office as Magazines. Where there is a considerable water-borne trade, the use of such vessels as distributing centres might prove of advantage.

(4) *Control of Transportation.*—The control of transportation by rail is in the hands of the Railway Commissioners, and the only way in which the proposed legislation will affect this method of transportation will be as regards the quality of the explosive conveyed. I understand that the regulations adopted by the Commissioners are those promulgated by Col. Dunne's bureau in New York. The great value of these regulations has been amply proved, but being a private concern there are not the same facilities for maintaining the standards of quality of the explosives as will be the case when the authorization of explosives is in the hands of the Government.

I understand that at present it is practically impossible to transport legally small quantities of explosive by rail. It is generally certain that this traffic is carried on, probably in passenger trains, and with detonators and blasting explosive packed together. I would venture to suggest, therefore, that your Department should approach the Railway Commissioners, with a view to discussing the question of recognizing and controlling the transportation of small quantities. I may mention that in Great Britain the railway companies have agreed to transport small quantities of explosive in cars loaded with other freight, when packed in a special manner.

As regards transportation by water or road, I think power should be included in the bill to regulate generally the method of stowage, the method of packing, the limiting of the nature of freight which may be transported with explosives, and the limiting the quantity of explosive transported at any one time, according to the nature of the vessel or vehicle in which the transportation is being effected.

(5) *Importation.*—Before any explosive is imported into the Dominion for sale or use, a sample should be submitted for authorization. The terms of the license for

subsequent importations should require the importer to have at his disposal a licensed place of storage, in which the explosive would be detained until the chemical department have satisfied themselves by examination of the samples taken by the Customs that the explosive is of the requisite standard.

(6) *Inspection and Sampling.*—I need only remark that when a factory or magazine have been licensed it is necessary that they should be periodically inspected, to ascertain that the terms of the licenses are being complied with. Similarly, it is essential that after an explosive has once been authorized, samples should be periodically examined to see that the manufacturer is maintaining the required standard. Most explosives deteriorate in quality and chemical stability after prolonged storage. It is necessary, therefore, to obtain samples not only from factories and distributing magazines, but also from magazines in the occupation of the users of explosives. I have reason to believe that the Provincial authorities will be glad to co-operate with your Department in this respect.

(7) *Establishment of Testing Station.*—Apart from the chemical laboratory, which will be in the hands of the chemical advisers of the explosives department, it will be necessary to establish a station for the testing of explosives for use in coal mines. I understand that it is also considered desirable to erect an apparatus for testing types of safety lamps. I would suggest, however, that before deciding on the final details of the tests it would be well to await the conclusion of the experiments which are shortly to be carried out in Great Britain. It may be of interest to state that the Home Government have not contemplated instituting an official test for the so-called rescue apparatus. The word 'rescue' appears to give the general public the idea that after an explosion has occurred in a coal mine it is only necessary for men wearing these breathing apparatus to enter the mine, to enable them to rescue the unfortunate miners who have been exposed to the effects of the explosion and the deadly effect of after damp. I think the more reasonable view to hold as regards the practical utility of breathing apparatus is that their chief scope lies in the direction of coping with fires below ground in the early stages, and it is only in the sense of preventing the spread of a fire which would endanger the lives of those present in the mine that the term 'rescue' can be applied to them.

Apparatus should be installed at the testing station to enable comparisons to be made between the kinetic energy of different natures of explosives and also to determine the velocity of detonation of explosives. Information on these two points should prove of value to the users of explosives, to enable them to select the explosive most suitable for the work which they are undertaking.

(8) *Accidents in Explosives Factories.*—It is of the utmost importance that the explosives department should have full information regarding all accidents which occur in factories either by fire or explosion, even when no personal injuries are sustained. It is often from an accident in which no persons are injured that the most valuable information can be derived. I think that it should be obligatory for the occupiers of factories to report as soon as possible all such accidents, and to leave things untouched as far as is practicable, in case it should be deemed advisable to have the circumstances of the accident investigated by an official of the department.

(9) *Accidents in Storage, Transportation, and Use.*—Accidents which occur by fire or explosion in the storage and transportation of explosives should also be brought to the notice of the department; in those cases in which the storage or transportation comes under the control of the new Act, it may be desirable to have an inquiry held by an official of the department. In other cases, the co-operation of the Provincial Governments and the Railway Commissioners should be sought, in order to

obtain as complete a record as possible of such accidents. Doubtless, the Provincial Inspectors of mines will be willing to inform the new department of the results of their investigations. As regards accidents in transportation by rail, the services of an inspector of explosives should be placed at the disposal of the Railway Commissioners, should they so desire it, to assist in carrying out investigations.

By far the larger number of accidents which occur with explosives arise from their use; it is of the utmost importance that all accidents occurring when the explosives are in use should be thoroughly investigated and classified. I have reason to believe that the Provincial Inspectors of Mines will be willing to co-operate with the department by forwarding accounts of accidents occurring in the mines under their jurisdiction. I understand, however, that a large number of accidents occur in works where there is no legislation affecting the use of explosives. I think it would be advisable for the Minister of Mines to take power in the proposed bill to frame rules to regulate the storage and use of explosives in such works, to require the reporting of accidents, and to have investigations made when such a course appears necessary.

It may be of interest to summarize the causes of the more frequently occurring accidents which arise from the use of explosives in mines, quarries, and construction works in Great Britain.

1. *Prematures.*—Often due to the use of short or bad fuse, or the use of straws and squibs to ignite the charge. May arise from a man attempting to light too many shots and thus being unable to take cover.

2. *Hang-fires.*—Often due to irregular fuse, or the ignition of explosive, which burns until sufficient pressure is set up to cause it to explode; this may be due to inferior quality of explosive or a weak detonator. Sometimes due to miscounting shots and returning too soon.

3. *Electrical Prematures.*—Generally due to the shot firer allowing another man to connect the detonator leads to the firing cable, which has been previously attached to the battery.

4. *Ramming.*—Due to frozen nitro-glycerine explosive, broken cartridge leaving a thin film of explosive in the bore hole. Cartridge sticking in the bore hole and being violently forced home. It is of the utmost importance that no explosive which is unduly sensitive to friction or percussion should be authorized for use.

5. *Striking Unexploded Charge when Removing Debris.*—Generally due to frozen nitro-glycerine explosive, or to weak detonator which fails to cause propagation of detonation through all the cartridges, or to the cartridges becoming separated by a layer of dirt in the shot hole.

6. *Boring into a Missed Shot.*

7. *Tampering with a Missed Shot.*

8. *Not Taking Proper Cover.*—In the case of electrical firing generally due to use of too short a cable.

9. *Fumes.*—Either due to defective ventilation, men returning too soon, or ignition instead of detonation of high explosive. The gases evolved by burning nitro-glycerine explosives are very poisonous. The burning may be originated by weak detonator or inferior quality of explosive.

10. *Preparing Charges.*—Generally due to frozen nitro-glycerine explosive, unduly sensitive explosive, recklessness, or lack of skill.

11. *Ignition of Explosive by Spark.*—Principally confined to gunpowder, where open lights are used below ground.

12. *Socketting or Springing.*—Due to re-charging before sufficient time has elapsed.

13. *Ignition of Fire-damp or Coal Dust.*—Apart from the quality of the explosive, generally due to the firing of two shots, one after the other, without examining for gas after firing the first shot. The firing of overcharged shots is perhaps the more usual cause.

It may be of interest to state that during 1909 over 30 million pounds of blasting explosives were used in mines, quarries, and construction works in Great Britain, and that (exclusive of fatalities from explosions of fire-damp or coal dust) 53 lives were lost thereby.

*Staff of the Explosives Department.*—The technical staff of the new department should, I think, consist of a Chief Inspector, two Inspectors, and a Chemist. I cannot state too emphatically that the Chief Inspector should have sufficient technical knowledge not only to enable him to administer what must of necessity be a very technical act, but also to deserve the confidence of the explosives manufacturers. As men possessing such qualifications are rare, I would venture to suggest that it would be very unwise to attempt to economize by offering an inadequate salary. As regards the two inspectors, it will hardly be possible to obtain the services of technically qualified gentlemen, and I think it would be sufficient if these gentlemen possessed practical experience of the use of explosives, one of them at least having gained his experience in coal mining. In assigning their salaries, the fact that their work must of necessity be somewhat hazardous should not be lost sight of.

The responsibility of the chemical adviser to the department will be considerable, as in his hands will rest the recommendation for the acceptance or rejection of explosives. When it is remembered that the authorization of an explosive or otherwise, or the condemnation of a batch of explosive which has been issued from a factory may involve large financial interests, it is hardly necessary for me to point out that this gentleman should be possessed of the highest technical qualifications and integrity. The salary of the chemical advisers of the Home Office is entirely dependent on fees, but it would be far preferable if the chemist of the new department were paid an adequate salary so that his whole time should be at the disposal of the government.

It will be necessary to employ a mechanic at the Testing Station, who will be competent to carry out minor repairs to the apparatus, and who would assist in carrying out official tests and experiments. He should also be responsible for the care of explosives stored in the magazine and for apparatus and stores used in connexion with the Testing Station.

I have the authority of Major Cooper Key, His Majesty's Inspector of Explosives, for stating that he will be glad to afford facilities for any person who may be appointed as an Inspector to be attached to the Explosives Department of the Home Office, to enable him to get an insight into the administration of the Explosives Act and the methods adopted for the testing of explosives for use in coal mines. Major Cooper Key also states that he would be glad to make arrangements for the chemical adviser of the new department to work in the laboratory of Messrs. Dupré, who are the chemical advisers of the explosives department. I would strongly urge that these facilities be taken advantage of.

If my proposal as to the regulation of the use of explosives be adopted, I would suggest that two or three gentlemen be appointed as assistant inspectors, whose duty would be confined to the administering of these regulations. Their principal functions would be to endeavour to educate the users of explosives by means of lectures and practical demonstrations to avoid the misuse of explosives, and also to investigate any accidents which might occur.

I have the honour to be,

Sir,

your obedient servant,

(Signed) **A. Desborough**, Capt.

*H. M. Inspector of Explosives.*

MEMORANDUM.

## Magazine Construction Committee.

The Committee should consist of a member of the Mines Department, a representative of the Militia Department, a representative of the Public Works Department, and two members of the explosives trade.

The object of the Committee would be to test different natures of construction by exploding from a half to one ton of explosive inside each building, and noting the distance to which the debris is projected.

The Committee should satisfy themselves that each building is reasonably secure against unlawful entry.

I would suggest that the explosive be invariably stacked at one end of the building, so as to leave as great an air space as possible from the other end. This point is especially important where the construction is of concrete.

The types of construction which might be experimented with are as follows:—

1. Expanded metal and cement plaster.
2. German special re-inforced concrete.
3. Log magazine.
4. Any type which the Committee suggest.

I think the attention of the Committee might be directed to the possibility of the expanded metal being carried above the roof, and also being grounded to form an economical system of protecting from lightning.

## Transportation of Liquid Nitro-glycerine by Road.

Mr. Lowry, at the recent conference, raised this point with regard to the use of liquid nitro-glycerine in opening oil wells.

When nitro-glycerine was first used on a commercial scale, it was invariably transported in the liquid state. In consequence of the large number of accidents which occurred, the practice was prohibited in all European countries. Alfred Nobel then absorbed the liquid in an infusorial earth, solely with the view of rendering its transportation reasonably safe, and with the intention of extracting the nitro-glycerine by a process of displacement by water when it had been transported to the place at which it was required to be used. He found, however, that for ordinary blasting purposes it was not necessary to use the nitro-glycerine as a liquid, and he called the plastic explosive dynamite. I have been told that it is essential to use liquid nitro-glycerine in opening oil wells, but I do not know if this practice is universal. If it is absolutely necessary to do so, I think that at any rate the nitro-glycerine should not be transported as a liquid but as dynamite. In Great Britain dynamite No. 1 is defined as a mixture of not more than 75 parts of nitro-glycerine absorbed in kieselgur.

A factory license could then be granted to allow of the nitro-glycerine being displaced in the immediate neighbourhood of where it was intended to be used; the operation to be effected in a definite building and to be under proper control and supervision.

## Testing Station and Chemical Laboratory.

I attach to this paper a rough specification of the testing gallery which is being erected in England. The sketch drawings mentioned in the specification have been omitted, as there was not time to have copies made before I left England.

The ballistic pendulum is shown in detail on the plan furnished herewith. I may mention that the bob of the pendulum consists of a 13″ mortar, weighing 5 tons.

I have not yet received plans of the gun which it is proposed to use in England.

It will be necessary to erect an observation chamber at least 15 yards from the gallery. The front wall should be substantial, and fitted with narrow horizontal windows, suitably protected against the possible, but very remote, chance of a disruptive explosion in the gas gallery.

It will also be necessary to provide several sheds, or a shed divided into compartments, to be used as a safety lamp room, oil store, coal store, coal dust disintegration. Two small magazines should also be erected for the storage of explosives awaiting test, and for detonators.

Narrow gauge rails will have to be laid for use in connexion with the gas gallery and pendulum. It would be convenient if the rails were so arranged that the guns in use could be shifted from the gallery to the pendulum, or vice versa, as required.

At the station in England it is proposed to install a gallery for testing safety lamps, but the details have not yet been settled. The general idea is that the explosive atmosphere will be prepared in the explosives testing gallery, and that a branch gallery of small sectional area will lead from the big gallery through the lamp testing chamber back of the gallery.

The estimated cost in England of the above is £3,000, but I would suggest that a second gun be obtained (cost about £600). These guns are manufactured in the Royal Arsenal, Woolwich.

As far as the chemical laboratory is concerned, the only special feature to be attended to is the provision of a separate compartment, or a small detached building with a north light, in which stability tests will be carried out. It is essential that the atmosphere in which these tests are carried out should not be contaminated with acid fumes.

A very small detached shed of a few cubic feet capacity should be erected to store samples of explosive submitted for chemical examination. It is not advisable to store these samples in the testing gallery magazine, as they will doubtless often be of low chemical stability.

I attach a rough sketch of the disposition of the new apparatus in England

(Signed) **A. Desborough**, Capt

SESSIONAL PAPER No 26a

3rd Session, 11th Parliament, 1 George V, 1910-11.

THE HOUSE OF COMMONS OF CANADA.

# BILL 79.

## An Act to regulate the manufacture, testing, storage, and importation of Explosives.

HIS Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

SHORT TITLE.

**1.** This Act may be cited as *The Explosives Act*. Short title.

INTERPRETATION.

**2.** In this Act, unless the context otherwise requires,— Definitions.

(*a*) "Department" means the Department of Mines; "Department."

(*b*) "Minister" means the Minister of Mines; "Minister."

(*c*) "authorized explosive" means any explosive the manufacture of which has been authorized under this Act; "Authorized explosive."

(*d*) "explosive" means and includes gunpowder, blasting powder, nitro-glycerine, gun cotton, dynamite, blasting gelatine, gelignite, fulminates of mercury or of silver, fog and other signals, fireworks, fuses, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, and every other substance, whether chemical compound or mechanical mixture, which has physical properties similar to those of the substances above mentioned, and every adaptation or preparation of everything above named; "Explosive."

(*e*) "factory" means and includes any building, structure, or premises in which the manufacture or any part of the process of manufacture of an explosive is carried on, and any building or place where any ingredient of an explosive is stored during the process of manufacture; "Factory."

(*f*) "inspector" means and includes the chief inspector of explosives, an inspector of explosives, a deputy inspector of explosives, and any other person who is directed by the Minister to inspect an explosive or explosive factory or magazine, or to hold an inquiry in connexion with any accident caused by an explosive; "Inspector."

"Magazine." (g) "magazine" means and includes any building, storehouse, structure, or place in which any explosive is kept or stored; other than at or in and for the use of a mine or quarry in a Province in which provision is made by the law of such Province for the efficient inspection of mines and quarries;

"Occupier." (h) "occupier" means any person who operates a factory for manufacturing explosives, or is the manager of or in charge of such factory, or who is the occupant of or uses a magazine for the storage of explosives;

"Regulations." (i) "regulations" means any regulations made by the Governor in Council under the authority of this Act;

"Safety cartridges." (j) "safety cartridges" means cartridges for guns, rifles, pistols, revolvers, and other small arms, of which the case can be extracted from the small arm after firing, and which are so closed as to prevent any explosion in one cartridge being communicated to other cartridges.

Departments exempted. **3.** This Act does not apply to the Department of Militia and Defence or the Department of Naval Service.

IMPORTATION, MANUFACTURE, AND USE.

Explosives prohibited unless authorized. **4.** Except as herein provided, no person shall have in his possession, or import, store, use, or manufacture, whether wholly or in part, or sell, any explosive unless such explosive has been declared by the Minister to be an authorized explosive.

Small quantities excepted. **5.** Nothing in this Act shall apply to the making of a small quantity of explosive for the purpose of chemical experiment, and not for practical use or sale.

Certain process prohibited. **6.** Except in so far as may be permitted by regulations made under this Act, no person except in licensed, manufacturing factories, shall carry on any of the following processes, namely: of dividing into its component parts, or otherwise breaking up or unmaking, any explosive; of making fit for use any damaged explosive; or of remaking, altering, or repairing any explosives; provided that this section shall not apply to the process of thawing explosives containing nitro-glycerine, if a proper apparatus or thawing-house is used.

LICENSES AND PERMITS.

Licenses. **7.** The Minister may issue licenses for factories and magazines, and no one shall manufacture, either wholly or in part, or store explosives except in licensed factories and magazines.

Permits for importation. **8.** The Minister may issue permits for the importation of authorized explosives, and no one shall import any explosive into Canada without such permit; provided, however, that nothing in this section shall prevent any explosive from being transported through Canada by railway in bond, if such transportation is made in a manner authorized by *The Railway Act* or any regulation or order made thereunder.

Transport in bond.

**9.** The Minister may, on application, and on payment of the prescribed fees, issue a special permit to import, for the purpose of chemical analysis or scientific research, an amount not exceeding two pounds of any explosive specified in such permit. Special permits.

**10.** Application for factory or magazine licenses shall be made in such form and manner as are prescribed by regulation, and the application shall be accompanied by,— Application for license.

(*a*) a plan, drawn to scale, of the proposed factory or magazine, and of the land on which such factory or magazine is situated, and also of the lands adjacent thereto on which buildings are erected, with the uses to which such lands and buildings are now put. Such plan to have the exact distances between the several buildings marked thereon: Plan of factory and premises.

(*b*) a description of the situation, character, and construction of all buildings and works connected with the factory or magazine, and the maximum amount of explosive to be kept in each building: Description.

(*c*) a statement of the maximum number of persons to be employed in each building in the factory or magazine: Statement of employes.

(*d*) any information or evidence which the Minister may require: Required information.

(*e*) in the case of an application for a factory license, a statement of the maximum amount of explosive, and of ingredients thereof wholly or partially mixed, to be allowed at any one time in any building, machine, or process of the manufacture, or within the distance from such buildings or machine which is limited by regulation; Statement of maximum amount and ingredients.

(*f*) a statement of the nature of the processes to be carried on in the factory and in each part thereof, and the place at which each process of the manufacture, and each description of work connected with the factory is to be carried on, and the places in the factory at which explosives and anything liable to spontaneous ignition, or inflammable or otherwise dangerous, are to be kept. Statement of processes and position of explosives.

**11.** No license shall be granted for any factory or magazine hereafter established within the limits of, or within one mile of the limits of, any city, town or incorporated village, or elsewhere except with the approval of the municipal corporation or other local authority having jurisdiction, or the Government of the Province, if in a Province, and in territory where there is no local authority having jurisdiction, and also with the consent of the Minister. Consent of municipality and Minister before license granted.

**12.** The Minister may, on application and on payment of such fees as are prescribed by regulation, issue a permit to manufacture for experimental purposes or for testing and special blasting operations only, and not for sale, any new explosive, upon such conditions and subject to such restrictions as are fixed by the Minister. Permits for experiments, and testing new explosives.

**13.** The owner or occupier of a factory or magazine shall not make any material alteration or addition to a licensed factory or magazine, or rebuild any part thereof, until he has obtained a per- Permit for alteration or addition to factory.

mit from the Minister: and before such permit may be granted he shall submit such plans and other information and evidence as the Minister may require.

Change of owner or occupier.

Notice to Minister.

Penalty.

**14.** A factory or magazine license shall not be affected by any change in the person of the owner or occupier of the factory or magazine; but notice thereof, with the address and calling of the new owner or occupier, shall be sent by the owner to the Minister within three months after such change, and in default thereof, the new owner and occupier shall each be liable to a penalty not exceeding one hundred dollars for every week during which such default continues.

License for factory now in operation.

Proviso.

**15.** In the case of a factory now in operation or a magazine now in existence, no license shall be required until the first day of January, one thousand nine hundred and sixteen; provided, however, that if the owner or occupier of such factory or magazine desires to make any material alteration in or addition to such factory or magazine, or to rebuild the same or any part thereof, he shall comply with the provisions of section 13 of this Act.

Application for continuing certificate.

Particulars.

2. The owner or occupier of any such factory or magazine shall, within three months after the passing of this Act, make application to the Minister for a continuing certificate, stating in such application his name and address and the situation of the factory or magazine, and shall supply such particulars and information respecting the same as the Minister may require; and the applicant shall, thereupon, be granted a continuing certificate in such form as may be prescribed by the Minister, and such factory or magazine shall thereupon be deemed to be duly authorized to manufacture and store explosives.

Powers of Minister in case of special danger.

3. Notwithstanding anything in this section, the Minister may require the owner or occupier of any factory or magazine to stop using, or to use only under and subject to conditions to be specified by him, any building, structure, or premises which, from its situation or from the nature of the processes carried on therein, constitutes, in his opinion, a special danger.

INSPECTORS.

Appointment of inspectors.

**16.** The Governor in Council may appoint a chief inspector of explosives, one or more inspectors of explosives, one or more deputy inspectors of explosives, and a chemist of explosives.

Powers of inspectors.

**17.** An inspector may, at any time, visit and inspect any factory, magazine, and premises where any explosive is being manufactured or stored, or where he has reason to suspect any explosive is being manufactured or stored, and to open and examine any package that he may there find; and the owner and occupier of such factory, magazine, and premises, shall afford such inspector every facility to make such inspection full and complete, and shall supply the inspector with any information that he may require, other than information relating to the cost of manufacturing any explosive.

2. An inspector may require the owner or occupier of any factory or magazine, where any explosive is manufactured or stored, or any person employed in any such place, to give him such samples as he may require of any substance therein, whether in the state of raw material, material in course of manufacture, or manufactured material, which the inspector believes to be an explosive, or to be an ingredient from which an explosive may be manufactured. May require samples.

3. An inspector may, at any time, open or cause to be opened any package or store of material of whatsoever nature, which he believes to contain explosives or ingredients for the manufacture of explosives. May open packages.

INQUIRIES INTO EXPLOSIONS.

**18.** The Minister may direct an inquiry to be made whenever any accidental explosion of an explosive has occurred, or when any accident has been caused by an explosive, and the person authorized by the Minister to conduct such inquiry shall have all the powers and authority of a commissioner appointed under Part I of *The Inquiries Act*. Inquiry into accidents.

2. This section shall not apply, however, where an accident has been caused by an explosion of an explosive occurring in any mine or quarry, or metallurgical work in any Province in which provision is made by the law of such Province for a proper and thorough investigation and inquiry into the cause of such accident. Exemption: where covered by Provincial legislation.

REGULATIONS.

**19.** The Governor in Council may make regulations,— Regulations.

(*a*) for classifying explosives, and for prescribing the composition, quality, and character of explosives; Classify explosives.

(*b*) prescribing the form and duration of licenses, permits, and certificates issued under this Act, the terms and conditions upon which such licenses, permits, and certificates shall be issued, and the fees to be paid therefor; Licenses, Permits, and certificates.

(*c*) for regulating the importation, packing, and handling of explosives, and the transportation of explosives otherwise than by railway; Importation, packing, and transportation.

(*d*) for inquiries into the accidental explosion of explosives, and any accident caused by explosives; Inquiries into accidents.

(*e*) for the taking of samples of explosives required for examination and testing, and for the establishing of testing stations, and of the tests and other examinations to which explosives shall be subjected; Samples. Testing.

(*f*) prescribing the manner in which an explosive shall be tested and examined before it is declared to be an authorized explosive, and for determining to what examinations and tests authorized explosives shall be subject; Authorized explosives.

(*g*) to be observed by inspectors and other officers and employes charged with any duty under this Act, or under any regulations made thereunder; Inspectors and officers.

Factories. (*h*) relating to the construction and management of factories and magazines;

Safety of public and employes. (*i*) for the safety of the public and of the employes at any factory or magazine, or any person engaged in the handling, or packing of explosives, or the transportation of explosives otherwise than by railway;

Location and manufacture. (*j*) governing the establishment, location, and maintenance of factories and magazines, and the manufacture and storage of explosives;

Operation of Act. (*k*) for the more effective carrying out of this Act.

Publication. 2. All regulations made under this Act shall be published in *The Canada Gazette*, and upon being so published they shall have the same force as if they formed part of this Act.

OFFENCES AND PENALTIES.

Obstruction of entry and examination by inspector. **20.** Every person who fails to permit an inspector to enter upon any property, and to inspect, examine, or make inquiries in pursuance of his duties, and every person who fails to comply with any order or direction of such inspector, in pursuance of the requirements of this Act, or any regulation made thereunder, or who, in any manner whatsoever, obstructs such inspector in the execution of his duties under this Act, shall be liable to a penalty not exceeding five hundred dollars and costs. Penalty.

Manufacturers objections to Inspectors ruling referable to Minister for adjudication. 2. Any manufacturer who takes exception to the ruling of an inspector, before such ruling or before the penalty provided for in subsection (1) one of this section is enforced, as the case may be, may have the facts upon which such ruling is based submitted to the Minister for his consideration and decision.

Trespassing upon premises. Penalty. **21.** Every person who enters without permission or lawful authority, or otherwise trespasses upon any factory or magazine, shall, for every offence, be liable to a penalty not exceeding fifty dollars and costs, and may be forthwith removed from such factory or magazine by any constable, or by any person employed at such factory or magazine.

Causing explosion or fire. Penalty. **22.** Every person who commits any act which is likely to cause an explosion or fire in or about any factory or magazine, shall be liable to a penalty not exceeding five hundred dollars and costs.

Possession, sale, manufacture, or importation of unauthorized explosive. **23.** Every person who, by himself or his agent, has in his possession, sells, offers for sale or manufactures or imports any unauthorized explosive within the meaning of this Act shall, for a first offence, be liable to a penalty not exceeding two hundred dollars and costs, or to imprisonment for a term not exceeding three months, or to both penalty and imprisonment, and for each subsequent offence shall be liable to a penalty not exceeding five hundred dollars and costs, and not less than fifty dollars and costs, or to imprisonment for a term not exceeding six months, or to both penalty and imprisonment. Penalty.

**24.** Every person who violates any provision of this Act for which a penalty has not been provided, or any regulation made thereunder, shall, for a first offence, incur a penalty not exceeding two hundred dollars and costs, and for each subsequent offence a penalty not exceeding five hundred dollars and costs. Contravention of Act. Penalty.

**25.** Every penalty and forfeiture may be recovered in a summary manner under the provisions of Part XV of *The Criminal Code.* Recovery of penalties.

COMMENCEMENT OF ACT.

**26.** This Act shall come into force on a day to be fixed by proclamation of the Governor in Council. Commencement of Act.

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# CANADA
# DEPARTMENT OF MINES
## MINES BRANCH

HON. ROBERT ROGERS, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER;
EUGENE HAANEL, PH.D., DIRECTOR.

## REPORTS AND MAPS OF ECONOMIC INTEREST.

PUBLISHED BY THE

## MINES BRANCH.

### REPORTS.

1. Mining Conditions of the Klondike, Yukon. Report on—by Eugene Haanel, Ph.D., 1902.

2. Great Landslide at Frank, Alta. Report on—by R. G. McConnell and R. W. Brock, M.A., 1903. (Out of print.)

3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Dr. Haanel, 1904. (Out of print).

4. Rapport de la Commission nommée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe—by Dr. Haanel. (French Edition), 1905. (Out of print).

5. On the location and examination of magnetic ore deposits by magnetometric measurements—by Dr. Haanel, 1904.

7. Limestones, and the Lime Industry of Manitoba. Preliminary Report on—by J. W. Wells, 1905. (Out of print).

8. Clays and Shales of Manitoba: Their Industrial Value. Preliminary Report on—by J. W. Wells, 1905. (Out of print).

9. Hydraulic Cements (Raw Materials) in Manitoba: Manufacture and Uses of. Preliminary Report on—by J. W. Wells, 1905. (Out of print).

10. Mica: its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (Out of print: see No. 118).

11. Asbestos: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, 1905. (Out of print: see No. 69).

12. Zinc Resources of British Columbia and the Conditions affecting their Exploitation. Report of the Commission appointed to investigate—by W. R. Ingalls, 1905. (Out of print).

16. *Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final Report on—by Dr. Haanel, 1907. (Out of print).

17. Mines of the Silver-Cobalt Ores of the Cobalt district: Their Present and Prospective Output. Report on—by Dr. Haanel, 1907. (Out of print).

18. Graphite: Its Properties, Occurrence, Refining, and Uses—by Fritz Cirkel, 1907. (Out of print).

19. Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nyström, M.E., 1908. (Out of print).

20. Iron Ore Deposits of Nova Scotia. Report on (Part 1)—by Dr. J. E. Woodman.

* A few copies of the Preliminary Report, 1906, are still available.

21. Summary Report of Mines Branch, 1907-8.

22. Iron Ore Deposits of Thunder Bay and Rainy River districts. Report on—by F. Hille, M.E.

23. Iron Ore Deposits, along the Ottawa (Quebec side) and Gatineau rivers. Report on—by Fritz Cirkel. (Out of print).

24. General Report on the Mining and Metallurgical Industries of Canada, 1907-8.

25. The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.

26. The Mineral Production of Canada, 1906. Annual Report on—by John McLeish, B.A.

27. The Mineral Production of Canada, 1908. Preliminary Report on—by John McLeish.

28. Summary Report of Mines Branch, 1908. (Out of print).

29. Chrome Iron Ore Deposits of the Eastern Townships. Monograph on—by Fritz Cirkel. (Supplementary Section: Experiments with Chromite at McGill University—by Dr. J. B. Porter).

30. Investigation of the Peat Bogs and Peat Fuel Industry of Canada, 1908. Bulletin No. 1—by Erik Nyström, and A. Anrep, Jr., Peat Expert.

31. Production of Cement in Canada, 1908. Bulletin on—by John McLeish.

32. Investigation of Electric Shaft Furnace, Sweden. Report on—by Dr. Haanel.

42. Production of Iron and Steel in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish.

43. Production of Chromite in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish.

44. Production of Asbestos in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish.

45. Production of Coal, Coke, and Peat in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish.

46. Production of Natural Gas and Petroleum in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish.

47. Iron Ore Deposits of Vancouver and Texada islands. Report on—by Einar Lindeman.

55. Report on the Bituminous, or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale Industry of Scotland—by Dr. R. W. Ells.

58. The Mineral Production of Canada, 1907 and 1908. Annual Report on—by John McLeish.

59. Chemical Analyses of Special Economic Importance made in the Laboratories of the Department of Mines, 1906-7-8. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the Commercial Methods and Apparatus for the Analysis of Oil-shales—by H. A. Leverin, Ch.E.)

Schedule of Charges for Chemical Analyses and Assays.

62. Mineral Production of Canada, 1909. Preliminary Report on—by John McLeish.

63. Summary Report of Mines Branch, 1909.

67. Iron Ore Deposits of the Bristol Mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman, and Geo. C. Mackenzie, B.Sc.

68. Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Dr. Haanel. (Out of print).

69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel, M.E. (Second Edition, enlarged).

71. Investigation of the Peat Bogs, and Peat Industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem,' 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. Anrep (Second Edition, enlarged). (Out of print).

79. Production of Iron and Steel in Canada during the calendar year 1909. Bulletin on—by John McLeish.

80. Production of Coal and Coke in Canada during the calendar year 1909. Bulletin on—by John McLeish.

82. Magnetic Concentration Experiments. Bulletin No. 5—by Geo. C. Mackenzie.

83. An investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others—
    Vol. I—Coal Washing and Coking Tests.
    Vol. II—Boiler and Gas Producer Tests.

84. Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen islands. Report on—by W. F. Jennison, M.E. (Out of print).

85. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials during the calendar year, 1909. Bulletin on—by John McLeish.

88. The Mineral Production of Canada, 1909. Annual Report on—by John McLeish.

89. Reprint of Presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Dr. Haanel.

90. Proceedings of Conference on Explosives.

92. Investigation of the Explosives Industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Second Edition).

93. Molybdenum Ores of Canada. Report on—by Dr. T. L. Walker.

102. Mineral Production of Canada, 1910. Preliminary Report on—by John McLeish.

103. Summary Report of Mines Branch, 1910. (Out of print).

104. Catalogue of Publications of Mines Branch, from 1902 to 1911; containing Tables of Contents and List of Maps, etc.

110. Western Portion of Torbrook Iron Ore Deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Fréchette, M.Sc.

111. Diamond Drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph.D.

114. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, 1910. Bulletin on—by John McLeish.

115. Production of Iron and Steel in Canada during the calendar year 1910. Bulletin on—by John McLeish.

116. Production of Coal and Coke in Canada during the calendar year 1910. Bulletin on—by John McLeish.

117. General Summary of the Mineral Production in Canada during the calendar year 1910. Bulletin on—by John McLeish.

118. Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid, M.E.

142. Summary Report of Mines Branch, 1911.

143. The Mineral Production of Canada, 1910. Annual Report on—by John McLeish.

150. The Mineral Production of Canada, 1911. Preliminary Report on—by John McLeish.

NOTE.—"*Lists of manufacturers of clay products, stone quarry operators, and operators of limekilns, are prepared annually by the Division of Mineral Resources and Statistics, and copies may be had on application.*"

IN THE PRESS.

81. French Translation: Chrysotile-Asbestos, Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel.

83. An Investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, R. J. Durley, and others—

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Producer Tests and Diagrams, by R. J. Durley.

Vol. VI—

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Coking Tests, by Edgar Stansfield and J. B. Porter.

Appendix V
Chemical Tests, by Edgar Stansfield.

100. The Building and Ornamental Stones of Canada. Report on—by Professor W. A. Parks.

145. Magnetic Iron Sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie.

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156. French Translation: The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.

167. Pyrites in Canada: Its Occurrence, Exploitation, Dressing, and Uses. Report on—by A. W. G. Wilson.

170. The Nickel Industry: with Special Reference to the Sudbury region, Ont. Report on—by Prof. A. P. Coleman, Ph.D.

180. Investigation of the Peat Bogs and Peat Industry of Canada, 1910-1911. Bulletin No. 8—by A. Anrep, Jr.

181. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada during the calendar year 1911. Bulletin on—by John McLeish.

182. Production of Iron and Steel in Canada during the calendar year 1911. Bulletin on—by John McLeish.

183. General Summary of the Mineral Production in Canada during the calendar year 1911. Bulletin on—by John McLeish.

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6. Magnetometric Survey, Vertical Intensity: Calabogie mine, Bagot township, Renfrew county, Ontario—by E. Nyström, 1904.

13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905.

14. Magnetometric Survey of the Wilbur mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905.

15. Magnetometric Survey, Vertical Intensity: Iron Ore Deposits at Austin brook, Bathurst township, Gloucester county, N.B.—by E. Lindeman, 1906.

33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909.

34. Magnetometric Survey, Vertical Intensity: Lots 2 and 3, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909.

35. Magnetometric Survey, Vertical Intensity: Lots 10, 11, and 12, Concession IX, and Lots 11 and 12, Concession VIII, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909.

36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nyström, and A. Anrep.

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