PUBLIC DOCUMENTS

OF THE

STATE OF MAINE

BEING THE

REPORTS

OF THE VARIOUS

PUBLIC OFFICERS, DEPARTMENTS AND INSTITUTIONS

FOR THE YEAR 1915

VOLUME 4

FIRST ANNUAL REPORT

OF THE

Public Utilities Commission,

State of Maine

FOR THE

YEAR ENDING OCTOBER 31,

1915

VOL. II.

RELATING TO TOPOGRAPHY, GEOLOGY AND WATER RESOURCES

WATERVILLE
SENTINEL PUBLISHING COMPANY
1916

PUBLIC UTILITIES COMMISSION OF THE STATE OF MAINE.

THE COMMISSION

Benjamin F. Cleaves, *Chairman*
William B. Skelton, *Commissioner*
Charles W. Mullen, *Commissioner*

George F. Giddings, *Clerk*
Roy F. Leach, *Assistant Clerk*

ENGINEERING DEPARTMENT

Paul L. Bean, *Chief Engineer*
George C. Danforth, *Assistant Engineer*
Walters G. Hill, *Hydrographer*

ACCOUNTING DEPARTMENT

Ralph A. Parker, *Chief Accountant*
Elmer E. Parkman, *Chief of Rates and Schedules*
George A. Colburn, *Auditor*

INSPECTIONS DEPARTMENT

William M. Brown, *Chief Inspector*
Irving O. Stone, *Assistant to Chief Inspector*

CONTENTS.

GENERAL STATEMENT.

The Legislature of 1899 passed a law creating what is known as the State Survey Commission. In 1909 the Legislature passed a law creating another commission known as the State Water Storage Commission. The Legislature of 1911 consolidated or combined these two Commissions, and the Legislature of 1913, by section 71 of the Act Creating the Public Utilities Commission, repealed the Law creating the State Water Storage Commission, and gave the Public Utilities Commission "All powers vested in said Board (Water Storage Commission) together with the duties and privileges now conferred upon said Board by law."

Thus the Public Utilities Commission, when it came into existence by Act of the Legislature, was given charge of all the survey work of the State that had been carried on in former years under the different State Commissions.

We have had in mind from the first the great importance of this work to the citizens of the State, and immediately after we met for organization, took all the steps necessary to insure the continuation of the work of carrying on and extending the stream and river measurements of the flow of water, as well as the topographical survey.

Satisfactory arrangements were made with the United States Geological Survey to continue the different investigations and work in connection with the Commission.

The importance of the work that we are undertaking is fully realized by the Members of the Commission, and by its Engineering Staff and Assistants.

Every supply of water in the State used for domestic purposes must necessarily depend for its purity, upon the condition of the streams and rivers above the point from which it is taken.

It is just possible that persons taking under consideration the development of any particular section or any particular Water Power, have considered only one phase of the situation. They have given perhaps their full attention to the development of the power, neglecting to realize that it is of great importance that they have before them all the information possible, in relation to the whole plan of development, considering not only the amount of the power to be used and what it may be used for, but particularly the health and comfort of the community who are to use it.

Whenever such developments are to be made, the engineer should give special attention to the question of pollution of the stream or river by the factories that are proposed to be built, as well as from the domestic sewerage.

During the last year the Commission has had submitted to it, for its consideration, samples of water from many of our rivers and streams, and upon analysis these samples were found almost invariably to be so bad that the water was not fit for domestic use.

In this connection it is timely and right to say that the State Health Officers should have authority to enforce obedience to their demands and suggestions for cleanliness in every locality of the State.

The people of Maine are well aware of the importance and value of the water powers of the State, regardless of whether they are owned by private individuals or otherwise.

We have water power enough in the State, capable of economic development, to carry on large industries, in a manner to enable us to compete successfully with other States.

True, our Geographical position removes us much farther from the great markets, than some of our sister states and the only way to overcome this, it seems to us, is by cheap transportation, and the facilities offered by our Water Powers, for this cheap transportation, both for raw material coming into and across our State, to the different points, where it may be manufactured, and for the manufactured goods that are taken to the markets, should finally solve this problem satisfactorily.

We doubt, if any student, who has taken the trouble to study the question carefully and intelligently, could give a good reason for using one pound of coal for motive power within the whole State, and is it not possible, and is it not probable, that an electric line may be operated at no very distant day, the entire length of our State with many electrified branches, for the purpose solely of giving this cheap transportation in favor of our industries?

This does not necessarily mean that new trunk lines of railroad should be constructed, or that any road now existing should be injured in any way.

This cheap transportation would take care of our goods within our State only, but there could be no possible objection, while we have the electricity to spare, to electrify a line from our State border to one or more of the great markets of the East, in order to give our own manufactured goods, and our own raw material the benefit of this cheap transportation entirely to and from markets where the goods may be bought or sold.

The electric current, however, that would be used outside of the State border, should be used for transportation, and transportation only, and should, as stated above, only be installed with the idea of getting cheaper transportation for our own products, and this method of permitting electricity to go out of the State is partially cared for in Chapter 244 of the Laws of 1911.

The Commission has undertaken in every possible way to secure data in relation to this development project, and hopes in its next annual report, to be able to present to the people of the State, a much more comprehensive report than we are now making.

As the topographical work of the State progresses, the data for the intelligent consideration of water power development is getting more and more available, and this Commission proposes to extend this topographical work as fast as it is made, over the great northern forests of the State, where the water supply of our great rivers must be conserved and stored.

A great deal had been accomplished in late years, upon all three of our great rivers in storage of flood water, and further work is now being done to create additional storage by the erection of the Ripogenus dam on the West Branch of the Penobscot.

The reservoir created by this dam will practically take care of all the precipitation in the drainage area of the West Branch above it, as the erection of the Aziscohos dam on the Androscoggin has done for the upper end of that river.

It is the intention of the Commission during the next season, to investigate so far as it is able the question of the distribution of light and power in the small villages and sparsely settled communities of the State.

Regardless of the wealth of our manufacturing industries, and of our mines and our forests and fisheries, still the great wealth of our State has, and must continue, to be obtained from agriculture, and with the abundance of water powers that we have either in use or idle, it seems that some arrangement should be made for supplying these communities with light for their houses, and small power for their farm machinery and dairies, if it can be possibly accomplished, and the Commission feels that no more worthy study than this can be taken up by the Legislature and the servants of the State.

Cheap electric lighting in the farm houses of the State would do more for the comfort, convenience and happiness of the people on the farms, than many times the same amount of money would accomplish if expended in almost any other direction.

We call public attention to the above at this time, because we believe that the farming community in the State is certainly not of less importance than other communities of the State, and often it is much greater.

Section 8, of Chapter 212, of the Laws of 1909, creating the State Water Storage Commission provides, as follows:

"The Commission shall ascertain what townships or parts of townships of land can be purchased by the State and the cost thereof, with all the necessary data for a correct understanding of their value as a forest reserve or for conserving the water powers of the State, or for reforestation, and shall further investigate the question of denuded, burnt over or barren lands in the State, their extent and value with a view to their purchase by the State for reforestation."

It is quite evident that the Legislature in creating the Water Storage Commission, had in mind the necessity on the part of the State of securing, for the purpose of the State and for the purpose of reforestation, by purchase, some of the so-called hard-cut wild lands.

So far as we are informed no action has been taken or investigation made up to this time in relation to the carrying out of the order of the Legislature in this regard.

It will be the effort of this Commission in its next annual report to give to the people whatever knowledge it may be able to obtain in relation to such lands as are referred to, where they are located, their value, adaptability for the purposes to which they are to be put, and the cost of same.

That the State has much wealth in the shape of minerals within its surface is becoming more and more apparent, and while this subect has, in a manner been neglected for the past several years, the Commission hopes to be able in its next annual report, to give to the public something of a valuable and definite nature in relation to our Geological resources.

It is believed by many that the great peat deposits of Maine are sometime to be of great value, and the Commission has already taken up the investigation of this material, but as yet the results of our research are not sufficiently complete for publication.

On the whole, the Commission feels that its first year has not been wasted, but it hopes to make the coming year one of great interest and usefulness to the people of our State, and to that end it asks the cooperation of every citizen with the hope that we, by working together, may get better acquainted, and obtain a greater knowledge of the resources of our great Commonwealth.

REPORT OF CHIEF ENGINEER ON TOPOGRAPHY, GEOLOGY AND WATER RESOURCES.

Public Utilities Commission,
State of Maine,
Hon. B. F. Cleaves, Chairman,
Augusta, Maine.

DEAR SIR:—

I herewith submit for your consideration, a report of the work of the Engineering Department on the topographic and hydrographic work done in this State, also a statement of the work accomplished by the United States Geological Survey in investigating the geological resources of this State.

This report covers the work done under the special appropriations in making the topographic maps of this State during the years 1914 and 1915. It also contains a statement of the work accomplished by the United States Geological Survey in investigating the geological resources of the State in 1913, 1914 and 1915. Monthly estimates of river discharge from October 1, 1912, to September 30, 1915, at the regular gaging stations in this State, arranged on the climatic year basis, are given.

Respectfully submitted,

PAUL L. BEAN,

Chief Engineer.

Legislation.

The State Water Storage Commission was abolished by Chapter 129, Public Laws of 1913, creating the Public Utilities Commission, with the provision that the Public Utilities Commission shall be vested with all the powers, duties, and privileges of the former Commission and shall have custody of and control of all records, maps and papers of the Water Storage Commission.

CHAPTER 129, PUBLIC LAWS OF 1913.

SECTION 71 AND 72.

"Section 71. The office of railroad commissioners and the boards created and known as railroad commissioners and state water storage commission are hereby abolished and the tenure of office of all officers and clerks connected with said boards is hereby terminated. All powers now vested in said boards together with all the duties and privileges now imposed or conferred upon said boards by and under existing laws are hereby imposed and conferred upon the Public Utilities Commission. All proceedings pending before the railroad commissioners or before the state water storage commission at the time this act takes effect shall be transferred to the docket of the Public Utilities Commission and be reheard or decided by it as justice may require. All existing decisions, orders and decrees of the railroad commissioners in force when this act takes effect shall continue until modified or reversed by the Public Utilities Commission. Said commission shall have custody and control of all records, maps and papers pertaining to the offices of the railroad commissioners and the state water storage commission.

"Section 72. All acts and parts of acts inconsistent with the provisions of this are hereby repealed.

Approved March 27, 1913."

PART I.

TOPOGRAPHY

TOPOGRAPHY.

Five Thousand Dollars per year was appropriated for the years 1915 and 1916, to continue the topographic mapping in this State. The law requires that this money be expended in co-operation with the United States Geological Survey.

The Commission, after a conference with the representative of the Director of the United States Geological Survey, became a party to the following agreement for the continuance of this work:

AGREEMENT.

AGREEMENT between the Director of the United States Geological Survey and the Public Utilities Commission of the State of Maine for the continuation of the cooperative topographic survey of Maine, as provided for in a resolve of the State Legislature, Chapter 9, Session of 1915. Signed by the Governor February 25, 1915.

1. The preparation of the map shall be under the supervision of the Director of the United States Geological Survey, who shall determine the methods of survey and map construction.

2. The order in which, in point of priority, different parts of the State shall be surveyed shall be agreed upon in detail by the Public Utilities Commission and the Director of the United States Geological Survey, or their respective representatives.

3. The survey shall be executed in a manner sufficiently elaborate to prepare a map upon a scale of 1 : 62500, exhibiting the hydrography, hypsography and public culture, and all town and county boundary lines, township and section lines, as marked upon the ground at the time of its completion, in form similar to sheets already completed in the State of Maine. The preliminary field maps shall be on such scale as the Director of the United States Geological Survey shall select to secure accuracy in the construction of the final map.

4. The hypsography shall be shown by contour lines, with vertical intervals of 10 or 20 feet, as may hereafter be mutually agreed upon.

5. The heights of important points shall be determined and furnished to the Public Utilities Commission of Maine.

6. The outlines of wooded areas shall be represented upon proofs of the engraved maps and furnished to the Public Utilities Commission of Maine.

7. Under ordinary conditions the salaries of permanent employees doing field work shall be paid by the United States Geological Survey, while the traveling expenses, including actual cost of subsistence or a per diem in lieu of subsistence in camp, and field expenses for the same time, shall be paid by the State. During the office season the salaries shall be divided between the two agreeing parties in such a way as to equalize all expenses, provided that the total cost to the State of Maine for field and office work shall be not less than Five Thousand Dollars, ($5,000), and provided that the United States Geological Survey shall expend an equal amount upon the work before June 30, 1916, the Federal allotment to bear an approximate charge of 12 1-2 per cent for the necessary expenses in connection with the proper execution of the field and office work. All accounts shall be approved by a representative of the United States Geological Survey before payment.

8. During the progress of the work, free access to the field sheets and records of the topographers and draftsmen shall be afforded the Public Utilities Commission of Maine, or its representatives, for examination and criticism; and should the said Commission deem that the work is not being executed in a satisfactory manner, then it may, on formal notice, terminate this agreement.

9. The resulting maps shall fully recognize the cooperation of the State of Maine.

10. When the work is completed, the Public Utilities Commission of Maine shall be furnished by the United States Geological Survey with photographic copies of the manuscript sheets; and when the engraving is completed, and at all times thereafter when desired, it shall be furnished by the said Survey with transfers from copper plates of the maps for use in printing editions of said maps.

MEMORANDUM giving areas proposed for survey under this agreement by the Topographic Branch of the United States Geological Survey in cooperation with the Public Utilities Commission of Maine for the fiscal year ending June 30, 1916:

The completion of the mapping of the Belfast and Passadumkeag fifteen-minute quadrangles, or so much thereof as the funds will permit.

Washington, D. C., June 24, 1915.

GEO. OTIS SMITH,
Director, U. S. Geological Survey.

Augusta, Maine, June 30, 1915.

BENJAMIN F. CLEAVES,
Chairman, Public Utilities Commission.

All field work on the Belfast and Passadumkeag quadrangles has been completed. The office drafting of the Liberty sheet has been completed, and the map submitted for engraving. The Primary level circuit on the Passadumkeag quadrangle has been adjusted and the results typewritten for publication.

The Portland and Casco Bay quadrangles have been resurveyed without cost to the State, and advance sheets issued.

The Machias, Farmington, Calais, Greenville, Forest and Vanceboro quadrangles have been controlled by triangulation preparatory to mapping.

The cost of Topograhic work in this State for the year 1915 has been as follows:

ITEM.	Paid from.	Amount.
Office work and reconnaissance....................	General appropriation	$330 00
Field work on Belfast and Passadumkeag quadrangles	Special appropriation.	$4,999 19
Total....................................	....	$5,329 19

The unit of publication for these maps is an atlas sheet showing a tract (quadrangle) 15′ in extent each way or about 215 square miles, varying with the latitude. The scale is 1 : 62,500 or about one mile to an inch. Contours, or lines of equal elevation, are shown with a 20-foot interval. These sheets are sold by the United States Geological Survey at the rate of ten cents a sheet. When fifty or more are ordered, the rate is $6.00 per hundred. Sheets should be ordered from The Director, United States Geological Survey, Washington, D. C., enclosing money order for the amount due. Stamps will not be accepted. The Public Utilities Commission's office is not a distributing point for these maps.

The following sheets have been issued for the State of Maine:

Augusta
Anson
Bar Harbor
Blue Hill
Bucksport
Bangor
Boothbay
Bath
Bingham
Buckfield
Biddeford
Buxton
Berwick
Bryant Pond
Bethel
Cherryfield
Castine
Casco Bay
Deer Isle
Dover
Eastport
Ellsworth
Freeport
Fryeburg
Gardiner
Gray
Gorham, N. H.
Kennebunk
Kezar Falls
Lewiston
Livermore
Mt. Desert
Matinicus
Monhegan
Norridgewock
Norway
Newfield
North Conway, N. H.
Orland
Orono
Petit Manan
Penobscot Bay
Portland
Poland
Rockland
Swan Island
Small Point
Sebago
Skowhegan
Tenant's Harbor
The Forks
Vinalhaven
Vassalboro
Waldoboro
Wiscasset
Waterville
York

Local Agents for Topographic Maps.

Purchasers may save delay incident to ordering through the mails by buying of the following agents, who carry in stock maps of areas in their vicinity.

Augusta:
J. F. Pierce, Bookseller and Stationer.

Bangor:
E. F. Dillingham, Bookseller and Stationer.

BATH:

Charles A. Harriman, Jeweler and Optician, 106 Front Street.

BELFAST:

M. P. Woodcock & Son, Books and Stationery.

BOOTHBAY HARBOR:

R. G. Hodgdon, Clothier and Furnisher.

BRIDGTON:

H. A. Shorey & Son.

BRUNSWICK:

F. W. Chandler & Son.

CASTINE:

W. A. Ricker, Stationery and Miscellaneous.

GARDINER:

Beane's Corner Drug Store.

LEWISTON:

John G. West, Journal Building.

PORTLAND:

Edw. G. Haggett, Bicycles, Cameras, and Sporting Goods, 9 Casco St. Loring, Short & Harmon, 474 Congress Street. William Senter & Co., Jewelers, Nautical and Optical Goods, 51 Exchange Place.

ROCKLAND:

E. R. Spear & Co., 408 Main Street.

WATERVILLE:

John H. Burleigh, 93 Main Street. Green & Wilson, 132 Main Street.

The cooperative topographic mapping of the State of Maine was begun in 1899. From this time until 1905 annual cooperative allotments of $2,500 each, by the United States Geological Survey and the State of Maine, were made. The work accomplished in this period is shown in table I.

From 1906 to 1915 inclusive, the allotments by the United States Geological Survey and by the State of Maine, are given in table II.

The classification of the expenditures from May, 1905 to June, 1915, on such sheets as the cost data is available, is shown in table III.

The figures given in the tables have been furnished the Commission by the United States Geological Survey.

Maine Cooperation in Topographic Surveys.

Table I.

Annual cooperative allotments of $2,500 each Federal and State 1899 to 1905, expended in the control and topographic mapping of the following quadrangles, as shown by United States Geological Survey reports for that period:

1899-1900	Bucksport
	Orland
1900-1901	Bangor
	Castine
	Orono
1901-1902	Bar Harbor
	Bluehill
	Cherryfield
	Deer Isle
	Mount Desert
	Petit Manan
	Swan Island
	Vinal Haven
1902-1903	Anson
	Cherryfield
1903-1904	Bingham
	Bluehill
	Castine
	Mount Desert
	Swan Island
	Vinal Haven
1904-1905	Belfast
	Matinicus
	Monhegan
	Rockland
	Tennants Harbor
	The Forks

Total allotment by State of Maine = $15,000
Total allotment by Federal Government = $15,000

TABLE II.

STATEMENT OF ALLOTMENTS.

MAINE COOPERATION.

		Federal.	State.	Total.
Fiscal year 1906		$3,200 00	$3,200 00	–
Additional State funds		–	307 50	$6,707 50
Fiscal year 1907		$3,500 00	$3,500 00	–
Additional State funds	$96 69	–	–	–
State funds which lapsed	19 46	–	$77 23	$7,077 23
Fiscal year 1908		$2,500 00	$2,500 00	–
State funds transferred to Water Resources Branch for levels	$421 00	–	–	–
State funds which lapsed	95	–	-$421 95	$4,578 05
Fiscal year 1909		$2,500 00	$2,500 00	$5,000 00
Fiscal year 1910		3,500 00	3,500 00	7,000 00
Fiscal year 1911		4,500 00	4,500 00	–
Withdrawn		-1,184 47	1,184 47	6,631 06
Fiscal year 1912		$4,500 00	$4,500 00	
Additional State funds which were met by Federal funds in 1913	$200 00	–	–	–
State funds which lapsed	-6 35	–	193 65	9,193 65
Fiscal year 1913		$3,850 00	$3,650 00	–
Additional State funds for Great Moose Lake map		–	76 42	$7,576 42
Fiscal year 1914		$4,900 00	$4,900 00	–
State funds which lapsed		–	-1 19	$9,798 81
Fiscal year 1915		$4,000 00	$4,000 00	–
State funds which lapsed		–	-1 70	$7,998 30
Fiscal year 1916		$5,000 00	$5,000 00	$10,000 00
Total allotments from fiscal year 1906 to fiscal year 1916				*$81,561 02

*Expended in the control and topographic mapping of quadrangles, as shown in Table III.

TABLE III.

MAINE COOPERATIVE EXPENDITURES.

TOPOGRAPHIC SURVEYS MAY, 1905–JUNE, 1915.

SHEET.	CONTROL.		Sketching.	Federal.	State.	Total.
	Triangulation.	Levels.				
Eastport	$397 55		$2,290 11	$1,100 00	$1,587 15	$2,687 66
Freeport	158 15		–	58 15	100 00	158 15
Fryeburg	113 25		4,574 85	3,300 68	1,387 42	4,688 10
Kezar Falls	310 31		4,386 20	1,731 64	2,964 87	4,696 51
Lewiston	347 90		3,919 34	2,423 81	1,843 43	4,267 24
Poland	297 49		3,313 21	2,155 90	1,454 80	2,610 70
Portland	96 75		–	20 00	76 75	96 75
Sebago	172 19		–	22 19	150 00	172 10
The Forks	–		4,674 74	3,366 09	1,308 65	4,674 74
Belfast	–	$257 26	2,441 13	829 74	1,868 65	2,698 39
Bethel	$318 84	317 67	4,012 24	2,420 24	2,228 51	4,648 75
Bryant Pond	332 74	79 35	5,244 44	1,797 54	3,858 99	5,656 53
Buckfield	203 90	105 53	4,545 57	3,932 25	922 75	4,855 00
Burnham	257 02	–	–	257 02	–	257 02
Ellsworth	354 34	154 46	5,228 57	3,263 20	2,474 17	5,737 37
Liberty	263 45	657 34	6,948 54	4,908 68	2,960 65	7,869 33
Livermore	215 51	127 87	3,781 94	2,265 71	1,859 61	4,125 32
Skowhegan	14 00	316 07	3,986 09	1,785 38	2,530 78	4,316 16
Waldoboro	266 60	821 51	5,633 85	2,502 65	4,219 31	6,721 96
Rangeley Lakes (Great Moose)	–	–	–	–	76 42	76 42

PORTION OF FISCAL YEAR 1916. JULY 1—AUGUST 31, 1915.

Belfast	–	–	$1,553 61	$318 29	$1,235 32	$1,553 61
Passadumkeag	–	$393 81	2,503 31	659 30	2,237 82	2,897 12
Total expenditures May, 1905, to August, 1915						$76,465 02

Balance according to August, 1915 statement, Federal	$3,569 14	–
State	1,526 86	$5,096 00
Total amount allotted from fiscal year 1906 to fiscal year 1916		$81,561 02

Total expended by State of Maine since 1899	$55,795 49
Total expended by United States Geological Survey	55,765 53
Total expended in mapping State	$111,561 02

Fifty-eight quadrangles lying wholly or partly within the State have been mapped. One hundred and thirty-four still remain unmapped. At the present rate of 1 1-2 quadrangles finished each year, it will take about 90 years to complete the mapping of the State.

River and Lake Surveys.

Special river and lake surveys of many of the more important rivers and lakes in the State have been made. The river maps, generally on a scale of 1 inch to 2000 feet, show the plan of the rivers with five-foot contours along the banks, and the profiles. These maps are of great value in studying both developed water powers and undeveloped water power possibilities. From these maps can be obtained a close estimate of the total horsepower that can be developed at the various unutilized falls and rapids when studied in connection with the stream gaging work.

The special lake maps are on varying scales of one inch to 1,200 feet, 2,000 feet, 3,000 feet and 4,000 feet. Some large scale maps, one inch to 200 feet, of the outlets of a number of the lakes are also shown. These maps in general show the high water line, the low water line, and the five-foot contour lines from 10 to 25 feet above the lake. Soundings are often shown, and occasionally several five-foot sub-contours, representing the shore lines that would result if the lakes should be drawn down 5 or 10 feet as the case may be. These lake maps are of special value in computing the capacity of the various lakes when their use as storage reservoirs is contemplated.

River and Lake Surveys.

The following is a complete list of these maps as issued and as surveyed to date:

River and Lake Surveys.

Kennebec Basin.

1. Kennebec River, Skowhegan to The Forks, Sheet No. 1.
2. Kennebec River, Skowhegan to The Forks, Sheet No. 2.
3. Kennebec River, Skowhegan to The Forks, Sheet No. 3.
4. Kennebec River, Skowhegan to The Forks, Sheet No. 4.
5. Kennebec River, The Forks to Moosehead Lake.
6. Kennebec River, Profile, Augusta to Moosehead Lake.
7. Brassua Lake and plan of outlet.

*8. Wood Pond and plan of outlet.

*9. Attean Pond.

*10. Long Pond; Holeb Pond; Moose River, Moosehead Lake to Brassua Lake.

*11. Flagstaff Lake; West Carry Pond; Spring Lake; Spencer Ponds; Middle Roach Pond; Lower Roach Pond.

---

*Edition exhausted.

PENOBSCOT BASIN.

12. Penobscot River, Bangor to North Twin Lake, Sheet No. 1.
13. Penobscot River, Bangor to North Twin Lake, Sheet No. 2.
14. Penobscot River, Bangor to North Twin Lake, Sheet No. 3.
15. Penobscot River, Bangor to North Twin Lake, Sheet No. 4.
16. Penobsoct River, Bangor to North Twin Lake, Sheet No. 5.
17. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 1.
18. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 2.
19. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 3.
20. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 1.
21. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 2.
22. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 3.
23. Chamberlain, Telos and Webster Lakes and Round Pond.
24. Baskahegan, First and Second Grand and Allagash Lakes.
25. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 1.
26. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 2.
27. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 3.
28. Schoodic, Seboeis, Endless and Mattawamkeag Lakes and Pleasant Pond.
29. West Branch Penobscot River, Chesuncook Lake to Seeboomook, Sheet No. 1.
30. West Branch Penobscot River, Chesuncook Lake to Seeboomook, Sheet No. 2.

ANDROSCOGGIN BASIN.

31. Androscoggin River, Brunswick to Umbagog Lake—profile only, Sheet 1.
32. Androscoggin River, Brunswick to Umbagog Lake—profile only, Sheet 2.
33. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 3.
34. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 4.
35. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 5.
36. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 6.
37. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 7.
38. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 8.

39. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 9.
40. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 10.
41. Umbagog, Lower and Upper Richardson Lakes, Sheet No. 1.
42. Mooselucmaguntic Lake.
43. Mooselucmaguntic and Richardson Lakes, Outlet plans, Sheet No. 3.

Union River Basin.

44. Abraham, Scammons and Molasses Ponds and Webbs Pond Outlet, Sheet 1.
45. Alligator, Rocky and Spectacle Ponds, Sheet 2.
46. Great Pond, Green Lake Outlet and Branch Lake Outlet, Sheet 3.
47. Union River, Ellsworth to Great Pond, Sheet 1.
48. Union River, Ellsworth to Great Pond, Sheet 2.

Kennebec Basin.

49. Dead River, mouth to Chain of Ponds, Sheet No. 1.
50. Dead River, mouth to Chain of Ponds, Sheet No. 2.
51. Dead River, mouth to Chain of Ponds, Sheet No. 3.
52. Dead River, mouth to Chain of Ponds, Sheet No. 4.
53. Dead River, mouth to Chain of Ponds, Sheet No. 5.
54. Dead River, Chain of Ponds and outlet; Jim Pond and outlet, Sheet 6.
55. Dead River, South Branch; Tim Pond and outlet, Sheet 7.
56. Spencer Stream; Little Spencer Stream; King and Bartlett Lake and outlet; Little Bartlett Lake and outlet; Baker Pond and outlet, Sheet 8.
57. Dead River, Long Falls, special map, Sheet 9.
58. Sandy River, mouth to Madrid, Sheet No. 1.
59. Sandy River, mouth to Madrid, Clearwater Pond and outlet, Sheet No. 2.
60. Sandy River, mouth to Madrid, Sheet No. 3.
61. Sandy River, mouth to Madrid, Sheet No. 4.
62. Sandy River, mouth to Madrid, Sheet No. 5.

Piscataquis Basin.

63. Piscataquis River, mouth to Blanchard, Sheet No. 1.
64. Piscataquis River, mouth to Blanchard, and Schoodic Stream, Sheet No. 2.
65. Piscataquis River, mouth to Blanchard, Sheet No. 3.
66. Piscataquis River, mouth to Blanchard, Sheet No. 4.
67. Piscataquis River, mouth to Blanchard, Sheet No. 5.
68. Sebec River, mouth to Sebec Lake, Sheet No. 6.
69. Sebec Lake and outlet, Sheet No. 7.

70. Pleasant River, mouth to Katahdin Iron Works, Sheet No. 8.
71. Pleasant River, mouth to Katahdin Iron Works, Sheet No. 9.
72. Houston Stream, mouth to Big Houston Pond, Sheet No. 10.
73. Big Houston Pond and outlet; Silver Lake and outlet, Sheet No. 11.

Androscoggin Basin.

74. Rangeley Lake, Sheet No. 1.
75. Rangeley Lake outlet.
76. Rangeley River; Kennebago River, Sheet No. 2.
77. Kennebago Lake; Little Kennebago Lake, Sheet No. 3.
78. Rapid River; Pond-in-River.

PART II.

GEOLOGY.

GEOLOGY.

The investigation of the peat deposits of the Livermore quadrangle are not at this time available for publication, but will be included in the next annual report.

Following is a brief summary of the work performed in this State by the United States Geological Survey during the last three years. With the exception of the investigation of peat deposits there has been no cooperation by the State, the cost of the work being paid wholly from Federal allotments.

1913.

Portland and Casco Bay Quadrangles.

Review of geology for a geologic folio by Mr. F. J. Katz, and inspection thereof by Arthur Keith, Geologist in charge. The field work occupied about eight weeks; the office work was continued during the winter months.

Examination of fertilizer quarry and plant at North Rumford for Mineral Resources report.

Bath and Boothbay Quadrangles.

A reconnaissance was made in these quadrangles by Arthur Keith.

Frenchman's Bay Quadrangle.

Prof. C. W. Brown continued the office work on the folio covering this area.

Eastport Quadrangle.

Study and description of the Silurian Faunas in this quadrangle were continued by Prof. H. S. Williams for a special report.

1914.

Portland and Casco Bay Quadrangles.

A review of the geology of these quadrangles was completed by Mr. F. J. Katz and much of it adjusted in the field to the new topographic base. This field work occupied about seven weeks. The final inspection of this work was made by Arthur Keith, Geologist in charge.

1915.

Field work.—Mr. F. J. Katz, associate geologist, spent about seven weeks in June and July, 1915, on revision, completing the detailed areal mapping and geologic studies on the Portland and Casco Bay quadrangles; about ten weeks in August and September, 1915, on detailed examination and mapping the geologic formations in South Berwick, York, Eliot, and Kittery, York County; and about two weeks on general reconnaissance in York and Cumberland Counties, for about half this period accompanying Mr. Arthur Keith, geologist in charge.

Office work.—Geologic studies in Maine during the year required about half of Mr. Katz's time, seven months.

PART III.

WATER RESOURCES.

WATER RESOURCES.

The compiling and computation of the records of stream flow has been carried out by the Assistant Engineer, Mr. George C. Danforth, who has had the services of a field assistant a part of the time. His report appears in the following pages.

Records are obtained at 28 stations located on 21 rivers. Temperature and rainfall records have also been compiled. Studies of evaporation from water areas are being carried on, the results of which are not ready for publication.

All records obtained, and available for publication, are published in the report of this division. Special attention has been given to the determination of winter flow at the various stations, and the value of the records has been materially increased thereby.

The Water Resources Branch of the United States Geological Survey has cooperated in maintaining the gaging stations and in compiling the records. The District Engineer of the Geological Survey has made field inspections of the work in order that the methods employed in collecting the data may conform to those used by the Geological Survey.

The United States Geological Survey has recently changed the basis used in compiling the stream flow records from the calendar year (January 1 to December 31) to the so-called climatic year, extending from October 1, to September 30. It has seemed best to change the records compiled in this office to this latter basis. This decision has necessitated the alteration of the records for 1913 and 1914 for publication in this annual report. Past records of stream flow will be revised on this basis as rapidly as possible.

The gaging stations on the St. George River at Union, and on the St. Croix above Baring, have been discontinued. A new cable station has been installed on the Passadumkeag Stream in the Town of Lowell. Material is on the site for a new cable station at Reeds Rips on the West Branch of the Penobscot River at Medway.

Locations for possible stations on the Saco River in York County are under advisement at this time.

COST OF WORK.

ITEM.	Appropriation.	Amount.
Salaries........	General appropriation for Public Utilities Commission.....	$1,235 00
Expenses.......	Public Utilities Commission...........................	2,460 18
Total......	....	$3,695 18

REPORT OF GEORGE C. DANFORTH, ASSISTANT ENGINEER.

WATER RESOURCES.

This work includes the collection and computation of data in connection with the stream gaging work. For each gaging station is given the following data for the years 1913, 1914 and 1915.

1. Description of Station.
2. Table of monthly discharge and run-off.

Lists of discharge measurements and tables of daily gage heights and discharges are published in the Water Supply Papers of the United States Geological Survey as follows:

1899:	35	1904:	124	1910:	281
1900:	47	1905:	165	1911:	301
1901:	65, 75	1906:	201	1912:	321
1902:	82	1907-8:	241	1913:	351
1903:	97	1909:	261	*1914:	381

In some sections of the State information regarding topographical features is very incomplete and the computed drainage areas are inaccurate. As surveys are extended these computations are checked and corrected.

This is the most important branch of work in connection with the investigation of the water resources of the State and their development for power purposes. In the determination of the value of a stream for storage a continuous record of its discharge should be available in order to determine the maximum and minimum run-off and the dependable run-off from year to year. The methods used in the collection and computation of data are the standardized methods of the U. S. Geological Survey and are uniformly in use throughout the United States and Canada.

---

*In Press.

Cooperation.

Cooperation with the Water Resources Branch of the U. S. Geological Survey having been continued, the collection and computation of river discharge data is being carried on without charge, and the results will be published from time to time in the Water Supply Papers of the U. S. Geological Survey as well as in the annual reports of this Commission. The methods of conducting the field work are at all times subject to the approval of competent engineers of the Geological Survey, and the final computations are checked by their District Engineer, preparatory to publication by the Washington Office. The Geological Survey has also furnished the necessary instruments for carrying on the field work, and forms for use in the computation of results.

Scope of Work.

The investigations of river discharge in the State are not complete nor do they include all the streams that might advantageously be studied. They include, however, as many of the rivers as is practicable with the force available for the work. It is essential that records of stream flow be kept during a period of years sufficient to determine within reasonable limits the range of flow from maximum to minimum. Experience has shown that this period, varying with different streams, should be from five to twenty years. Certain important stations in each basin, the records of which already extend over a long period, should be maintained permanently.

Field Methods of Measuring Stream Flow.

The following description of methods is compiled from various publications of the United States Geological Survey with the necessary changes and additions for its application to conditions in this state.

Base Data.

In making plans for power, irrigation, municipal water supply, and other projects involving the use of water from surface streams it is necessary to have data from which both the total flow of the stream and its distribution from day to day throughout the year can be obtained. The data necessary for obtaining such information are daily gage heights, which give the fluctuations of rise and fall of the stream, and measurements of discharge at various stages, from which a rating curve can be prepared, giving the discharge for any stage. Such a curve is possible from the fact that so long as the conditions at the controlling point in the stream remain the same there will be the same discharge for any given gage height.

The determination of the quantity of water flowing is termed a discharge measurement, and points at which discharge measurements are made, and where daily records of stage are kept for determining the flow, are termed gaging stations.

Gaging stations may be divided into two classes, known as weir stations and velocity-area stations. At weir stations the head of water on the crest of the weir is measured and the discharge computed by means of a suitable formula. The discharge at velocity-area stations is obtained by measuring the velocity of the current and the area of the cross-section, the product of the two giving the discharge.

Weir Measurements.

Unquestionably a weir properly constructed and of a type for which accurate coefficients have been determined is one of the most convenient and reliable means of measuring small quantities of water. In practice, however, weirs rarely conform to the requirements imposed by the experimenter who derived the coefficients. If the crest of the weir is sharp and clean and sufficiently high above the bottom of the leading channel and the end contractions are complete and the velocity of approach is wanting, or negligibly small, and if the head on the crest is measured at a distance of 6 or 8 feet back of the overfall, the Francis formula will give good results. On the other hand, if these essential conditions do not obtain, especially if the velocity of approach is considerable, and the contractions are imperfect, the Francis formula will not give accurate results. This is particularly true if the weir is improperly constructed and there is leakage around and under it, as is so frequently the case in practice.

The weir formulas are applied, with suitable coefficients, to dams and where the flow through the wheels can be computed with reasonable accuracy, this method is used for determining the discharge and is used at a number of the power plants in the State.

VELOCITY-AREA-METHOD.

The velocity-area method of measurement consists of determining the mean or average velocity of the water past a given cross-section area. The area of the cross section at right angles to the direction of flow is determined by soundings which are taken at such distances apart as will develop the contour of the stream bed. The depths are recorded and also their distances from some arbitrarily chosen initial point on one side of the stream.

The method of making the soundings depends on the size and stage of the stream. On small streams, where the depths and velocities are not large, a graduated rod may be used to advantage; on large streams, which must be measured from bridges or cables, a lead weight and sounding line must be used. The weights are of different sizes—6 1-2 or 15 pounds—according to the swiftness of the current, and are torpedo shaped, so as to offer as little resistance as possible to the moving water.

On streams with beds which are permanent or nearly so, a standard cross section is constructed from careful soundings and referred to the zero of the gage, so that the depths for any stage can be found by adding the gage height at that stage to the depths below the zero of the gage. This method is especially useful at high stages, where it is difficult to make accurate soundings.

After the cross-section area of the stream has been measured by soundings and horizontal distances, the velocity is determined at a number of points. These measurements of velocity should be made at frequent intervals across the stream and close enough to take account of any abrupt change in the velocity. For convenience, the velocities are usually observed in the same verticals at which soundings are made. On some streams fairly good measurements of velocities may be made by means of subsurface floats. This method is applicable, however, only to channels of uniform cross-section area over a considerable distance.

The velocity of flow is best determined by the current meter. The new type of penta-recording current meter consists of six cups attached to a vertical shaft which revolves on a conical hardened-steel point. The revolutions are indicated electrically. The rating, or relation between the velocity of 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 these data a rating table is prepared which gives the velocity in feet per second for any number of revolutions in a given time interval. The ratio of revolutions per second to velocity of flow in feet per second is very nearly a constant for all speeds and is approximately 0.45.

Three classes of methods of measuring velocity with current meters are in general use; multiple-point, single-point, and integration.

The two principle multiple-point methods in general use are the vertical velocity-curve and 0.2 and 0.8 depth methods.

In the vertical velocity-curve method a series of velocity determinations are made in each vertical at regular intervals, usually about 10 to 20 per cent of the depth apart. By plotting these velocities as abscissas and their depths as ordinates and drawing a smooth curve among the resulting points, the vertical velocity curve is developed. This curve shows graphically the magnitude and changes in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the area bounded by this velocity curve and its axis by the depth. This method of obtaining the mean velocity in the vertical is probably the best, but on account of the length of time required to make a complete measurement its use is largely limited to the determination of coefficients for purposes of comparison.

In the second multiple-point method the meter is held successively at 0.2 and 0.8 depth, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity curve is a common parabola with horizontal axis, the mean of velocities at 0.22 and 0.79 depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this multiple-point method gives the mean velocity very closely for open-water conditions and that in a completed measurement it seldom varies as much as a 1 per cent from the value given by the vertical velocity-curve method. It is extensively used in the regular practice of the United States Geological Survey.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined or must be assumed.

Extensive experiments by means of vertical velocity curves show that the thread of mean velocity generally occurs between 0.5 and 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and at this point the meter is held in most of the measurements made by the single-point method. A large number of vertical velocity curve measurements, taken on many streams and under varying conditions, show that the average coefficient for reducing the velocity obtained at 0.6 depth to mean velocity is practically unity. The variation of the coefficient from unity in individual cases is, however, greater than in the 0.2 and 0.8 method and the general results are not as satisfactory.

In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the effect of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocity taken at the subsurface to the mean has been found to be in general from about 0.85 to 0.95, depending on the stage, velocity, and channel conditions. The higher the stage the larger the coefficient. This method is especially adapted for flood measurements, or for measurements when the velocity is so great that the meter can not be kept in the correct position for the other methods.

The vertical integration method consists in moving the meter at a slow but uniform speed from the surface to the bottom and back again to the surface, and noting the number of revolutions and the time taken in the operation. This method has the advantage that the velocity at each point of the vertical is measured twice. It is useful as a check on the point methods. In using the Price meter great care should be taken that the vertical movement of the meter is not rapid enough to vitiate the accuracy of the resulting velocity determination.

In practical work on rough streams the meter should be held at 0.6 depth for depths of 2.5 or less. For greater depths the meter should be held at two points in the vertical, 0.2 and 0.8 from the surface.

When the mean velocities in the different verticals have been found, the average of two adjacent means is taken as the mean velocity for that individual section. The area of the section is computed by multiplying the width of the section by the mean depth. The discharge of each section is then the product of the area multiplied by the mean velocity, and the total discharge of the stream results from summing up the discharge of the individual sections. In practice the work is tabulated in such a way as to render the computation very simple.*

Current-meter measurements are not practicable where there are eddies, cross currents, swirls, or passages for the water underneath stones. It is usually possible, however, to improve the channel by removing bowlders and rocks, so that a satisfactory measuring section may be obtained, even on rough, steep streams.

Three kinds of velocity-area gaging stations are in general use in Maine, according to the means provided for making the observations of the depth and velocity. They are wading, bridge, and cable stations.

A wading station is one at which measurements are made only by wading. Such stations are usually on ditches or wide, shallow streams, which do not fluctuate greatly in flow. Frequently, however, measurements are made at low stages by wading, even though other means exist for making measurements at higher stages.

A bridge station is one at which the meter is used from a bridge. In some places highway or other bridges are available from which to make measurements, but often they are not at the right place on the stream. Special bridges are then built.

A cable station is one at which measurements are made from a cable spanning the stream. The cable supports the car from which a man works above the water. Distances are marked off on a small auxiliary cable.

A suitable place for a gaging station having been selected, a staff or chain gage is set, graduated to tenths, half-tenths, or

*For a discussion of methods of computing the discharge see Engineering News, June 25, 1908.

hundredths of feet vertically. The gage is securely fastened to prevent displacement by floods and is so placed that the zero, or reference datum, is below extreme low water. The datum is also referred to a permanent bench mark as an additional precaution. An observer is then engaged to record the heights of water, morning and evening; the mean of the two readings being used as the mean gage height for the day.

Owing to the rapid rise and fall of some of the streams in Maine, two gage-height readings a day will not as a rule give a true mean for the 24 hours. For this reason, and also owing to the fact that some of the gaging stations are necessarily situated at points remote from all habitations and difficult of access, the use of automatic recording-gages has been found to be necessary.

The essential features of the automatic gage consist of a float free to rise and fall with fluctuations of the water surface, a means of transferring this motion of the float to the record, either directly or through a reducing mechanism, the recording device, and the clock. In most gages used on natural streams the float is connected with a counter weight by means of a chain or perforated tape which passes over a sprocket wheel connected with gearing in such a way as to reduce the motion caused by the rise and fall of the water surface to a convenient scale. This vertical motion of the float may be transferred either to the pencil or other recording device or to the cylinder carrying the paper. The time interval is given by the clock, which may move either the paper or the pencil, according to the float connection. For all autographic records the motions controlled by the float and the clock are brought at right angles so that there results a continuous curve where one set of ordinates represents gage heights, and the other the time interval.

The gage may be designed to accommodate any range of stage. Those used by the United States Geological Survey are designed for variations of 5, 10, 20, 30, and 36 feet, but so far those having a 20-foot range have been found to be sufficient for any stage.

Definition of Terms.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated more or less definitely with a certain class of work. These terms may be divided into two groups: (1) Those which represent a rate of flow, as "second-feet," "gallons per minute," "gallons per 24 hours," and "run-off in second-feet per square mile," and (2) those which represent the actual quantity of water, as "run-off in depth in inches," and "million gallons." They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 square foot in cross section at a velocity of 1 foot per second. It is generally adopted as the fundamental unit in the measurement of flowing water and is the "natural" unit, as the foot and the second are the units used in making the physical determinations. Other units may be computed from this by the use of factors given in the table of equivalents.

"Gallons per minute" is generaly used in connection with pumping and city water supply, the United States gallon of 231 cubic inches being the unit of quantity and 1 minute the unit of time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

A unit commonly used in connection with the measurement of water is the "million gallons." This is used with two meanings—(1) to indicate a rate of flow and (2) to express an actual quantity of water. In the former sense "million gallons per 24 hours" is inferred, 1,000,000 gallons being taken as the unit of quantity, and 24 hours as the unit of time. With this meaning the term is generally used in connection with pumping and irrigation. In the latter sense "million gallons" as an absolute quantity is used in the measurement of storage capacities of reservoirs.

Convenient Equivalents.

The following is a list of convenient equivalents for use in hydraulic computations:

Table for converting discharge in second-feet per square mile into run-off in depth in inches over the area.

Discharge (Second-feet per Square Mile).	Run-off (Depth in Inches).				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	0.03719	1.041	1.079	1.116	1.153
2	.07438	2.083	2.157	2.231	2.306
3	.11157	3.124	3.236	3.347	3.459
4	.14876	4.165	4.314	4.463	4.612
5	.18595	5.207	5.393	5.578	5.764
6	.22314	6.248	6.471	6.694	6.917
7	.26033	7.289	7.550	7.810	8.070
8	.29752	8.331	8.628	8.926	9.223
9	.33471	9.372	9.707	10.041	10.376

Note.—For partial month multiply the values for one day by the number of days.

1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,317 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.

1 second-foot for one day equals 86,400 cubic feet.

1,000,000,000 (1 United States billion) cubic feet equals 11,570 second-feet for one day.

1,000,000,000 cubic feet equals 414 second-feet for one 28-day month.

1,000,000,000 cubic feet equals 399 second-feet for one 29-day month.

1,000,000,000 cubic feet equals 386 second-feet for one 30-day month.

1,000,000,000 cubic feet equals 373 second-feet for one 31-day month.

1,000,000 United States gallons per day equals 1.55 second-feet.

100 United States gallons per minute equals 0.223 second-foot.

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 foot equals 0.3048 meter.

1 mile equals 1.60935 kilometers.

1 mile equals 5,280 feet.

1 acre equals 0.4047 hectare.

1 acre equals 43,560 square feet.

1 acre equals 209 feet square, nearly.

1 square mile equals 2.59 square kilometers.

1 cubic foot equals 0.0283 cubic meter.

1 cubic foot of water weighs 62.4 pounds.

1 cubic meter per minute equals 0.5886 second-foot.

1 horsepower equals 550 foot-pounds per second.

1 horsepower equals 76.0 kilogram-meters per second.

1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1 1-3 horsepower equals about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

Office Methods of Computing and Studying Discharge and Run-Off.

At the end of each year the field or base data for current-meter gaging stations, consisting of daily gage heights, discharge measurements, and notes from observers' books are assembled. The measurements are plotted on cross-section paper and rating curves are drawn wherever feasible. The rating tables prepared from these curves are then applied to the tables of daily gage heights to obtain the daily discharge, and from these applications the tables of monthly discharge and run-off are computed.

Rating curves are drawn and studied with special reference to the class of channels which they represent. The discharge measurements for all classes of stations, when plotted with gage heights in feet as ordinates and discharges in second- feet as abscissas, define rating curves which are generally more or less parabolic in form. For many stations curves of area in square feet and mean velocity in feet per second are also constructed to the same scale of ordinates as the discharge curve. These are used mainly to extend the discharge curves beyond the limits of the plotted discharge measurements, to check the form of the discharge curve, and to determine and eliminate erroneous measurements.

For every rating table the following assumptions are made for the period of application of the table: (a) That the discharge is a function of and increases gradually with the stage; (b) that the discharge is the same whenever the stream is at a given stage, and hence such changes in conditions of flow as may have occurred during the period of application are either compensating or negligible, except that the rating is not applicable for periods during which the channel was obstructed; (c) that the increased and decreased discharge due to change of slope on rising and falling stages is either negligible or compensating.

As already stated, the gaging stations may be divided into several classes, as indicated in the following paragraphs:

The stations of class 1 represent the most favorable conditions for an accurate rating and are also the most economical to maintain. The bed of the stream is usually composed of rock and is not subject to the deposit of sediment and loose material. This class includes also many stations located in a pool below which is a permanent rocky riffle that controls the flow like a weir. Provided the control is sufficiently high and close to the gage to prevent cut and fill at the gaging point from materially affecting the slope of the water surface, the gage height will for all practical purposes be a true index of the discharge. Discharge measurements made at such stations usually plot within 2 or 3 per cent of the mean discharge curve, and the rating developed from that curve represents a very high degree of accuracy.

Class 2 comprises mainly stations on rough, mountainous streams with steep slopes. The beds of such streams are, as a rule, comparatively permanent during low and medium stages, and when the flow is sufficiently well defined by an adequate number of discharge measurements before and after each flood the stations of this class give nearly as good results as those of class 1. As it is seldom possible to make measurements covering the time of change at flood stage, the assumption is often made that the curves before and after the flood converged to a common point at the highest gage height recorded during the flood. Hence the only uncertain period occurs during the few days of highest gage heights covering the period of actual change in conditions of flow.

Class 3 includes those stations where the stream bed is of a shifting character, or the controlling section below the gage frequently changes owing to cutting out by the current and the filling in of sand, gravel, and drift. In some cases changes are caused by the growth of vegetation in the stream bed. No absolute rule can be laid down for stations of this class. Each rating curve must be constructed mainly on the basis of the measurements of the current year, the engineer being guided largely by the history of the station and the following general law; if all measurements ever made at a station of this class are plotted on cross-section paper, they will define a mean curve which may be called a standard curve. It has been found in practice that if after a change caused by high stage a relatively constant condition of flow occurs at medium and low stages, all measurements made after the change will plot on a smooth curve which is practically parallel to the standard curve with respect to ordinates or gage heights. This law of the parallelism of rating curves is the fundamental basis of all ratings and estimates at stations with semi-permanent and shifting channels. It is not absolutely correct, but, with few exceptions, answers all the practical requirements of estimates made at low and medium stages after a change at a high stage. This law appears to hold equally true whether the change occurs at the measuring section or at some controlling point below. The change is, of course, fundamentally due to change in the channel caused by cut or fill, or both, at or near the measuring section. For all except small streams the changes in section usually occur at the bottom. The following simple but typical examples illustrate this law:

(a) If 0.5 foot of planking were to be nailed on the bottom of a well-rated wooden flume of rectangular section, there would result, other conditions of flow being equal, new curves of discharge, area, and velocity, each plotting 0.5 foot above the original curves when referred to the original gage. In other words, this condition would be analogous to a uniform fill or cut in a river channel which either reduces or increases all three values of discharge, area, and velocity for any gage height. In practice, however, such ideal conditions rarely exist.

(b) In the case of a cut or fill at the measuring section, there is a marked tendency toward decrease or increase, respectively, of the velocity. In other words, the velocity has a compensating effect, and if the compensation is exact at all stages the discharge at a given stage will be the same under both the new and old conditions.

(c) In the case of uniform change along the crest of a weir or rocky control, the area curve will remain the same as before the change, and it can be shown that here again the change in velocity curve is such that it will produce a new discharge curve essentially parallel to the original discharge curve.

Of course, in actual practice such simple changes of section do not occur. The changes are complicated and lack uniformity, a cut at one place being largely offset by a fill at another, and vice versa. If these changes are very radical and involve large percentages of the total area—as, for examle, on small streams—there may result a wide departure from the law of parallelism of rating curves. In complicated changes of section the corresponding changes in velocity which tend to produce a new parallel discharge curve may interfere with each other materially, causing eddies, backwater, and radical changes in slope. In such extreme conditions, however, the measuring section would more properly fall under class 4 and would require very frequent measurements of discharge. Special stress is laid on the fact that in the lack of other data to the contrary the utilization of this law will yield the most probable results.

Slight changes at low or medium stages of an oscillating character are usually averaged by a mean curve drawn among them parallel to the standard curve, and if the individual measurements do not vary more than 5 per cent from the rating curve the results are considered good for stations of this class.

Class 4 comprises stations on streams that have soft, muddy, or sandy beds. Good results can be obtained from such sections only by frequent discharge measurements, the frequency ranging from a measurement every two or three weeks to a measurement every day, according to the rate of diurnal change in conditions of flow. These measurements are plotted and a mean or standard curve drawn among them. It is assumed that there is a different rating curve for every day of the year and that this rating is parallel to the standard curve. On the day of a measurement the rating curve for that day passes through that measurement. For days between successive measurements it is assumed that the rate of change is uniform, and hence the ratings for the intervening days are equally spaced between the ratings passing through the two measurements. This method must be modified or abandoned altogether under special conditions. Personal judgment and a knowledge of the conditions involved can alone dictate the course to pursue in such cases.

The computations have as a rule been carried to three significant figures. Computation machines and the 20-inch slide rule have been generally used. All computations are carefully checked.

After the computations have been completed they are entered in tables and carefully studied and intercompared to eliminate or account for all gross errors so far as possible. Missing periods are filled in, so far as practicable, by means of comparison with records for adjacent streams. The attempt is made to complete years or periods of discharge, thus eliminating fragmentary and disjointed records.

Explanation of Tables.

Distances and depths are measured in feet, and velocities in feet per second. The flow is thus obtained in cubic feet per second, or more briefly in "second-feet." To convert second-feet into million gallons per 24 hours multiply by 0.646.

In the table of monthly discharge the column headed "Maximum" gives the mean flow, as determined from the rating table, for the day when the mean gage height was highest. As the gage height is the mean for the day, it does not indicate correctly the stage when the water surface was at crest height, and the corresponding discharge was consequently larger than given in the maximum column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow in cubic feet per second during the month.

Accuracy and Reliability of Field Data and Comparative Results.

Practically all discharge measurements made under fair conditions are well within 5 per cent of the true discharge at the time of observation. Inasmuch as the errors of meter measurements are largely compensating, the mean rating curve, when well defined, is much more accurate than the individual measurements. Numerous tests and experiments have been made to test the accuracy of current-meter work. These show that it compares very favorably with the results from standard weirs, and, owing to simplicity of methods, usually gives results that are much more reliable than those from the ordinary weir used under conditions widely different from those under which the weir formula was derived.

The work is, of course, dependent on the reliability of the observers. With relatively few exceptions, the observers perform their work honestly. Care is taken, however, to watch them closely and to inquire into any discrepancies. It is, of course, obvious that one or two gage readings a day do not always give the mean height for that day if the stage is changing rapidly. As an almost invariable rule, however, errors from this source are compensating and virtually negligible in a period of one month, although a single day's reading may, when taken by itself, be considerably in error.

Attention is called to the fact that the monthly discharge in second-feet per square mile and the run-off in depth in inches do not represent the natural flow from the basin because of artificial storage. The yearly discharge and run-off doubtless represent more nearly the natural flow for probably little stored water is held over from year to year.

Winter Flow.

Owing to the difficulty of computing the discharge of rivers during the frozen season which usually extends over a part of two different calendar years, the U. S. Geological Survey has adopted the climatic year extending from October 1 to September 30, inclusive, as the basis for its computations. The data for this State for the year 1915, has been computed on the basis of the climatic year and the computations for 1913 and 1914 have been rearranged to conform with the new method.

The methods of computing winter flow have been revised within the past year. The observed gage heights for all stations subject to ice cover are plotted on cross-section paper. Below this curve are drawn curves of back-water and effective gage height. Where discharge measurements have been made, points on these curves are definitely fixed and intermediate sections are filled in with the aid of the observers notes and curves of precipitation and temperature which are plotted for different sections of the State from data obtained from the U. S. Weather Bureau. The accuracy of the winter figures has been materially increased by the adoption of these methods.

PRECIPITATION.

In the first annual report of the State Water Storage Commission, complete records of rainfall, to include 1910, for weather bureau stations in this State were published. Records for 1911 and 1912 were published in the 2nd and 3rd annual reports of the Water Storage Commission, and the records for 1913, 1914, and 1915 are given in the following tables:

MEAN MONTHLY PRECIPITATION.

1913.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Aziscohos Dam	3.30	1.54	5.66	2.54	3.20	1.73	2.86	2.49	3.02	5.37	2.04	1.83	35.68
Augusta	2.63	2.17	4.83	2.11	3.58	1.17	1.93	3.63	3.81	6.81	1.94	3.97	38.58
Ashland	5.66	1.98	3.68	2.74	....	....	....	....	....	....	....	....	....
Bar Harbor	4.13	3.35	7.85	2.64	3.56	0.10	3.38	1.88	2.15	9.54	1.00	4.70	44.28
Cambridge	3.26	1.28	4.25	2.31	2.75	0.96	....	2.73	2.77	6.08	2.28	2.91	....
Chesuncook	2.48	2.04	4.02	2.39	3.13	2.66	3.68	2.84	1.92	4.56	2.48	2.70	34.90
Cornish	2.84	2.45	6.20	2.83	4.21	0.93	2.12	1.91	3.63	7.67	3.48	3.76	42.03
Danforth	3.93	2.04	4.75	2.13	5.40	0.73	3.80	2.24	3.10	6.89	2.52	2.71	40.24
Eastport	4.01	2.66	6.43	2.23	4.02	0.71	2.68	2.24	1.69	5.70	0.90	3.14	36.41
Eustis	2.68	1.76	4.40	2.26	2.53	1.52	3.10	2.14	1.82	6.57	2.33	2.52	33.63
Fairfield	2.47	2.92	3.29	....	2.53	0.21	1.51	2.50	2.81	5.18	0.65	3.01	....
Farmington	2.54	1.17	5.11	2.30	3.46	0.79	2.90	3.09	6.00	6.59	2.31	3.02	39.28
Gardiner	2.97	2.09	5.32	2.60	3.51	1.10	1.62	3.19	4.85	7.14	1.93	4.17	40.49
Greenville	2.15	1.52	5.29	2.54	3.01	1.82	5.01	2.80	4.30	7.64	2.98	4.10	43.16
Houlton	0.85	1.00	4.30	0.85	1.83	1.21	1.64	1.70	2.10	5.73	1.26	2.70	25.17
Howe Brook	0.76	0.76	....	1.35	1.08	1.27	4.48	1.04	2.00	2.89	1.16	2.75	....
Lewiston	3.67	2.40	5.51	2.28	4.22	1.20	1.53	2.27	4.02	6.26	2.14	4.43	39.93
Livermore Falls	3.00	1.70	5.13	2.67	3.60	1.34	2.12	3.48	5.51	6.52	2.25	3.12	40.44
Madison	3.36	1.69	5.27	2.74	4.29	1.40	3.07	4.81	4.85	8.64	3.20	4.01	47.31
Middle Dam	2.47	1.56	3.41	2.67	3.68	2.31	3.24	2.30	2.64	4.72	2.76	1.95	33.71
Millinocket	3.40	2.65	4.84	1.67	2.87	1.04	3.49	3.24	3.79	6.77	1.62	4.03	39.41
Mirror Lake	....	....	....	....	....	....	....	....	....	....	1.13	4.57	....
North Bridgton	3.23	2.31	4.23	2.31	4.71	1.40	2.03	2.47	4.16	5.69	2.78	2.96	38.28
Orono	2.80	2.06	4.42	3.57	3.15	1.38	5.86	3.15	4.42	7.35	3.39	2.87	44.42
Oquossoc	....	....	4.11	....	....	0.99	....	2.40	1.55	4.40	2.57	1.95	....
Patten	3.40	2.60	3.14	....	3.64	1.64	4.00	4.29	1.65	7.18	0.20	2.14	....
Pemaquid	....	....	....	....	....	....	....	....	....	....	1.37	....	....
Portland	2.47	2.70	5.35	2.02	2.92	0.59	2.27	2.99	3.46	5.72	1.20	4.29	35.98
Presque Isle	2.69	1.28	3.28	1.41	3.53	1.20	5.18	3.01	2.01	3.99	0.71	3.59	31.88
Rumford Falls	2.38	1.48	5.01	2.91	3.68	1.08	2.65	2.46	4.12	6.86	2.69	2.65	37.97
Saco	2.20	1.80	5.20	2.50	3.40	0.60	1.60	3.90	2.40	6.90	1.30	3.00	34.80
Songo	2.41	2.38	4.86	2.58	4.09	0.50	1.21	2.22	4.89	5.62	2.13	3.64	36.53
The Forks	2.39	2.62	4.10	1.04	0.71	2.78	1.37	3.83	1.28	7.98	2.48	4.00	34.58
Upper Dam	3.07	1.78	4.76	2.36	3.28	1.55	2.75	1.90	1.96	4.36	2.22	2.18	32.17
Van Buren	2.83	1.98	2.72	1.42	3.86	2.37	3.53	2.71	2.72	3.14	0.62	3.87	31.77
Winslow	2.62	1.74	3.99	2.62	3.45	0.92	1.65	3.52	3.74	6.96	1.68	3.15	36.04
Woodland	3.70	1.53	6.66	2.36	4.62	1.41	3.26	2.82	4.84	7.85	1.88	1.80	42.73
Errol Dam, N. H.	4.37	1.44	5.18	2.61	2.84	2.11	3.36	2.16	2.54	4.97	2.31	2.06	35.95
Pontocook Dam, N. H.	4.03	1.76	6.60	2.62	3.23	1.95	3.00	2.35	2.77	5.07	2.24	2.50	38.12

Mean Monthly Precipitation.

1914.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Aziscohos Dam	1.85	1.06	2.52	4.12	2.51	3.00	3.94	2.62	2.54	2.29	1.89	1.45	29.79
Augusta	2.25	1.86	4.09	5.39	1.96	3.73	2.80	4.86	0.69	2.04	2.31	2.03	34.01
Ashland	1.71	2.62	2.67	3.14	1.69	4.49	2.33	2.51	2.06	2.80	1.94	1.32	29.58
Bar Harbor	4.00	1.89	4.15	3.15	1.30	....	2.85		0.50	....	3.15	1.95	....
Cambridge	2.69	1.18	2.93	2.98	2.20	2.87	2.04	2.97	1.65	3.08	2.05	1.65	28.29
Chesuncook	2.77	1.44	4.17	3.46	0.68	3.76	1.79	2.93	2.41	2.98	2.73	2.05	31.17
Cornish	2.87	1.94	4.95	5.45	1.57	3.81	4.58	5.98	0.84	1.17	3.27	2.54	39.87
Danforth	3.55	1.66	5.26	4.95	0.70	3.88	2.73	3.19	1.18	2.84	3.14	1.95	35.03
Eastport	4.18	2.26	3.77	3.93	0.80	3.23	1.21	2.54	2.92	2.56	2.78	1.95	32.13
Eustis	1.43	1.61	4.09	4.00	1.61	2.84	2.53	3.02	2.31	3.34	2.25	1.86	30.89
Fairfield	1.54	1.85	3.40	4.64	0.73	1.38	0.93	3.36	0.68	1.62	1.58	1.14	22.85
Farmington	2.18	1.81	5.32	4.90	1.62	2.67	2.68	4.41	1.71	2.28	3.15	2.16	34.89
Gardiner	2.38	2.55	4.09	5.26	1.93	4.23	2.58	3.77	0.67	1.92	2.10	2.24	33.72
Greenville	3.39	1.82	4.15	4.51	1.70	3.34	2.62	2.90	2.68	3.07	2.10	1.50	33.78
Houlton	1.95	0.90	1.20	1.27	1.20	4.05	1.31	1.01	1.35	2.21	1.50	0.80	18.75
Howe Brook	2.78	1.55	1.60	1.20	1.07	1.73	0.69	0.74	0.90	1.00	2.41	0.68	16.35
Lewiston	2.76	1.93	5.04	5.12	2.44	2.92	3.00	4.54	0.53	1.61	2.92	2.50	35.31
Livermore Falls	1.76	1.19	4.63	4.77	2.19	2.86	2.21	4.87	1.50	2.33	2.68	2.00	32.99
Madison	2.72	1.32	5.54	6.42	2.41	3.23	2.38	6.76	1.76	3.77	3.53	2.19	42.03
Middle Dam	1.20	1.41	3.01	3.88	2.45	3.12	3.51	5.08	2.54	1.71	1.63	1.40	30.94
Millinocket	3.71	1.60	4.43	4.18	1.11	3.56	3.79	3.05	2.06	3.16	2.74	2.40	35.79
Mirror Lake	3.38	1.31	3.97	5.00	1.97	2.58	2.04	4.09	0.24	2.17	1.50	3.41	31.66
North Bridgton	2.53	1.47	4.65	5.12	1.52	2.74	2.70	3.70	0.58	1.63	2.99	1.96	31.59
Orono	4.36	2.52	2.72	4.71	1.58	3.92	2.84	3.05	3.03	3.33	1.69	1.20	34.95
Oquossoc	0.95	1.15	3.05	2.20	1.80	2.80	2.85	3.40	1.80	2.80	1.40	1.05	25.25
Patten	2.10	1.50	3.20	1.40	1.00	4.08	....	1.00	1.90	1.98	2.50	1.20	....
Pemaquid	....	....	....	....	....	....	....	....	....	....	....	....	....
Portland	3.19	3.92	4.37	4.42	2.02	2.34	3.10	3.81	0.73	2.05	3.17	2.98	36.10
Presque Isle	2.95	2.70	2.50	4.05	2.74	4.80	2.23	2.35	2.10	2.75	3.50	2.10	34.77
Rumford Falls	1.98	1.42	4.78	4.95	1.75	2.16	3.74	5.02	1.13	1.92	2.64	2.09	33.58
Saco	0.30	....	4.10	5.60	2.30	1.70	3.70	2.50	....	1.40	2.40	2.00	26.00
Songo	2.59	1.99	3.65	6.44	1.30	3.47	2.60	4.71	0.87	2.42	3.64	2.73	36.41
The Forks	....	....	....	....	....	....	....	....	....	....	....	....	....
Upper Dam	1.32	1.70	2.88	4.62	1.87	2.19	3.52	3.59	1.81	2.03	1.80	1.24	28.57
Van Buren	1.93	1.45	1.65	2.64	2.19	5.15	2.63	4.16	4.07	3.43	2.09	1.39	32.78
Winslow	1.44	1.34	4.00	5.14	1.12	2.07	1.07	4.88	0.95	2.49	1.52	1.77	27.79
Woodland	1.52	0.54	2.04	3.65	0.55	4.69	4.02	3.14	1.93	4.30	3.84	1.95	32.17
Errol Dam, N. H.	1.76	2.04	3.20	4.61	2.01	2.57	4.78	4.33	2.41	1.46	2.47	2.26	33.90
Pontocook Dam, N. H.	1.92	1.33	3.07	4.84	1.55	2.70	4.05	4.78	2.57	1.33	2.53	1.90	32.57

MEAN MONTHLY PRECIPITATION.

1915.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Annual.
Ashland	2.80	1.94	1.32	1.98	3.38	0.59	1.84	....	....	....	....	3.10	....
Augusta	2.04	2.31	2.03	3.68	4.07	0.07	1.82	3.44	1.99	10.01	6.14	1.34	38.94
Aziscohos Dam	2.29	1.89	1.45	2.97	2.63	0.20	2.48	1.29	2.10	8.27	4.94	2.53	33.04
Bar Harbor	....	3.15	1.95	....	3.07	....	....	....	....	....	....	....	....
Biddeford	1.4	2.4	2.0	4.3	3.7	0.0	2.3	2.6	1.6	12.0	6.1	0.5	38.9
Cambridge	3.08	2.05	1.65	2.53	4.22	0.03	3.21	3.44	1.33	....	....	....	....
Chesuncook	2.98	2.73	2.05	2.40	3.92	0.55	1.59	4.87	1.90	4.69	4.59	2.44	34.71
Cornish	1.17	3.27	2.54	4.00	5.54	0.21	3.33	1.08	1.36	10.42	4.94	1.64	39.50
Danforth	2.84	3.14	1.95	3.85	3.92	0.54	2.27	3.90	3.11	5.26	2.75	1.07	34.60
Eastport	2.56	2.78	1.95	5.80	2.57	0.57	3.58	3.14	3.45	3.75	2.68	1.21	34.04
Eustis	3.34	2.25	1.86	2.60	2.54	0.11	2.36	1.69	1.66	7.11	3.44	2.43	31.39
Errol Dam, N. H.	1.46	2.47	2.26	3.01	3.22	0.29	2.75	1.59	2.72	9.95	3.52	3.10	36.34
Fairfield	1.62	1.58	1.14	3.26	3.46	0.13	2.42	0.91	0.85	7.78	4.96	1.31	29.42
Farmington	2.28	3.15	2.16	3.51	4.21	0.13	3.12	2.66	2.47	7.54	3.89	2.02	37.14
Gardiner	1.92	2.10	2.24	3.83	4.02	0.12	1.89	2.41	2.06	9.17	3.92	1.21	34.89
Greenville	3.07	2.10	1.50	3.03	4.36	0.24	3.49	2.99	2.00	8.98	6.13	3.74	41.63
Houlton	2.21	1.50	0.80	2.31	1.14	0.35	1.63	4.19	1.32	4.03	2.17	2.37	24.02
Howe Brook	1.00	2.41	0.68	1.84	2.98	0.52	2.07	4.41	2.07	3.86	3.81	3.04	28.69
Lewiston	1.61	2.92	2.50	4.29	4.78	0.17	3.32	1.81	1.89	9.52	4.25	1.13	38.19
Livermore Falls	2.33	2.68	2.00	3.68	4.59	0.12	2.50	1.63	1.54	11.57	6.41	1.69	40.74
Madison	3.77	3.53	2.19	4.21	5.27	0.31	4.78	2.50	2.00	7.98	3.69	2.20	42.43
Middle Dam	1.71	1.63	1.40	1.87	2.47	0.33	1.71	2.55	3.11	7.70	6.14	2.75	33.37
Millinocket	3.16	2.74	2.40	3.76	3.48	0.11	4.41	3.50	2.12	5.48	3.51	3.13	37.80
Mirror Lake	2.17	1.50	3.41	4.70	3.23	0.17	2.06	3.76	2.23	12.19	4.78	1.54	41.74
North Bridgton	1.63	2.99	1.96	3.41	5.21	0.07	2.74	1.62	1.48	11.03	7.05	1.64	40.83
Oquossoc	2.80	1.40	1.05	....	1.15	....	2.20	1.30	2.05	9.40	6.35	2.95	....
Orono	3.33	1.69	1.20	2.49	3.56	0.34	3.30	4.97	2.47	6.67	4.67	1.19	35.88
Patten	1.98	2.50	1.20	2.50	3.60	0.30	2.90	3.90	2.30	6.30	4.20	2.80	34.48
Pontocook	1.33	2.53	1.90	3.19	2.89	0.33	2.73	1.54	2.58	7.50	5.49	3.87	35.88
Portland	2.05	3.17	2.98	6.00	3.69	0.09	3.43	2.05	1.72	10.84	5.87	0.62	42.51
Presque Isle	2.75	3.50	2.10	2.75	4.10	1.40	....	....	....	3.40	3.50	....	....
Rumford	1.92	2.64	2.09	3.82	4.65	0.21	3.48	0.78	2.46	8.38	5.84	1.84	38.11
Schoodic	....	....	....	....	....	0.16	....	....	....	....	....	....	....
Songo	2.42	3.67	2.73	3.51	6.06	0.14	3.25	1.36	1.24	12.93	5.81	1.49	44.61
Upper Dam	2.03	1.80	1.24	1.76	2.33	.14	1.34	2.06	2.83	7.47	4.94	1.93	29.87
Van Buren	3.43	2.09	1.39	1.31	4.22	1.56	1.99	5.14	1.08	4.36	2.99	4.75	34.31
Winslow	2.49	1.52	1.77	2.98	4.35	0.18	2.70	2.95	2.09	9.16	4.35	1.48	36.02
Woodland	4.30	3.54	1.95	4.35	5.98	0.00	4.57	4.22	2.26	4.58	2.91	1.58	40.24

EVAPORATION.

An attempt to study the laws governing evaporation was made by the establishment on June 4, 1915 at the gaging station for the Cobbosseecontee Stream at Gardiner, where the actual evaporation from a tank was measured, meteorological data kept, and the run-off of the stream computed. The records include maximum and minimum air temperatures, water temperatures in the tank and in the stream, precipitation records, and anemometer and psychrometer readings between June 4th and November 17th, 1915. The tank was constructed from U. S. Weather Bureau designs, and a standard weather bureau hook gage was used. Records and conclusions will be published in the next annual report of this Commission.

STREAM FLOW.

On Sept. 30, 1915, records had been obtained for the following stations:

St. John River near Dickey, (1910-1911).
St. John River at Fort Kent, (1905-).
Allagash River near Allagash, (1910-1911).
St. Francis River near St. Francis, (1910-1911).
Fish River at Wallagrass, (1903-1908).
Madawaska River at St. Rose du Degele, (1910-1911).
St. John River near Van Buren, (1908-).
Aroostook River at Fort Fairfield, (1903-1910).
St. Croix River at Woodland, (1902-1911).
St. Croix River near Baileyville, (1910-1912).
St. Croix River near Baring, (1913-1915).
Machias River at Whitneyville, (1903-).
Union River at Amherst, (1909-).
Green Lake Stream at Lakewood, (1909-1913).
Branch Lake Stream near Ellsworth, (1909-1915).
West Branch Penobscot River at Millinocket, (1901-).
Penobscot River at West Enfield, (1902-).
East Branch Penobscot River at Grindstone, (1902-).
Mattawamkeag River at Mattawamkeag, (1902-).
Piscataquis River at Foxcroft, (1902-).
Cold Stream at Enfield, (1904-1906).
Kenduskeag Stream near Bangor, (1908-).
Phillips Lake and outlets, (1904-1908).
St. George River near Union, (1913-1915).
Moose River at Rockwood, (1902-1908; 1910-1912).
Moosehead Lake at Greenville, (1903-1906). Stage only.
Moosehead Lake at East Outlet, (1895-). Stage only.
Kennebec River at The Forks, (1901-).
Kennebec River at Bingham, (1907-1911).
Kennebec River at North Anson, (1901-1907).
Kennebec River at Waterville, (1893-).
Roach River at Roach River, (1901-1908).
Dead River at The Forks, (1901-1907; 1910-).
Carrabasset River at North Anson, (1901-1907).
Sandy River at Farmington, (1910-).
Sandy River at Madison, (1904-1908).
Messalonskee Stream at Waterville, (1903-1905).
Sebasticook River at Pittsfield, (1908-).
Cobbosseecontee Stream at Gardiner, (1890-).

Androscoggin River at Errol, N. H., (1905-).
Androscoggin River at Berlin, N. H., (1913-).
Androscoggin River at Gorham, N. H., (1903) Fragmentary.
Androscoggin River at Shelburn, N. H., (1903-1907; 1910).
Androscoggin River at Rumford Falls, (1892-).
Androscoggin River at Dixfield, (1902-1908).
Little Androscoggin River near So. Paris, (1913-).
Presumpscot River at outlet Sebago Lake, (1887-).
Saco River near Center Conway, N. H., (1903-1911).
Saco River at West Buxton, (1907-).

ST. JOHN RIVER BASIN.

ST. JOHN RIVER AT FORT KENT, MAINE.

LOCATION.—At the suspension footbridge in the town of Fort Kent, a short distance above the mouth of Fish River and about 15 miles below the mouth of St. Francis River.

RECORDS AVAILABLE.—October 13, 1905, to September 30, 1915.

DRAINAGE AREA.—4,880 square miles.

GAGE.—Inclined staff, 22 feet long, in two sections, attached to the new concrete pier nearest the New Brunswick shore of the river. The lower part of the gage is placed in a groove in the side of the pier; the upper part is fastened to the downstream end of the same pier. The gage datum has remained unchanged during the maintenance of the station.

CHANNEL.—Practically permanent; both banks high, rocky, cleared, and not subject to overflow except in extreme freshets.

DISCHARGE MEASUREMENTS.—Made from footbridge.

WINTER FLOW.—Affected by ice. Estimates for 1914-1915 not made.

ARTIFICIAL CONTROL.—A few dams on the upper headwaters are used for log driving; the operation of these dams only slightly affects the flow past the gage. No corrections applied.

ACCURACY.—Relation between gage height and discharge is occasionally affected by backwater caused by logs jamming on the bridge piers and, during the winter, by ice; otherwise the conditions for accurate determination of discharge are fair. A fairly good discharge rating curve has been developed.

MONTHLY DISCHARGE OF ST. JOHN RIVER AT FORT KENT, ME.

[Drainage area, 4880 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-13					
October	25,900	3,140	7,560	1.55	1.79
November	38,000	7,170	14,800	3.03	3.38
December	6,690	4,900	5,520	1.13	1.30
January	....	....	5,100	1.04	1.20
February	....	....	2,900	.59	.61
March	....	....	6,400	1.31	1.51
April	81,900	12,700	31,900	6.54	7.30
May	75,000	8,690	21,400	4.38	5.05
June	22,300	3,140	10,000	2.05	2.29
July	11,300	3,140	6,170	1.26	1.45
August	3,370	1,160	1,900	.39	.45
September	4,760	660	1,590	.32	.36
The year	81,900	660	9,600	1.97	26.69
1913-14					
October	13,500	1,520	4,810	0.98	1.13
November	10,100	3,370	5,660	1.16	1.29
December	6,690	2,510	4,220	.86	.99
January	....	....	1,500	.308	.36
February	....	....	1,350	.276	.29
March	....	....	1,450	.297	.34
April	26,100	1,300	7,780	1.59	1.77
May	73,000	19,500	38,100	7.81	9.00
June	17,800	2,920	8,550	1.75	1.95
July	4,630	1,810	2,420	.496	.57
August	2,420	1,060	1,570	.322	.37
September	7,010	1,660	2,970	.609	.68
The year	73,000	1,060	6,700	1.37	18.74
1914-15					
October	12,300	1,220	5,530	1.13	1.30
November	6,380	2,710	4,910	1.01	1.13
December 1-13	10,100	4,110	6,730	1.38	0.67
January	....	....	....	....	....
February	....	....	....	....	....
March	....	....	....	....	....
April 15-30	41,400	26,400	35,700	7.32	4.36
May	43,100	8,690	23,800	4.88	5.63
June	8,170	3,030	5,010	1.03	1.15
July	8,860	1,330	3,900	.799	.92
August	6,070	900	2,890	.592	.68
September	15,400	840	3,070	.629	.70
The year	43,100	840	....	....	....

St. John River at Van Buren, Maine.

Location.—At new International Bridge at Van Buren, Maine, about 14 miles above Grand Falls, New Brunswick.

Records available.—May 4, 1908, to September 30, 1915.

Drainage area.—8,270 square miles.

Gage.—Painted vertically on second pier from Van Buren side of bridge; zero of gage is 407.69 feet above sea level; daily gage heights for 1910 and 1911 were read on a vertical rod attached to the pier of the sawdust carrier of Hammonds mill, about 700 feet below the International Bridge, but as published they are reduced to the bridge datum. Daily gage heights since 1911 have been read on the gage at the International Bridge and no reduction is necessary.

Discharge measurements.—Made from the International Bridge.

Winter flow.—Affected by ice.

Artificial control.—The little storage above for log driving probably does not affect the discharge.

Accuracy.—Relation between gage heights and discharge is probably not materially affected by the control of the stream for log driving; for the winter months gage heights for the open section at Grand Falls were applied. An excellent open-channel discharge rating curve has been constructed.

Coöperation.—Station established by the International Commission, River St. John, but maintained since May 6, 1912, by the Maine State Water Storage Commission, and this Commission.

MONTHLY DISCHARGE OF ST. JOHN RIVER AT VAN BUREN, ME.

[Drainage area, 8270 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-13					
October	44,000	5,920	11,900	1.44	1.66
November	58,200	15,300	25,500	3.08	3.44
December	24,300	6,700	13,600	1.64	1.89
January	8,790	5,950	6,940	.839	.97
February	7,250	2,520	3,740	.452	.47
March	31,900	2,080	9,810	1.19	1.37
April	123,000	21,900	45,500	5.50	6.14
May	102,000	20,400	38,700	4.68	5.40
June	36,900	8,110	19,300	2.33	2.60
July	16,000	6,010	9,440	1.14	1.31
August	7,220	2,460	4,060	.491	.57
September	6,670	1,720	2,960	.358	.40
The year	123,000	1,720	15,900	1.92	26.22
1913-14					
October	16,200	2,640	6,840	.827	.95
November	13,000	5,500	8,800	1.06	1.18
December	7,540	3,350	4,800	.580	.67
January	3,500	2,080	2,590	0.313	0.36
February	2,770	2,080	2,310	0.279	0.29
March	2,770	2,080	2,510	0.304	0.35
April	50,000	1,880	11,500	1.39	1.55
May	102,000	38,600	61,100	7.40	8.53
June	35,200	8,850	19,100	2.31	2.58
July	10,200	2,790	5,660	0.684	0.79
August	4,160	2,040	2,660	0.322	0.37
September	12,800	2,530	4,820	0.582	0.65
The year	102,000	1,880	11,100	1.34	18.27
1914-15					
October	14,600	2,040	7,160	0.866	1.00
November	13,000	5,820	9,660	1.17	1.30
December	10,100	3,660	6,320	.764	.88
January	3,820	2,410	3,030	.366	.42
February	8,150	2,190	3,350	.405	.42
March	10,100	5,400	8,390	1.01	1.16
April	83,000	5,400	38,900	4.70	5.24
May	86,500	20,000	47,500	5.74	6.62
June	19,200	7,720	12,300	1.49	1.66
July	13,600	4,170	8,250	.998	1.15
August	7,720	2,530	4,320	.522	.60
September	22,400	1,740	5,220	.631	.70
The year	86,500	1,740	12,900	1.56	21.15

ST. CROIX RIVER BASIN.

REPORT ON THE RELATIONS OF THE ST. CROIX PAPER COMPANY WITH THE STATE OF MAINE.

In an order from the executive council of Maine, dated November 21, 1912, the chief egineer of the State Water Storage Commission was directed to ivestigate the Grand Falls Dam project of the St. Croix Paper Company. A party was put into the field on December 3 for the purpose of determining the following points:

1. The accuracy of the location on the ground by the engineer of the St. Croix Paper Company of the flowage line on Indian Township.
2. The effect of the Grand Falls Dam and the old Princeton Dam on water levels at the village of Princeton.
3. Relative elevations at Princeton and Grand Falls referred to the mean sea-level datum of the United States Geological Survey.

These points having been determined, a deed was drawn in which the State of Maine conveyed to the St. Croix Paper Company the right to flow and to cut timber on certain lands belonging to the State in Indian Township subject to the following conditions, i. e.:

That the dam at Grand Falls be constructed so that the height of water shall not exceed an elevation of 204.31 M. S. L. at a point just below the highway bridge at Princeton;

That the Princeton Dam be reconstructed so that the maximum flood height shall not exceed this high-water limit nor allow the water to drop below an elevation to be later determined and specified;

That the design of these dams be approved by the chief engineer of the State Water Storage Commission or his successor in office on the basis of a possible flood run-off of 28 second-feet per square mile on the drainage area of 1,380 square miles at Grand Falls.

Both Grand Falls and Princeton were connected by levels with mean sea-level datum at Calais, and it was found that the necessary correction to be applied to the levels of the St. Croix Paper Company at Grand Falls (which are based on the Maine Central Railroad datum) is +5.10. The correction to be applied to the St. Croix Paper Company levels at Princeton is +5.56.

Computations were made on the basis of a possible flood run-off of 28 second-feet per square mile, and the following elevations were determined and specified, the datum being mean sea level:

High water at Princeton Bridge	204.31
Low water at Princeton Dam	198.45
High water and top of flashboards at Grand Falls	201.20
Lower crest of Grand Falls Dam	193.70
Higher crest of Grand Falls Dam	198.10

On the application of the Company to the International Joint Commission for approval of the diversion and obstruction of the St. Croix River at Grand Falls, a hearing was held at Calais June 15, 1915. At this hearing further consideration of the case was continued to the Semi-annual Session of the Commission to be held at Ottawa the first Tuesday in October, and provision was made for an engineering examination of the river.

This examination was made on August 3, 4 and 5, 1915, by Major F. A. Pope, Engineer Corps, United States Army, and Mr. William J. Stewart, Hydrographic Office, Canadian Naval Service, accompanied by Mr. G. C. Danforth, Assistant Engineer of this Commission, and engineers representing the St. Croix Paper Company.

Memoranda obtained during this examination, together with the report of Major Pope and Mr. Stewart which was submitted to the International Joint Commission at Ottawa, October 5, 1915, are appended.

General Description of Hydroelectric Development on the St. Croix River, at Grand Falls, Maine, for the St. Croix Paper Company.

The purpose of the development is to increase the natural head and fall at Grand Falls, Maine, of the waters flowing down the St. Croix River and control them so that they can be utilized to operate water wheels and generate electric power; and said electric power can be transmitted by wire to Woodland, Maine, and used in the mill there in the manufacture of paper.

The main dam, approximately eleven hundred feet long, is of the hollow, reinforced concrete type and was designed by the Ambursen Hydraulic Construction Company. It is built on solid rock and is essentially a concrete slab reinforced with steel rods supported on concrete buttresses. It is more stable than a solid masonry dam as practically designed.

The canal is an artificial waterway excavated through a natural gulley. Its purpose is to divert the waters of the St. Croix River without appreciable loss in head to a point on the river bank from which said waters can be conveniently carried to water wheels discharging back into the St. Croix River below the natural falls.

At the lower end of the canal is a solid concrete head-gate wall from which the water is conducted by steel penstocks fourteen feet in diameter to the power house. The openings through the head-gate wall to the penstocks can be closed by gates and are guarded by steel racks or screens against the entrance of sticks or other foreign substances suspended in the water. The racks are sufficiently strong to hold the entire water pressure should it become necessary to close them with planks to repair the gates behind them. Two penstocks are now installed and provision is made for a third when the additional power shall be required.

The power station is a permanent structure with brick walls, concrete roof supported on steel trusses, and concrete foundations resting on the solid rock. In the station are two 4,000-horsepower water-wheel units, each direct connected to an electric generator and other accessory equipment required. There is also space in the building, and all provisions are made for a third water wheel and generator unit. The electric current from the generators passes through step-up transformers and thence by the transmission line to Woodland, Maine. The transformers are housed in a brick building adjacent to the power station and in every way similar to it.

REPORT OF MAJ. POPE AND MR. STEWART.

OTTAWA, CANADA, October 5, 1915.

The honorable the International Joint Commission, the United States and Canada:

GENTLEMEN: In compliance with your instructions, we, the undersigned, have the honor to submit the following report on water powers on the St. Croix River, Maine and New Brunswick.

2. At the hearing held before the International Joint Commission at Calais, Me., on June 15, 1915, we were requested by the commission to secure permission from the heads of the departments of our Governments under which we are serving to investigate the water powers on the St. Croix River, and to submit a report thereon to the commission at its annual meeting at Ottawa, Canada, on October 5, 1915. This permission was secured, and an allotment of $1,000 was made by the two Governments for carrying on the work. One-half of this amount was allotted by the Government of the United States and one-half by the Government of Canada. Having secured permission to act in the matter, we reported the fact to the secretaries of the commission, each to the secretary representing his own government, and received from them written instructions as to the desires of the commission. These instructions are as follows:

Information is desired on the following points:

(1) The amount of power possible of development at each dam site.

(2) The amount of power actually developed at each dam site.

(3) The amount of power still undeveloped at each dam site.

(4) The owners, private individuals or companies (chartered or incorporated), of all developed powers and their nationalities.

(5) The possibilities of uniting any of the schemes with a view to better development, taking, of course, the commercial possibilities into view.

(6) Sites in the river at which power is still undeveloped and extent of such.

(7) Owners of such undeveloped sites.

(8) Any further information that will assist the commission in arriving at a solution of the question involved in the diversion of the water of the St. Croix River.

It is to be understood that the commission does not desire any costly surveys or examinations to be made. Recourse is to be had to all available data and only when these fail are rough surveys to be made. The extent of the power in each case is to be only closely enough determined to enable the commission to arrive at some basis for an order for division.

3. In connection with this report attention is respectfully invited to the last paragraph of the written instructions, in which it is stated that no costly surveys or examinations are to be made, and that the extent of the power in each case is to be only closely enough determined to enable the commission to arrive at some basis for an order for division. Neither the amount of funds allotted for carrying on this work, nor the time allowed for the purpose, was sufficient for making an elaborate or expensive investigation. However, by use of the data available, supplemented by personal investigations, we are prepared to submit a report which should be sufficiently accurate for the purposes of the commission. It should be understood, however, that the figures given in the tables attached to this report and in the report itself are, to a large extent, approximate only, although they give a fair representation of the case and are as accurate as could be obtained without expensive surveys extending over a considerable period of time.

4. This report, as stated in paragraph 3, is largely made from the compilation of information obtained from various sources. This information has, however, been checked up by comparing that received from each source with that received from all other sources and with that secured by our personal investigations. We can, therefore, state that, while some errors undoubtedly appear in this report, none are so large as to lessen its value to the commission. A list of reports, etc., consulted is attached hereto and marked "A."

5. In addition to such individual examinations as the time we could spare would permit, we made a joint examination of the river on August 3, 4, and 5, 1915. During this examination we were accompanied each by an assistant and by representatives of the St. Croix Paper Co., of their consulting engineer, and of the public utilities commission of the State of Maine. The river was examined at this time from Mud Lake to tidewater at Calais, Me. We did not go farther up the river than Mud Lake, as we had sufficient information for our purpose concerning the water power at Forest City, the only one above Mud Lake. A memorandum of this examination is attached hereto and marked "B."

6. In order to assist us in making a study of the water powers, and for the information of the commission, we have prepared a profile of the thread of the stream of the St. Croix River from Lake Chiputneticook (Lake Spednic) to Calais. This profile was prepared from various sources, chiefly from United States Coast and Geodetic Survey. It is as accurate as it could be made from the information at hand, and, as far up the river as Halls Brook, may be considered as giving conditions very closely. Above Halls Brook our data was incomplete, and for this reason this part of the profile was not filled in. A copy of this profile is herewith, marked "C."

7. A gauging station for measuring the flow of the St. Croix River was maintained by the United States Geological Survey, near Woodland, Me., from December, 1902, to December, 1911, when it was abandoned on account of log jams, which interfered so much with the regularity of the flow that the records of the gauge had become of little value. During part of the period when the gauge was in operation the record was interrupted from time to time by various causes, but from 1907 to 1911, inclusive, a continuous record was made. In making this report we have taken the record of flow for these five years as a basis. The rainfall over this region is quite uniform, varying from 44 inches per annum, at Eastport, Me., on the coast south of Calais, to 38 inches per annum in the northern portion of the drainage basin of the river. We have, therefore, assumed for the purpose of this report that the discharge of the river per square mile of drainage basin is the same at all points. This is not strictly accurate, but sufficiently so to serve as a fair basis

in comparing the flow at the different points on the river. A table of the discharge of the river at Woodland from 1907 to 1911, inclusive, is attached hereto and marked "D."

8. From the various sources of information available we have prepared a table of water powers on the St. Croix River, giving powers now developed and possible developments. The names of the proprietors of the dams, or sites for dams, and their nationalities have been secured from the records of the State of Maine and the Province of New Brunswick. The drainage areas have been measured from a map prepared for this purpose by the United States Geological Survey and the Public Utilities Commission of the State of Maine. This map is considered the most accurate map available for this purpose. The discharge at any point has been computed by multiplying the area in square miles of the drainage basin above that point by the discharge per square mile at Woodland. All elevations are taken from the profile and existing surveys, supplemented in a few cases by a reconnaissance made with a hand level. The head developed is, for purposes of comparison, given at the maximum in each case, although this condition would occur only when the dams are full. The power is computed from the discharge and head given in the table, assuming an efficiency of 80 per cent. The possible developments given are based on our best judgment as to the possible combination of existing powers, the heights to which existing dams could be raised, and the heights to which and the locations at which new dams could be built without unreasonable expense in building or unreasonable damage from flowage. An accurate survey might determine that the heights of dams should be increased or diminished somewhat, but not to any great extent. A copy of this table is attached hereto and marked "E."

9. The table referred to in paragraph 8 gives all developed water powers on the river and such other developments as might reasonably be made. Many of these would probably cost too much to develop under present conditions. To make a fairly accurate estimate of cost would require expensive investigations and surveys in each case, and we have not attempted it. It would be still more difficult to determine the commercial value of any development. We have, therefore, given in the table

only such developments as might be made under favorable conditions. There are other possible sites for power on the river, but they are such that the cost would be plainly far in excess of the value, and they have therefore not been included in the table.

10. The Union Dam with its present height is capable of developing a power varying from 2,694 horsepower with mean flow and low tide to 423 horsepower with low-water flow and high tide. Only about 600 horsepower is developed by the wheels, and of this about 250 horsepower is used. Any greater development at this point would be difficult, as the head can not be raised more than a foot on account of expensive flowage, and the tail race would not be dredged out on account of expensive rock excavation. The best plan here would be to abandon this site in favor of a site about one-third of a mile farther down the river. At this latter site, which is just above the International Bridge, the river is only about 300 feet wide, with nearly vertical banks. The banks and bottom of the stream are ledge rock. Any development here would be comparatively cheap. With mean flow and low tide 6,737 horsepower could be developed, and with low-water flow and high tide 508 horsepower could be developed. This would be a valuable water power, and, if used as are Woodland and Grand Falls for a pulp mill, the variation in power would not be a serious disadvantage.

11. The Cotton Mill Dam has all the head possible at this site, and the dam is in good condition. With the existing dam 4,940 horsepower could be developed with mean flow and 1,861 horsepower with low-water flow. At present 2,400 horsepower is developed and 1,500 horsepower is used.

12. The Milltown Lower Dam, the Murchie Dam, and Milltown Upper Dam are all close together. None of them completely cross the river, being either wing dams extending out into the river or connecting an island in the river with the shore. All are in bad condition except the Murchie Dam, which is as tight as could be reasonably expected of an old log dam. The Milltown Upper Dam is in particularly bad condition. It is an old dam, rotten in some places and with a variable head. The best development could be made here by building a dam across the stream a short distance above the upper mills. The

length of such a dam would be about 400 feet. The bottom and sides of the stream are ledge rock. The head of this dam could be raised to an elevation of 71 feet. This would overflow a certain amount of swamp land and about 500 feet of the track of the railroad connecting the Canadian Pacific Railroad with the Maine Central Railroad. This track would have to be raised about 3 feet. It is impossible to state just what power is developed by these dams at present. The Milltown Lower Dam develops 25 horsepower, all of which is used, and the Murchie Dam, 850 horsepower, of which 400 horsepower is used. At all these dams together but 725 horsepower is used. With a dam built as proposed, 6,287 horsepower could be developed with mean flow and 2,369 horsepower with low-water flow.

13. The Baring Dam is old and leaky and with an irregular head. The amount of power developed is not known. Only about 200 horsepower is used. By raising the height of the dam to 84 feet a 12-foot head could be developed, giving 2,547 horsepower with mean flow and 960 horsepower with low-water flow. This is the greatest height to which this dam could be raised without flooding out the railroad bridge and wagon bridge just above it and about 2 miles of railroad track. At Baileys Rips there is no development at present. A dam could be built here with a head of about 10 feet without backing water up to the Woodland Dam. This would give 2,116 horsepower with mean flow and 797 horsepower with low-water flow. A dam would have to be about 450 feet long and would have rock foundation.

The best development would be to build a dam at Baring, flooding out Baileys Rips. Any considerable increase of height in the Baring Dam would, as stated above, result in expensive flowage. By building the new dam above the railroad bridge the two bridges would be saved, and the only expensive damage due to flowage would be to the Maine Central Railroad tracks. It has been estimated that such damage would amount to about $10,000, and would be about the same for a dam combining the water powers at Baring and Baileys Rips as at Baileys Rips alone. This dam could be given a head of 23 feet without backing water up to the Woodland Dam, and would develop 4,882 horsepower with mean flow, and 1,839 horsepower with low water flow. The bottom and sides of the river at this point are partly ledge rock and partly bowlders and gravel.

14. At Woodland 13,200 horsepower has been developed. Mean flow would give but 9,918 horsepower, and low water flow 3,733 horsepower. As this is a pulp mill, it has been built to develop the greatest possible power, the variation of power not being as serious a disadvantage to a pulp mill as to other industries. All the power available is used.

15. At Grand Falls, 8,000 horsepower has been developed, and provision has been made for one additional turbine to give 4,000 horsepower more. At the present time, about 5,000 horsepower is used. Mean flow would give but 9,882 horsepower, and low water flow 3,723 horsepower. This dam is used for furnishing power by electrical transmission to the pulp mill at Woodland, and is designed to give the greatest possible power for the same reasons as the Woodland Dam.

16. At Canoose Rips a dam could be built with a head of 40 feet, giving 3,130 horsepower with mean flow, and 1,176 horsepower with low water flow. There are no signs of ledge in this vicinity, only bowlders and gravel, and it is probable that considerable excavation would have to be made for the foundation of the dam. The dam would be about 400 feet long, with about 800 to 1,100 feet of embankment in addition thereto. It would flood considerable low land, but this land is covered only by scrubby timber.

17. At Steep Bank, a dam could be built with a head of 40 feet, giving 2,995 horsepower with mean flow, and 1,129 horsepower with low water flow. The same remarks as to the foundation apply here as at Canoose Rips. A dam would have to be about 400 feet long with about 300 feet of embankment in addition thereto. Flowage conditions would be about the same as at Canoose Rips.

18. At Little Falls, 8 feet could be developed at a fairly reasonable expense, giving 572 horsepower with mean flow, and 216 horsepower with low water flow. It would be possible to develop as much as 18 feet at this point, but this would require a great deal of embankment. Such development would give 1,287 horsepower with mean flow, and 485 horsepower with low water flow. Flowage would not be expensive. The foundation of the dam would probably be in ledge rock.

19. At the Shaw Tannery Privilege, just below the railroad bridge, at Vanceboro, there was, at one time, a power developed

with 8 feet head. The dam is now in ruins. If this dam were rebuilt and a head of 8 feet developed, it would give 545 horsepower with mean flow, and 205 horsepower with low water flow. The river at this point is narrow, and a dam would not be expensive.

20. At the foot of Lake Chiputneticook, there is a storage dam with about 12 feet head. The dam, as built, would develop 820 horsepower with mean flow, and 309 horsepower with low water flow. The head might be increased by raising the dam, and thereby increasing the storage in the lake. The development would not be expensive.

21. At the foot of Mud Lake, there is a storage dam with about 8 feet head. With full storage in Mud and Chiputneticook Lakes, a head of 37 feet could be obtained at this point. This would give 854 horsepower with mean flow, and 322 horsepower with low water flow. With full storage in Mud Lake and low water in Chiputneticook Lake, a head of 47 feet could be developed, giving 1,084 horsepower with mean flow, and 410 horsepower with low water flow. If the height of the dam at the foot of Lake Chiputneticook were raised, as described in paragraph 20, the head developed by a dam at the foot of Mud Lake would be reduced. All these developments discussed for Mud Lake would be very expensive.

22. At Forest City, there is a dam at the foot of Grand Lake. This dam was built for storage, and has a head of about 8 feet; 10 feet head could be developed here, giving 233 horsepower with mean flow, and 85 horsepower with low water flow.

23. There is no available power site on the river not now developed which would be as valuable as the Grand Falls development, nor is there any one place where a single development, combining a number of existing developments, could be made that would have as great a value. The sum total of the undeveloped powers in the river is slightly in excess of that at Grand Falls, but as their use would require so many dams, some at remote localities, no such economical result can be expected.

Probably the best combination of powers (whether developed or undeveloped) would be those at Milltown and Baring (including Baileys Rips), where the cost of two new modern developments would probably not greatly exceed that at Grand Falls, and they would be well situated for immediate use.

5

The power at Grand Falls could have been developed on the Canadian side; the difference in cost between that on the Maine and that on the New Brunswick side can only be determined by accurate survey and careful study, but it is believed that it would not be excessive. The shore on the Canadian side is about 16 feet above the head race of the present dam and the excavation and foundation would be in rock. There would be greater expense by developing on two sides.

The present dam flooded out a small power at Princeton and also the possibility of creating power by erecting a dam across the outlet of the West Branch.

24. The St. Croix River is navigable for ocean-going vessels up to the wharves at Calais and St. Stephen under favorable conditions of tide. The river is now being improved by dredging from the upper steamboat wharf at Calais to deep water at Hills Point. This improvement is being carried on by the Governments of the United States and Canada, and, based upon the importance of the river and the interests which the two countries have in the commerce thereon, 90 per cent of the cost of improvement is borne by the Government of the United States and 10 per cent by the Government of Canada. Navigation above Calais consists solely in the floating of logs and in occasional canoes and power boats. The floating of logs is amply provided for at the existing dam, sluices having been constructed for this purpose. No complaints have been made concerning the matter of handling logs in these sluices, and the provisions therefor are considered ample.

Very respectfully, your obedient servants,

F. A. POPE,

Major, Corps of Engineers, United States Army.

WM. J. STEWART,

Hydrographer, Dept. Naval Service, Hydrographic Survey, Canada.

A.

List of Reports, etc., Consulted in Preparation of Report on Water Powers, St. Croix River, Maine and New Brunswick.

Report of an exploration survey made by William Anson, civil engineer, for the State of Maine. Submitted February 6, 1837.

The Water Power of Maine, by Walter Wells, superintendent, Hydrographic Survey of Maine. Published in 1869.

Water Supply and Irrigation Papers, United States Geological Survey, Nos. 69, 82, 97, 124, 165, 201, 241, 261, 281, 301, 321.

Annual Reports of the Maine State Water Storage Commission for the years 1910, 1911, 1912, and 1913.

Reports on the St. Croix River in the files of United States engineer office, Portland, Me.

United States Coast and Geodetic Surveys along the St. Croix River from the source to the mouth of the river.

Information as to water powers and drainage areas in the files of the Public Utilities Commission, State of Maine.

Information concerning the Grand Falls and Woodland developments furnished by the St. Croix Paper Co. and George F. Hardy, consulting engineer to the company.

Surveys and other investigations made by C. F. Pray, civil and electrical engineer, Calais Me., and other persons.

Report of hearing before the International Joint Commission, held at Calais, Me., June 15, 1915.

Nineteenth Annual Report of United States Geological Survey, volume 4.

B.

Memorandum of and Examination of St. Croix River, Aug. 3, 4, and 5, 1915.

Members of party.—Maj. F. A. Pope, Corps of Engineers, United States Army; Mr. Lindsay, assistant; Mr. William J. Stewart, hydrographic office, Canadian Naval Service; Mr. Charles McGreevy, assistant; Mr. T. T. Whittier, representing Mr. G. P. Hardy, consulting engineer for the St. Croix Paper Co.; Mr. George C. Danforth, assistant engineer, Public Utilities Commission, State of Maine.

August 3, 1915.—Examined power sites at the outlet of Chiputneticook and Mud Lakes. The present dam at the foot of Mud Lake is about 200 feet long and holds about 8 feet of storage. It has two 10-foot gates and is made of timber. To raise the dam 8 feet would necessitate lengthening it about 600 feet. No ledge rock in sight. Only large bowlders. Development could be near the dam or at the carrying place about one-half a mile south of the dam. A canal at this latter place would cross the divide between the lakes, the crest of which is about 15 feet above Mud Lake and about 50 feet above Lake Chiputneticook. The canal would have to be about 1,800 feet long. The expense appears to be prohibitive. The dam at the foot of Lake Chiputneticook gives 12 feet of storage. It is made of timber and has three gates.

At Forest City there is a small development that could be enlarged slightly if the level of Mud Lake is not raised.

August 4, 1915.—Journal of a canoe trip down the St. Croix River:

TIME.	Locality.	Drop.	Remarks.
A. M.		*Feet.*	
6.33	Left Vanceboro	1½	
6.50	Elbow Rips (first pitch)		Wing dam on island; American shore channel swings to left; low banks.
6.54	Elbow Rips (second pitch)		Main banks 15 feet high; small bowlders. New Brunswick bank low; falls on right of island combine the four drops of Elbow Rips in one.
6.56	Elbow Rips (third pitch; crooked pitch)	2	
6.58	Elbow Rips (fourth pitch). (Picnic Ground Rips)	1½	
7.09-7.12	Mile Rips (first pitch)	4	Main bank 40 feet high; New Brunswick shore very low at first, but higher lower down.
7.15-7.18	Mile Rips (second pitch)	4	
	Porters Meadows		2 miles of dead water; shores low
7.30	Trout Brook		On left.
7.46	Driving Camp		
7.47-7.51	Tunnel Rips (in two pitches)	4	Rips about ½ mile long; river narrow and shores very low.
7.58	Joe Georges Rips	2	Maine shore about 15 feet high; New Brunswick shore low; river turns to right.
8.08	Halls Rips (first pitch)	2	Rips about ¼ mile long; both shores low, lower on New Brunswick side.
8.11	Halls Rips (second pitch)	2	
8.23	Halls Brook		On left.
8.35	Little Falls	8	Old wing dam; Maine bank 15 feet high; ledge; New Brunswick bank 4 feet; ledge; ridge on left bank some distance from river; 8 feet could be developed with long embankment 18 feet.
9.03	Left Little Falls		Carried canoes over.
9.08	Upper Pork Rips	2	Maine shore high; New Brunswick shore lower; ledge.
9.12	Lower Pork Rips	2	
9.14	Wing Dam		On island on left bank; quick water at foot of island.
9.17	Duck pond		
.27	Cedar Island Rips	4	¼ mile long; low shores.

Time.	Locality.	Drop.	Remarks.
A. M.		*Feet.*	
9.32........	....	......	50-foot wing dam on island; quick water at head of island.
.33........	Tylers Rips..................	3	2 drops; two wing dams on right bank.
9.40........	Meadow Brook..............	......	On left.
9.46........	Scott Brook.................	......	On right; outlet of Lambert Lake very little flow.
9.52–9.55...	Albee Rips..................	2	Bank on New Brunswick side; 10 feet on Maine side; rips ¼ mile long.
9.56........	Big Simsquish...............	......	On right.
10.05.......	Rocky Rips..................	......	2 drops full of bowlders; carried over.
10.17.......	Left Rocky Rips.............	......	Wing dam.
10.25.......	Rolf Rolingtier Brook.........	......	On left.
10.30.......	Steep Bank..................	2	Bank 45 feet high on Maine side; low on New Brunswick side; river about 250 feet wide; dam would have to be about 400 feet long with 300-foot embankment in addition; no rock in sight; all gravel.
10.47.......	Left Steep Bank..............	......	
10.51–10.53.	Hog Island Rips..............	2	
11.01.......	Meetinghouse Rips...........	3	High bank on Maine side; lower on New Brunswick side.
	Little Simsquish.............	......	On right.
	Upper Grass Island...........	......	Wing dam on left; Tote road on right bank.
11.03.......	Drivers Camp................	......	Stopped for lunch.
P. M.			
12.34.......	Left Drivers Camp...........	......	
12.46.......	Elm Brook...................	......	On right.
12.53.......	Haycock Rips................	6	¼ mile long; carried over New Brunswick bank high; Maine bank low.
1.04........	Left Haycock Rips............	......	
1.15........	Road to St. Stephen from Loon Bay......................	......	On left bank 18 miles to St. Stephen.
1.45........	Foot of Loon Bay............	......	
1.55........	Canoose Rips................	5	Maine bank 50 to 60 feet high; New Brunswick bank low for about 900 to 1,200 feet back; no rock in sight; all bowlders and gravel carried over.
2.40........	Left Canoose Rips............	......	Canoose Stream on left.
2.50........	Dog Falls...................	4	Maine bank high; carried over.
2.55........	Left Dog Falls..............	......	
3.01........	Horse Island Rips............	1	
3.32........	Gleasons Point (end of canoe trip)......................	......	

August 5, 1915.—Inspected various dams and power sites from Grand Falls down.

Grand Falls.—Two pairs 54-inch wheels. Space provided for one more. Forty-nine-foot head gives 4,000 horsepower each. Dam in good condition and well built. Sluiceway for logs on American side ample.

Woodland.—Four pairs horizontal 42-inch wheels; three pairs horizontal 36-inch wheels; 3,000 horsepower. Grinding wheels give 9,500 horsepower with 47-foot head.

Union Dam.—Two vertical wheels (turbine) rated 12-foot head; 400 horsepower. Never attains this efficiency.

Canadian Cottons (Ltd.).—Three 51-inch vertical wheels; one 48-inch vertical wheel; two 36-inch horizontal wheels (2,400 horsepower on 22-foot head.)

None of the other mills have wooden wheels.

D.

Discharge in cubic feet per second of St. Croix River, Maine and New Brunswick, at United States Geological Survey gauging staion, Woodland, Me.

(Area of watershead, 1,420 square miles.)

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.	Foot-seconds per square mile.
1907........	1,740	971	1,360	3,120	3,690	4,230	3,440	3,300	3,130	2,470	2,530	2,920	2,830	1.993
1908........	2,700	1,800	2,200	3,360	5,230	3,500	1,500	1,800	1,500	1,250	1,000	900	2,230	1.570
1909........	2,330	1,580	2,570	7,440	4,680	2,320	1,960	1,990	4,120	4,390	2,580	2,150	3,180	2.232
1910........	2,310	2,260	2,680	2,670	2,430	2,640	2,280	1,960	1,990	1,900	1,270	1,350	2,140	1.507
1911........	1,400	1,510	1,370	3,030	1,850	1,420	1,470	1,410	1,120	977	1,220	2,020	1,570	1.105
Mean...	2,096	1,624	2,036	3,924	3,776	2,822	2,130	2,092	2,372	2,197	1,720	1,870	2,390	....
Foot-seconds per square mile.......	1.476	1.143	1.433	2.763	2.659	1.987	1.500	1.473	1.670	1.547	1.204	1.317	1.683	....

(These tables are all attached, except the profile,

INTERNATIONAL JOINT COMMISSION

IN THE MATTER OF

THE APPLICATIONS OF THE ST. CROIX WATER POWER COMPANY

AND THE

SPRAGUE'S FALLS MANUFACTURING COMPANY, LIMITED

FOR APPROVAL OF A DAM AND POWER CANAL AND THE OBSTRUCTION, DIVERSION, AND USE OF THE WATERS OF THE ST. CROIX RIVER AT GRAND FALLS IN THE STATE OF MAINE AND THE PROVINCE OF NEW BRUNSWICK

ORDER AND OPINION

Filed January 29, 1915. Decided November 9, 1915

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

INTERNATIONAL JOINT COMMISSION.

UNITED STATES.	CANADA.
OBADIAH GARDNER, *Chairman.*	CHARLES A. MAGRATH, *Chairman.*
JAMES A. TAWNEY.	HENRY A. POWELL, K. C.
R. B. GLENN.	P. B. MIGNAULT, K. C.
WHITEHEAD KLUTTZ, *Secretary.*	LAWRENCE J. BURPEE, *Secretary.*

INTERNATIONAL JOINT COMMISSION.

In Re the Applications of the St. Croix Water Power Co. and the Spragues Falls Manufacturing Co. (Ltd.), for Approval of a Dam and Power Canal and the Obstruction, Diversion, and Use of the Waters of the St. Croix River at Grand Falls in the State of Maine and the Province of New Brunswick.

Order of Approval.

The above applications having come on for hearing at the city of Calais, in the State of Maine, on the 15th day of June, 1915, and having been continued to the 5th, 6th, and 7th days of October, 1915, at the city of Ottawa, Canada, on which last day the hearing was concluded, the said applications relating to the same subject matter being consolidated and heard as one application, and due notice of the filing of said applications and of the time and place of the said hearings having been given to all parties interested in both countries, the commission having heard the evidence adduced by all parties interested, including the statements of the engineer representatives of the United States and the Dominion of Canada in respect thereto, and also having heard counsel on behalf of all parties interested, finds as follows:

(*a*) The St. Croix Water Power Co. is incorporated by special act of the legislature of the State of Maine (ch. 203, Acts of 1899), and the Spragues Falls Manufacturing Co. (Ltd.) is incorporated by statute of the Dominion of Canada (2 Edward VII, ch. 103), both companies being incorporated for substantially the same purpose.

(*b*) Acting upon the supposition that no other authority was necessary than that given them by the aforesaid acts of incorporation, the said companies, acting in unison, proceeded to construct, and did construct, at Grand Falls a dam across the St. Croix River and a power canal on the United States side of the St. Croix River to convey the waters of the river to a power house situate a short distance below the dam, which dam is for the purpose and has the effect of obstructing and holding back the waters of the said river.

(*c*) The dam is of the Ambursen type. It is 820 feet long between the present Canadian shore line and the international boundary and 280 feet long between the present United States shore line and the international boundary, with an abutment on the Canadian shore 40 feet long and an abutment on the United States shore 100 feet long.

(*d*) The crest of the dam for a length of 80 feet on the United States side of the international boundary and for a length of 218 feet on the Canadian side is at an elevation of 193.70 above mean sea level; for a length of 540 feet on the Canadian side it is at an elevation of 198.10 feet above mean sea level; and for a further length of 22 feet on the United States side and 54 feet on the Canadian side it is at an elevation of 205.10 above mean sea level. Flashboards at an elevation of 201.20 above mean sea level cap the whole of the two lower sections of the crest. In the dam on the Canadian side are two submerged sluices 6 feet by 8 feet, with sills at an elevation of 167.60. These are controlled by gates operated by electric power. On the United States side are nine Tainter regulating sluice gates 14 feet wide, with sills at an elevation of 196.10 and a log sluice at the shore end. The dam as now constructed contains no fishway.

(*e*) The power canal leaves the west branch of the St. Croix River a short distance above the dam and near the junction of the east and the west branches of the river. It is 2,700 feet long, 50 feet wide on the bottom at elevation 185.10, and 115 feet wide at elevation 202.10. This canal joins the St. Croix River a short distance below the dam, and at the junction is a power house having therein at present two (with space for a third) 54-inch Holyoke wheels with capacity of 4,000 horsepower each, under a 49-foot head.

(*f*) Provision for a fishway has been made in the dam at the lower end of the power canal. This fishway has been designed to permit the passage of fish up and down stream through the power canal, but the fishway is not yet completed.

The log sluiceway above referred to in the dam across the river is ample for the purpose of driving logs or lumber downstream.

(*g*) The two companies have constructed and are now using the said dam and power canal at Grand Falls for the purpose of generating power supplied to the pulp and paper mill now owned by the St. Croix Paper Co. at Woodland, in the State of Maine, a few miles farther down said stream.

(*h*) The St. Croix River is a boundary water within the meaning of the treaty of January 11, 1909, between Great Britain and the United States of America. The effect of the said dam and power canal as constructed and maintained is to divert the waters of the said St. Croix River on the Canadian side and cause them to flow through the State of Maine, thereby altering the levels on the United States side of the international boundary; also to divert the waters of the said river on the United States side of the said boundary, thereby altering the levels of the waters of the said river on the Canadian side of the said boundary.

(*i*) The applicants are owners of the riparian lands on both sides of the said river which are affected by the change of the levels of the said river.

The companies having applied to the commission for its approval of the said dam and its maintenance and operation and of the obstruction, diversion, and use of said waters, and it appearing to the commission that such approval should be granted;

Therefore, it is hereby ordered that the maintenance and operation of the dam aforesaid and the diversion and use of the waters of said river for the purpose in paragraph (*g*) hereinbefore contained, be, and the same are hereby, approved upon and subject to the following conditions:

1. That the applicants have obtained, or shall hereafter obtain, from the United States and the Dominion of Canada within their respective jurisdictions authority for the maintenance of the said dam as constructed and the obstruction, diversion, and use of the waters of the St. Croix River at Grand Falls, in the State of Maine and the Province of New Brunswick, for the said purpose.

2. In case the waters so diverted cease to be used for the purpose mentioned in paragraph (*g*), this order of approval shall thereupon cease to be operative unless the commission,

upon the application of the United States or the Dominion of Canada, continue it on such terms and conditions as the commission may prescribe.

3. All the sluices, log sluices, flashboards, bypasses, power plant, and storage reservoirs shall be so operated as to prevent the level of the water at the dam rising above 202 (mean sea-level datum). For this purpose the operation of all the said works, canals, headgates, sluices, and log sluices of all kinds, dams, and bypasses shall be under the direct control of the board hereinafter designated.

4. All the sluices, log sluices, power plants, and storage dams shall be so operated as to pass continuously the minimum discharge of the river plus such other quantity as the board of control shall determine is available.

5. To enable the board to determine the quantity of water that should be passed downstream, two gauges for registering the precipitation shall be established by the two Governments at suitable stations in the valley of the said river.

6. An officer to be appointed by the Governor General in council of Canada and one to be appointed by the Secretary of War of the United States shall form a board whose duty it shall be to formulate rules under which the sluice gates, log sluices, power works, and storage dams are to be operated to prevent as nearly as possible a higher level than 202 (mean sea-level datum) and to secure to the users of water below Grand Falls the flow of water to which they are entitled. It shall be the further duty of this board to see that any rules or regulations now or hereafter made by proper authority are duly obeyed.

7. The power company at Grand Falls shall keep continuous records, satisfactory to the board, which will show the quantity of water used by it, and shall furnish to the board, when required, full information from such records.

8. The board will determine at all times the amount of water to be passed to the users of water below, and the owners of the said dam and power canal for the time being shall supply the necessary labor for the operation of the various gates.

9. The cost of maintaining all parts of the dam and all sluices and log sluices shall be borne by the owners thereof, and this work of maintenance shall be done in a manner satisfactory to both Governments.

10. In the event of a disagreement between the members of said board, in respect to anything required of said board herein, or in respect to the duties or powers of said board, or as to the exercise of such duties or powers, the question at issue shall, upon the application of either Government, be referred to this commission for its decision.

Dated at New York, N. Y., November 9, 1915.

O. GARDNER,
C. A. MAGRATH,
JAMES A. TAWNEY,
H. A. POWELL,
R. B. GLENN,
P. B. MIGNAULT.

INTERNATIONAL JOINT COMMISSION.

In the Matter of the Applications of the St. Croix Water Power Co. and the Sprague's Falls Manufacturing Co. (Ltd.), for Approval of a Dam and Power Canal and the Obstruction, Diversion, and Use of the Waters of the St. Croix River at Grand Falls in the State of Maine and the Province of New Brunswick.

Opinion.

These applications are for the approval of a dam already built across the St. Croix River, and the diversion of the waters of the said river through a canal already constructed, beginning at a point on the west bank above Grand Falls, and thence running through a part of the State of Maine to a point on the same side of the river a short distance below Grand Falls. The St. Croix River separates the State of Maine from the Province of New Brunswick and is a boundary water within the meaning of the treaty of January 11, 1909, between Great Britain and the United States of America.

The St. Croix Water Power Co. was incorporated by special act of the Legislature of the State of Maine (ch. 203, Acts of 1899), and the Sprague's Falls Manufacturing Co. (Ltd.) was incorporated by statute of the Dominion of Canada (2 Edward VII, ch. 103). Both companies were authorized by their respective acts of incorporation to dam the waters of the St. Croix, but neither has ever been authorized by either legislature to divert the waters of the river into other channels. The dam has not yet been authorized by the Congress of the United States, which is necessary to legalize it within the United States territory. The companies were advised that if they became riparian owners of the land on both sides of the stream throughout the whole course of the diversion, they would be justified in taking the waters from the bed of the river and using them, provided the waters were returned to the natural bed of the stream before reaching the lands of the lower riparian proprietors.

tion or diversion of the waters with respect to which, under Articles III and IV of this treaty, the approval of this commission is required, and in passing upon such cases the commission shall be governed by the following rules or principles which are adopted by the High Contracting Parties for this purpose:

The High Contracting Parties shall have, each on its own side of the boundary, equal and similar rights in the use of the waters hereinbefore defined as boundary waters * * *

The requirements for an equal division may, in the discretion of the commission, be suspended in cases of temporary diversions along boundary waters at points where such equal division can not be made advantageously on account of local conditions, and where such diversion does not diminish elsewhere the amount available for use on the other side * * * .

The facts that the St. Croix River is a boundary water within the meaning of the treaty, that the erection of the portion of the dam on each side of the boundary line has the effect of altering the level upon the other side, and that the diversion at times will rob the river for some distance below the dam of all its waters, bring the case within Article III and, subject to Article VIII, give the commission jurisdiction. While these facts were admitted at the hearings by all interested parties present, it was suggested by some that, as the undertaking had not been authorized by the United States or the Dominion of Canada, the commission could not make an order of approval. It was further contended that by Article III (especially in view of the interpretation of that article by the rules of the commission) the approval of the commission should have been obtained before the works were undertaken, and that inasmuch as this had not been done, the works were illegal and could not be approved of on these applications.

In support of this point it was urged that no statute had been passed by Congress, which was necessary, as the river is a navigable river within the law of the United States.

Another contention put forward by the Attorney General for New Brunswick was that the bed of the St. Croix River on the Canadian side of the boundary line, belonged to the Province of New Brunswick and that the consent of the Province to the works had not been obtained. In the opinion of the commission, it is not necessary to pass judgment on these contentions.

Under article III two things are necessary to legalize an obstruction or a diversion of boundary waters. In the first place, the act must be authorized "by the United States or the Dominion of Canada within their respective jurisdictions"; and in the second place, it must have the approval of the commission. Neither of these requirements is by the treaty required to be satisfied previously to the other, and however desirable under ordinary circumstances it might be that full authority should first be obtained from the United States or Canada, this order of sequence can never be more than a matter of desirable policy. The language of the article—"No further or other uses or obstructions or diversions * * * shall be made except by authority of the United States or the Dominion of Canada," etc.—is difficult to construe. Future cases may require the commission to undertake its construction, but the necessity for so doing has not arisen in the present case. Under the circumstances of the applications the commission is of opinion that inasmuch as hardship would be done to the applicants if its approval were postponed, it should grant approval now, and throw upon the applicants the responsibility of satisfying themselves that all necessary authority from the United States or the Dominion of Canada has or shall be obtained.

More difficult questions arise under Article VIII. This article expressly declares that each country on its own side of the boundary shall have equal and similar rights in the use of the boundary waters, and it refers to this declaration as "the requirement for an equal division."

The applications are not limited to a diversion of a moiety of the waters. They practically ask for approval of the diversion at Grand Falls of the whole or such portion of the waters of St. Croix River as the applicants may require. Has the commission power to approve of this diversion in the face of the clearly expressed principle of equal and similar rights and division? The treaty says that the requirements for an equal division may, in the discretion of the commission, be suspended in certain cases. The question, therefore, before the commission is whether or not the rule can in the case of these applications be suspended, and if it can be suspended, are the circumstances of the case such that the commission should do so?

The cases in which the commission can suspend the rule are cases of "temporary" diversion at points where an equal division can not be made advantageously on account of local conditions, and where such diversions do not diminish elsewhere the amount available for use on the other side.

The word "temporary" is somewhat vague and is not a term of exact science. During the argument it was contended on the one hand that the word applies to the period the diversion through the canal is to be enjoyed and that the commission has power to approve only of a diversion for a limited time. It was contended on the other hand that the word is used in somewhat of a secondary sense and expresses rather the character of the diversion than the period of time the diversion is to exist, and that inasmuch as in the case before the commission the waters are returned almost immediately to the channel of the stream the diversion is temporary; and as there is no limitation of the time the diversion is to be enjoyed, the commission has power to approve thereof for an unlimited period. A view similar in result to the last, but differently expressed, was also advanced, that the word "temporary" is used in its primary sense (that of time), and refers to the period that any particular portion of the waters of the stream has been diverted before its return to the channel.

In the view the commission takes of what is appropriate action on its part, it is unnecessary to express an opinion as to which, if any, of these contentions is correct. As the pulp and paper mill farther downstream at Sprague's Falls or Woodland is the industry in connection with which the power developed at Grand Falls is to be used, and as the company owning this mill and the applicants are virtually the same, the commission is of the opinion that it should, provided it has the power, grant its approval of the diversion of the waters for use by the St. Croix pulp and paper mill so long as the mill shall have occasion bona fide to use the same and when such use ceases the question of diversion should again be considered by the commission, in view of the local conditions then existing.

The next question that arises is, Can Canada advantageously use its moiety of the waters at this particular point—Grand Falls? The word "advantageously" is also an inexact term. Both companies had engineers as witnesses at the hearing, and they were all of the opinion that the Dominion could not, in view of the local conditions at this point, both physical and economical, advantageously use its moiety of the waters. Possibly the majority of people would be of a different opinion. The evidence of the engineers, however, was neither challenged nor contradicted. Taking it to be correct, the commission has jurisdiction, unless the diversion diminishes elsewhere, the amount of water available for use on the Canadian side. The diversion does not diminish the amount of water available for use on the Canadian side below Grand Falls. The question is with regard to Spednic Falls, situated a short distance above Grand Falls. At this point the water penned back by the dam drowns out a rapid which in the natural condition of affairs would be available for power purposes. The dam serves two purposes: First, the storage of water which would be a great benefit to all the water powers on the river below, both in the utilization of freshet water and the equalization of the flow of the stream; second, it assists to a certain degree in the diversion of the water through the canal. Standing by itslf as an obstruction of the river backing up its water, the dam falls within the jurisdiction of the commission, by virtue of Article III of the treaty. Does the fact that the dam does more than this, and incidently assists in the diversion of the water as asked for, place the diversion beyond the jurisdiction of the commission when the necessary effect of the dam is to deprive Canada of the use of the water available at Spednic Falls? At the hearing no objection was taken to the jurisdiction of the commission on account of the effect upon Spednic Falls, either of the diversion of water through the canal or of its being penned back by the dam. In view of all the circumstances of the case, and of the course pursued by the parties interested, the commission feels that it should act in accordance with the maxim, "*Boni judicis est ampliare jurisdictionem.*"

The facts of this case call strongly for the exercise of a discretion favorable to the applicants. The Parliament of Canada did not, it is true, by its act of incorporation of the Sprague's Falls Manufacturing Co. (Ltd.), authorize the diversion of these waters through the territory of the United States, but it did that which might work out the same result. It authorized the construction of a dam in terms sufficiently wide to cover the site without any expressed restrictions as to the place or country in which the power developed was to take place.

The companies interested through a mistake, but in good faith, believing they had a right to act as they did, expended the large amount of money referred to in the construction of the dam across the river and of the canal and power house in United States territory. They expended this money with the knowledge of Canada, or at least with the knolwedge of the citizens of Canada resident in the locality of the undertaking, that the expenditures were being made. Under all the circumstances of the case the commission feels the diversion should be approved.

There are other developments of water power farther downstream, and there are possibilities of still further development both above and below the dam. The lower proprietors of water power should not be at the mercy of the upper proprietors, and should not be subjected to losses consequent upon arbitrary interruptions of the flow of the water. To guard against this condition of affairs the operation of the sluices, gates, dam, power canal, and power house should be under the control of a board composed of a qualified representative from each country. The order of approval will therefore be subject to this condition. There are other conditions which the commission has seen fit to prescribe, and which are embodied in the order of approval.

One point was raised at the hearings to which reference may be made. The applicant companies, being owners in law or equity of the riparian lands throughout the whole course of the diversion, could do as they liked with the water of the stream so long as they returned it undiminished in quantity and uninjured in quality to the riparian owners lower down the river, and did not interfere with what might be called the right of highway. This contention would be unquestionably correct if applied to the rights of either the United States or Canadian proprietors *inter se,* but this principle of law can not be applied to the citizens of one country who seek to exploit the water rights of another country. The possibility of developing power and of thus creating and expanding industrial growth by the utilization of a country's natural features, in addition to being a private right, is a valuable national asset. No state should be called upon to part with such an asset without recompense. This phase of the case was not taken up or if taken was not emphasized before the commission, and little evidence, if any, in relation to it was submitted. The commission, therefore, feels itself relieved of the difficult task of determining the principle on which such recompense should be awarded as a condition of approval.

It should finally be observed that this is an entirely exceptional case, and the approval which is granted by the commission should not be taken as a precedent or as an indication that in another case the commission will sanction a work which has been built without its approval having been first obtained.

Opinion by Mr. Powell.

In concurring in the foregoing opinion Mr. Magrath wishes to point out that, while not strictly pertinent to the matter before the commission, the practice by Governments of making grants of land carrying riparian rights in streams was initiated when these rights were not looked upon as being of much value, and unfortunately the practice has outlived the old condition of things. In recent years, however, owing largely to electrical transmission, power rights have acquired great importance and may properly be regarded as public utilities. It would be well for all Legislatures of both the United States and Canada to consider the desirability of retaining or acquiring these valuable assets for the benfit of the public.

St. Croix River Near Baring, Maine.

Location.—Two miles above Baring, Maine, at the farm of Fulton Sinclair.

Records available.—November 13, 1913 to April 1, 1915. This station was designed to take the place of the Woodland station which was discontinued December 31, 1911.

Drainage area.—1390 square miles.

Gage.—Standard chain gage, horizontal timber attached to a large elm tree and post in ground and diagonally braced.

Channel.—Rock and gravel. Filling in with pulp from mill at Woodland.

Discharge Measurements.—Made from a cable about 400 feet below the gage.

Artificial Control.—The lake system of the St. Croix above the station comprises in the aggregate 83 square miles and is under extensive control by dams used both for log driving and for storage. The paper mill of the St. Croix Paper Co., at Woodland, four miles above the station, is run continuously, Sunday and week days with occasional shut-downs lasting only a few hours.

Accuracy.—It has been found that back water from the Baring Dam influenced this station to a marked extent and it has not been deemed advisable to publish records of discharge.

Station established.—November 13, 1913.

Station discontinued.—April 1, 1915.

St. Croix River at Baring Dam.

Location.—At dam of Granville Chase Company at Baring, 3 miles below station on the St. Croix near Baring.

Gage.—Staff attached to pier of dam.

Records available.—December 9, 1914, to March 31, 1915. Station was established for the purpose of comparing gage heights with the station above and determining the river slope. The two stations were connected by levels. Discharge not computed.

MACHIAS RIVER BASIN.

MACHIAS RIVER AT WHITNEYVILLE, MAINE.

LOCATION.—Wooden highway bridge in the town of Whitneyville; 4 miles above Machias; 200 feet below a storage dam.

RECORDS AVAILABLE.—October 17, 1903, to September 30, 1915.

DRAINAGE AREA.—465 square miles.

GAGE.—A standard chain gage installed on the wooden highway bridge October 10, 1911. Prior to October 3, 1905, a chain gage was located on the Washington County railroad bridge. Backwater was occasionally experienced here, however, from the dam at Machias, and on October 3, 1905, a staff gage was installed on the highway bridge three-fourths mile farther up stream. The datum of the present chain gage is the same as that of the staff gage on the highway bridge.

CHANNEL.—Practically permanent.

DISCHARGE MEASUREMENTS.—Still made at the railroad bridge, as the section there is better than above. Low-water measurements may be made by wading at a point 200 feet above the railroad bridge.

WINTER FLOW.—River does not ordinarily freeze over at the gage, although the relation of gage height to discharge is more or less affected by ice.

LOG DRIVING.—There is a certain amount of log driving every year and jams of short duration occasionally occur.

ARTIFICIAL CONTROL.—The gates in the storage dam immediately above the station are opened and closed each day during low stages of the river; as a result considerable fluctuation occurs at such times.

ACCURACY.—A fair rating curve has been developed under 5000 sec. ft. The operations of the gates of the storage dam render results somewhat uncertain.

MONTHLY DISCHARGE OF MACHIAS RIVER AT WHITNEYVILLE, MAINE.

[Drainage area, 465 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	6,340	224	1,030	2.22	2.56
November	4,690	875	1,560	3.35	3.74
December	2,290	534	1,130	2.43	2.80
January	4,180	755	1,800	3.87	4.46
February	1,420	642	819	1.76	1.83
March	5,900	698	2,360	5.08	5.86
April	2,920	1,420	2,120	4.56	5.09
May	4,180	1,210	2,120	4.56	5.26
June	3,780	260	1,040	2.24	2.50
July	482	191	288	0.619	.71
August	343	191	250	0.538	.62
September	698	191	336	0.723	.81
The year	6,340	191	1,240	2.67	36.24
1913-1914					
October	2,470	208	1,040	2.24	2.58
November	1,140	642	833	1.79	2.00
December	2,650	387	802	1.72	1.98
January	1,420	343	614	1.32	1.52
February	1,420	387	805	1.73	1.80
March	3,280	433	1,960	4.22	4.86
April	5,680	1,490	3,020	6.49	7.24
May	2,830	1,800	2,120	4.56	5.26
June	3,580	300	1,010	2.17	2.42
July	482	300	378	.813	.94
August	587	260	421	.905	1.04
September	482	61	191	.411	.46
The year	5,680	61	1,100	2.37	32.10
1914-1915					
October	800	30	231	.497	.57
November	1,490	107	489	1.05	1.17
December	800	267	402	.865	1.00
January	3,080	221	761	1.64	1.89
February	4,280	362	952	2.05	2.14
March	1,230	221	390	.839	.97
April	1,940	221	1,000	2.15	2.40
May	6,780	1,360	2,760	5.94	6.85
June	1,710	412	910	1.96	2.17
July	5,130	464	1,070	2.30	2.54
August	1,040	362	576	1.24	1.79
September	412	221	320	.688	.63
The year	6,780	30	822	1.77	20.34

UNION RIVER BASIN.

UNION RIVER AT AMHERST, MAINE.

LOCATION.—At highway bridge three-fourths of a mile west of Amherst post office on road to Bangor, about a mile below the highway bridge at the old tannery dam.

RECORDS AVAILABLE.—July 25, 1909, to September 30, 1915.

DRAINAGE AREA.—140 square miles.

GAGE.—Standard chain, established June 2, 1910, and placed at same datum as old vertical gage nailed to a log abutment.

CHANNEL.—Gravel, but not liable to change except in an unusual flood.

DISCHARGE MEASUREMENTS.—Made from downstream side of the bridge.

WINTER FLOW.—Affected by ice.

ARTIFICIAL CONTROL.—A few log-driving dams above the station, but the regimen of stream is only slightly affected by them.

ACCURACY.—Relation between gage height and discharge is affected by ice and to a certain extent, but for short periods, by backwater from log jams. A good rating curve has been developed under 1100 second-feet. Discharge values above that point should be used with caution. No corrections have been made for possible backwater from log jams.

Monthly Discharge of Union River at Amherst, Me.

[Drainage area, 140 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	651	72	200	1.43	1.65
November	948	282	535	3.82	4.26
December	876	226	466	3.33	3.84
January	1,420	433	628	4.49	5.18
February	....	....	359	2.56	2.66
March	2,030	270	996	7.11	8.20
April	1,580	520	828	5.91	6.59
May	966	140	368	2.63	3.03
June	753	83	296	2.11	2.35
July	132	72	94	.67	.77
August	72	23	37	.26	.30
September	461	31	105	.75	.84
The year	....	....	410	2.93	39.67
1913-1914					
October	1,270	164	544	3.88	4.47
November	814	264	419	2.99	3.34
December	605	226	347	2.48	2.86
January	240	30	118	.843	.97
February	230	120	183	1.31	1.36
March	750	150	443	3.16	3.64
April	1,960	284	1,160	8.28	9.24
May	1,460	140	527	3.76	4.33
June	254	78	136	.971	1.08
July	90	34	60	.428	.49
August	40	18	26	.186	.21
September	37	23	27	.193	.22
The year	1,960	18	332	2.37	32.21
1914-1915					
October	96	21	39.5	0.282	0.33
November	182	55	99.1	.708	.79
December	103	19	63.2	.452	.52
January	415	19	91.9	.657	.76
February	1,400	59	309	2.21	2.30
March	1,000	118	235	1.68	1.94
April	896	140	481	3.44	3.84
May	1,680	284	758	5.41	6.24
June	304	103	155	1.11	1.24
July	1,220	78	362	2.59	2.99
August	264	68	128	.914	1.05
September	182	44	87.1	.622	.69
The year	1,680	19	234	1.67	22.69

Branch Lake near Ellsworth, Maine.

Location.—Near the intake to the wheels of the Branch Pond Lumber Co's mill, at the lower end of Branch Lake, in Ellsworth, Maine.

Records available.—June 29, 1909, to May 25, 1915. Tables of daily gage heights are published in Water Supply Papers 351-381 and 401.

AREA OF LAKE SURFACE.—4.33 square miles.

GAGE.—8½-foot staff; datum unchanged. Readings indicate height of lake.

ALTITUDE.—Altitude as determined by Geological Survey, 236 feet above sea level, and this height was assumed as the height of the water surface at the time of the Union River surface reconnaissance. In accordance with this assumption, the top of the mill-pond dam at the lower end of the lake is 240 feet above sea level.

STATION DISCONTINUED.—May 25, 1915.

BRANCH LAKE STREAM NEAR ELLSWORTH, MAINE.

LOCATION.—At small highway bridge immediately below the sawmill at outlet of Branch Lake, 5 miles from Ellsworth.

RECORDS AVAILABLE.—July 1, 1909, to May 25, 1915.

DRAINAGE AREA.—31 square miles.

GAGE.—Seven-foot staff nailed to right abutment downstream side of bridge.

CHANNEL.—Gravelly and permanent in natural condition; filled up with sawmill waste, but generally cleared itself during spring freshets. The mill was removed during 1914.

DISCHARGE MEASUREMENTS.—Made from highway bridge.

WINTER FLOW.—Relation between gage height and discharge not affected by ice.

ARTIFICIAL CONTROL.—The flow from the lake is regulated in the interest of the sawmill and power plants of Ellsworth.

ACCURACY.—Questionable.

STATION DISCONTINUED.—May 25, 1915.

Monthly Discharge of Branch Lake Stream at Ellsworth, Maine.

[Drainage area, 31 square miles.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	60	30	42.5	1.37	1.58
November	88	30	43.5	1.40	1.56
December	35	30	32.8	1.06	1.22
January	86	30	52	1.68	1.94
February	101	82	90	2.90	3.02
March	128	82	96	3.10	3.57
April	152	65	117	3.77	4.21
May	76	67	72	2.32	2.68
June	76	70	76	2.45	2.73
July	63	44	45	1.45	1.67
August	129	30	55	1.77	2.04
September	82	30	46	1.48	1.65
The year	152	30	64	2.06	27.87
1913-1914					
October	40	30	33	1.06	1.22
November	44	41	44	1.42	1.58
December	44	44	44	1.42	1.64
January	44	44	44	1.42	1.64
February	44	44	44	1.42	1.48
March	44	44	44	1.42	1.64
April	108	44	88	2.84	3.17
May	101	88	94	3.03	3.49
June	44	44	44	1.42	1.58
July	18	18	18	.580	.67
August	129	18	72	2.32	2.68
September	129	5	71	2.29	2.55
The year	129	5	53	1.71	23.34
1914-1915					
October	44	26	34	1.09	1.26
November	22	0	4	.129	.14
December	22	12	18	.580	.67
January	44	12	28	.903	1.04
February	44	5	17	.548	.57
March	10	6	8	.258	.30
April	....	....	....	....	....
May	....	....	....	....	....
June	....	....	....	....	....
July	....	....	....	....	....
August	....	....	....	....	....
September	....	....	....	....	....
The year	....	....	....	....	....

GREEN LAKE AT GREEN LAKE, MAINE.

LOCATION.—At highway bridge at head of lake, 600 feet from Green Lake railroad station.

RECORDS AVAILABLE.—July 1, 1909, to December 31, 1913. Tables of daily gage heights are published in Water Supply Papers 351 and 381.

AREA OF LAKE SURFACE.—4.43 square miles.

GAGE.—Staff, nailed to log abutment of highway bridge. Record shows the fluctuation of the lake level.

STATION DISCONTINUED.—December 31, 1913.

GREEN LAKE STREAM AT LAKEWOOD, MAINE.

LOCATION.—At highway bridge one-half mile below dam at outlet of Green Lake, one-half mile from Lakewood post office, and 8 miles from Ellsworth.

RECORDS AVAILABLE.—July 1, 1909, to December 31, 1913.

DRAINAGE AREA.—47 square miles.

GAGE.—Seven-foot staff, nailed to right-hand abutment, upstream side of bridge.

CHANNEL.—Permanent; banks not subject to overflow.

DISCHARGE MEASUREMENTS.—Made from lower side of bridge.

WINTER FLOW.—Ice does not exist every year at this station.

ARTIFICIAL CONTROL.—The dam one-half mile above the station at the outlet of the lake controls the storage of the lake, and computation does not show the natural flow.

ACCURACY.—Results believed to be good for the length of record.

STATION DISCONTINUED.—December 31, 1913.

Monthly Discharge of Green Lake Str. at Lakewood, Maine.

[Drainage area, 47 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	146	38	79.5	1.69	1.95
November	38	†19	23.0	.489	.55
December	70	26	50.2	1.07	1.23
January	194	77	158	3.36	3.87
February	177	177	177	3.77	3.93
March	570	177	276	5.88	6.78
April	570	211	381	8.11	9.05
May	211	96	142	3.02	3.48
June	96	62	92	1.96	2.19
July	62	49	57	1.21	1.40
August	211	49	143	3.04	3.50
September	96	38	83	1.76	1.96
The year	570	19	138	2.94	39.89
1912-1914					
October	62	62	62	1.32	1.52
November	77	62	74	1.57	1.75
December	96	77	90	1.91	2.20
January					
February					
March					
April					
May					
June					
July					
August					
September					
The year					

Note.—† leakage thru dam.

PENOBSCOT RIVER BASIN.

PENOBSCOT RIVER AT WEST ENFIELD, MAINE.

LOCATION.—At the steel highway bridge 1 mile below the village of West Enfield, Maine; 1,000 feet below the mouth of Piscataquis River.

RECORDS AVAILABLE.—January 1, 1902, to September 30, 1915.

DRAINAGE AREA.—6,600 square miles.

GAGE.—Standard chain; Friez automatic installed December 11, 1912; datum unchanged.

CHANNEL.—Practically permanent; broken by four bridge piers; banks high and rocky and not subject to overflow; is straight above and below the station and the velocity is good.

CONTROL.—At Passadumkeag Rips 4 or 5 miles below. Ice is liable to form here, causing backwater of 0.1 to 3.0 feet at the gage, and the control changes at about 5.5 gage height when water goes over a wing dam at this point.

DISCHARGE MEASUREMENTS.—Made from downstream side of bridge. There is no wading section. Measurements under ice cover may be made about 2 miles below near the Enfield-Passadumkeag town line.

WINTER FLOW.—Affected by ice.

ARTIFICIAL CONTROL.—Flow of the river since about 1900 largely controlled by storage, principally in the lakes tributary to the West Branch. About 1 mile above the station is the dam of the International Paper Co., and the Piscataquis is dammed near its entrance into the Penobscot. Considerable water is held above these two dams at night.

ACCURACY.—Conditions favor the accurate determination of discharge. Results not corrected for storage.

COÖPERATION.—Many of the discharge measurements are made by students of the University of Maine under the direction of Prof. H. S. Boardman and by Thomas W. Clark, Hydraulic Engineer, Old Town, Maine.

Monthly Discharge of Penobscot River at West Enfield, Maine.

[Drainage area, 6600 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	49,500	5,770	12,800	1.94	2.24
November	63,200	13,500	25,500	3.86	4.31
December	17,000	6,650	11,300	1.71	1.97
January	16,800	7,440	12,200	1.85	2.13
February	10,300	3,840	5,900	.894	.93
March	52,400	4,060	19,800	3.00	3.46
April	46,400	17,600	33,300	5.05	5.63
May	45,100	10,700	20,700	3.14	3.62
June	26,000	5,300	12,900	1.95	2.18
July	11,100	5,300	7,310	1.11	1.28
August	6,260	3,630	4,840	.733	.85
September	12,100	3,330	5,060	.767	.86
The year	63,200	3,330	14,300	2.17	29.46
1913-1914					
October	33,300	5,080	13,100	1.98	2.28
November	22,000	7,440	12,600	1.91	2.13
December	13,500	6,390	8,010	1.21	1.40
January	7,440	4,960	5,990	.908	1.05
February	7,710	4,960	6,130	.929	.97
March	10,300	4,730	8,560	1.30	1.50
April	55,900	11,000	28,800	4.36	4.87
May	67,300	16,200	41,200	6.24	7.19
June	16,800	8,540	11,600	1.76	1.96
July	9,270	4,700	6,480	.982	1.13
August	5,200	3,100	4,100	.622	.72
September	5,200	3,200	3,980	.603	.67
The year	67,300	3,100	12,600	1.91	25.87
1914-1915					
October	4,500	3,230	3,750	.568	.65
November	6,910	3,430	4,670	.708	.79
December	5,530	3,230	4,140	.627	.72
January	7,840	2,570	4,650	.705	.81
February	20,100	4,730	6,690	1.01	1.05
March	17,000	5,190	8,370	1.27	1.46
April	35,400	6,650	18,200	2.76	3.08
May	52,700	11,300	26,000	3.94	4.54
June	11,500	7,040	8,190	1.24	1.38
July	29,300	6,260	11,100	1.68	1.94
August	9,720	5,890	7,320	1.11	1.28
September	7,710	4,060	5,410	.820	.91
The year	52,700	2,570	9,060	1.37	18.61

West Branch of Penobscot River at Millinocket, Maine.

Location.—Quakish Lake dam and the Millinocket mill of the Great Northern Paper Co. at Millinocket, Maine.

Records available.—January 11, 1901, to September 30, 1915.

Drainage area.—1,880 square miles.

Gage.—Automatic recording gage at Quakish Lake dam and gages in the forebay and tail races at the mill.

Channel.—Crest of concrete dam.

Determination of discharge.—The flow is computed by considering the flow over the dam, the flow through the wheels, and the water used from time to time through the log sluices, filters, etc. The wheels were rated at Holyoke, Mass., before being placed in position. As the head under which they work, averaging about 110 feet, is much greater than the head under which they were tested, numerous tube-float measurements of flow in the channel leading to the mill have been made by engineers of the company, in order to determine just how much water the mill used under different conditions of gate opening. In addition to this, a series of current-meter measurements were made by the United States Geological Survey to check the float measurements. It is believed that by means of the various checks on measurements, the estimates of discharge through the wheels are excellent. When the flow of the river is less than 2,500 second-feet, all of the water generally flows through the wheels of the mill.

Winter flow.—No difficulty is experienced in the winter on account of ice affecting the estimates of discharge or the running of the wheels. Ferguson Pond, just above the entrance to the canal, eliminates effect from anchor ice.

Artificial control.—Storage dams at the outlet of North Twin Lake and at the outlet of Chesuncook Lake store water on a surface of about 65 square miles with a capacity of about 32,000,000,000 cubic feet. Except during the time (usually in August) when excess water has to be supplied for log driving on the river below Millinocket and for a short time during the spring freshet, run-off is regulated by storage.

Coöperation.—Results obtained and computations made by engineers of the Great Northern Paper Co., who furnish these data to the commission. The company prefers to furnish values of monthly discharge only.

MONTHLY DISCHARGE OF PENOBSCOT RIVER, WEST BRANCH AT MILLINOCKET, MAINE.

[Drainage area, 1880 square miles]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October			2,240	1.19	1.37
November			6,340	3.37	3.76
December			3,270	1.74	2.01
January			2,170	1.15	1.33
February			2,170	1.15	1.20
March			2,360	1.26	1.45
April			6,120	3.26	3.64
May			6,820	3.63	4.18
June			3,800	2.02	2.25
July			2,560	1.36	1.57
August			2,220	1.18	1.36
September			2,300	1.22	1.36
The year			3,530	1.88	25.48
1913-1914					
October			2,320	1.23	1.42
November			2,340	1.24	1.38
December			2,330	1.24	1.43
January			2,570	1.37	1.58
February			2,710	1.44	1.50
March			2,870	1.53	1.76
April			3,390	1.80	2.01
May			6,920	3.68	4.24
June			3,300	1.76	1.96
July			3,180	1.69	1.95
August			3,120	1.66	1.91
September			2,540	1.35	1.51
The year			3,130	1.66	22.65
1914-1915					
October			2,300	1.22	1.41
November			2,280	1.21	1.35
December			2,230	1.19	1.37
January			2,230	1.19	1.37
February			2,060	1.10	1.14
March			1,700	.904	1.04
April			1,740	.926	1.03
May			2,240	1.19	1.37
June			2,260	1.20	1.34
July			2,470	1.31	1.51
August			2,680	1.43	1.65
September			2,270	1.21	1.35
The year			2,200	1.17	15.93

MONTHLY DISCHARGE OF PENOBSCOT RIVER, WEST BRANCH, AT MILLINOCKET, MAINE.

[Corrected for Storage]

[Drainage area, 1880 square miles]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910-11					
October	....	....	....	....	....
November	....	....	....	....	....
December	....	....	....	....	....
January	....	....	380	.20	.23
February	....	....	430	.23	.24
March	....	....	450	.24	.28
April	....	....	2,100	1.12	1.25
May	....	....	9,150	4.87	5.62
June	....	....	2,480	1.32	1.47
July	....	....	950	.51	.59
August	....	....	1,040	.55	.63
September	....	....	1,290	.69	.77
The year	....	....	....	....	....
1911-12					
October	....	....	1,650	.88	1.02
November	....	....	1,520	.81	.90
December	....	....	3,480	1.85	2.13
January	....	....	1,970	1.05	1.21
February	....	....	874	.46	.50
March	....	....	1,100	.59	.68
April	....	....	8,020	4.27	4.76
May	....	....	10,800	5.74	6.62
June	....	....	7,260	3.86	4.31
July	....	....	1,700	.90	1.04
August	....	....	3,340	1.78	2.05
September	....	....	1,690	.90	1.00
The year	....	....	3,620	1.92	26.22
1912-1913					
October	....	....	2,930	1.56	1.80
November	....	....	5,660	3.01	3.36
December	....	....	2,400	1.28	1.48
January	....	....	1,970	1.05	1.21
February	....	....	1,050	.559	.58
March	....	....	2,590	1.38	1.59
April	....	....	9,580	5.10	5.69
May	....	....	6,980	3.71	4.28
June	....	....	3,590	1.91	2.13
July	....	....	1,900	1.01	1.13
August	....	....	1,030	.548	.63
September	....	....	1,130	.601	.67
The year	....	....	3,400	1.81	24.55

Monthly Discharge of Penobscot River, West Branch,—Concluded.

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1913-1914					
October	....	....	2,620	1.39	1.60
November	....	....	3,020	1.61	1.80
December	....	....	1,930	1.03	1.19
January	....	....	1,230	.654	.75
February	....	....	603	.320	.33
March	....	....	353	.188	.22
April	....	....	4,280	2.28	2.54
May	....	....	14,400	7.66	8.83
June	....	....	2,940	1.56	1.74
July	....	....	1,400	.744	.86
August	....	....	1,030	.548	.63
September	....	....	749	.398	.44
The year	....	....	2,880	1.53	20.93
1914-1915					
October	....	....	1,260	0.670	0.77
November	....	....	1,730	.920	1.03
December	....	....	1,140	.606	.70
January	....	....	656	.349	.40
February	....	....	641	.341	.35
March	....	....	1,500	.798	.92
April	....	....	5,370	2.86	3.19
May	....	....	7,600	4.04	4.66
June	....	....	3,030	1.61	1.80
July	....	....	2,280	1.21	1.40
August	....	....	925	.492	.57
September	....	....	927	.493	.55
The year	....	....	2,260	1.20	16.34

Note.—First of April natural flow less than 1,500 second-feet; last of month natural flow increased to over 9,000 second-feet.

Note.—Similar data for the years 1901-1910 inclusive are published in Water Supply Paper 279, pp. 191-193 inclusive.

East Branch of Penobscot River at Grindstone, Maine.

Location.—Bangor & Aroostook Railroad bridge half a mile south of railroad station at Grindstone, one-eighth mile above Grindstone Falls, and about 8 miles above the mouth at Medway.

Records available.—October 23, 1902, to September 30, 1915.

Drainage area.—1,100 square miles.

Gage.—Standard chain; datum unchanged.

Channel.—Practically permanent; stream confined by abutments of bridge and broken by one pier at ordinary stages; velocity of current medium at moderate and high stages, but sluggish at low water.

Discharge measurements.—Made from railroad bridge.

Winter flow.—Affected by ice.

Artificial control.—Several dams are maintained at the outlets of a number of lakes and ponds near the source of the river and regulated in the interests of log driving. During the summer and fall gates are generally left open. The basin of the East Branch since about 1840 includes about 270 square miles of additional territory draining into Chamberlain Lake that formerly drained into the St. John River basin. This diversion is made through what is known as the Telos canal.

Accuracy.—The relation between gage height and discharge is materially affected by backwater from log jams that form at the station and at Grindstone Falls immediately below and during the winter months by ice. Results believed to be fair for moderate and high stages but uncertain for low water.

MONTHLY DISCHARGE OF PENOBSCOT RIVER, EAST BRANCH, AT GRINDSTONE, MAINE.

[Drainage area 1100 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912–1913					
October	13,800	766	2,530	2.30	2.65
November	11,400	1,840	4,290	3.90	4.35
December	2,650	1,380	1,760	1.60	1.84
January	2,280	1,520	1,740	1.58	1.82
February	2,000	620	938	.853	.89
March	7,400	560	2,880	2.62	3.02
April	11,000	3,140	6,160	5.60	6.25
May	8,050	1,250	3,840	3.49	4.02
June	8,290	715	3,570	3.24	3.62
July	2,960	480	1,520	1.38	1.59
August	1,250	405	674	.613	.71
September	2,280	185	493	.448	.50
The year	13,800	185	2,530	2.30	31.26
1913–1914					
October	6,780	405	2,300	2.09	2.41
November	3,320	1,130	1,960	1.78	1.99
December	1,520	....	997	.906	1.04
January	620	560	568	.516	.59
February	505	360	399	.363	.38
March	1,020	455	678	.616	.71
April	9,250	1,020	4,440	4.04	4.51
May	14,900	3,510	7,670	6.97	8.04
June	5,660	1,660	3,430	3.12	3.48
July	2,790	750	1,460	1.33	1.53
August	830	315	520	.472	.54
September	360	185	271	.246	.27
The year	14,900	185	2,060	1.87	25.49
1914–1915					
October	590	160	248	.225	.26
November	1,320	240	485	.441	.49
December	715	110	228	.207	.24
January	1,130	120	397	.361	.42
February	5,660	258	1,140	1.04	1.08
March	3,510	505	1,080	.982	1.13
April	6,780	480	3,360	3.05	3.40
May	9,880	2,280	4,940	4.49	5.18
June	3,890	920	2,680	2.44	2.72
July	5,990	1,020	1,920	1.75	2.02
August	1,520	405	872	.793	.91
September	1,450	210	432	.393	.44
The year	9,880	110	1,480	1.35	18.29

MATTAWAMKEAG RIVER AT MATTAWAMKEAG, MAINE.

LOCATION.—At Maine Central Railroad bridge at the village of Mattawamkeag, half a mile above the mouth of the river.

RECORDS AVAILABLE.—August 26, 1902, to September 30, 1915.

DRAINAGE AREA.—1,500 square miles.

GAGE.—Standard chain; datum unchanged.

CHANNEL.—Practically permanent; broken by two bridge piers.

DISCHARGE MEASUREMENTS.—Made from the bridge, which is slightly oblique to the current; low water measurements made by wading at a point about 1 mile above the station.

WINTER FLOW.—Affected by ice.

ARTIFICIAL CONTROL.—Dams are maintained at the outlets of several large lakes and ponds, but the stored water is used only for log driving.

ACCURACY.—Relation between gage height and discharge is at times affected by backwater from log jams that form during short periods in the log-driving season, and, during the winter months, by ice. A very good open-channel discharge rating curve has been developed.

Monthly Discharge of Mattawamkeag River at Mattawamkeag, Maine.

[Drainage area, 1500 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	7,990	1,380	2,830	1.89	2.18
November	15,000	3,070	7,310	4.87	5.43
December	3,710	....	2,640	1.76	2.03
January	....	....	3,450	2.30	2.65
February	....	....	960	.640	.67
March	....	....	7,450	4.97	5.73
April	21,000	11,900	16,200	10.80	12.05
May	16,200	2,580	5,140	3.43	3.95
June	7,860	818	2,960	1.97	2.20
July	1,320	470	955	.636	.73
August	1,560	223	736	.490	.56
September	1,820	223	678	.452	.50
The year	....	....	4,280	2.85	38.68
1913-1914					
October	11,000	818	3,620	2.41	2.78
November	10,800	4,480	6,320	4.21	4.70
December	6,250	2,820	4,090	2.73	3.15
January	3,400	590	1,170	.780	.90
February	1,210	660	890	.593	.62
March	2,820	660	1,940	1.29	1.49
April	17,500	3,160	9,020	6.01	6.70
May	20,800	3,520	12,300	8.20	9.45
June	4,000	1,260	2,580	1.72	1.92
July	1,820	525	942	.628	.72
August	525	295	378	.252	.29
September	375	114	226	.151	.17
The year	20,800	114	3,620	2.41	32.89
1914-1915					
October	630	123	295	.197	.23
November	1,470	450	985	.657	.73
December	1,040	265	560	.373	.43
January	1,040	145	515	.343	.40
February	4,090	740	1,260	.840	.87
March	4,380	1,040	2,400	1.60	1.84
April	10,400	1,780	6,310	4.21	4.70
May	16,400	3,000	8,500	5.67	6.54
June	3,520	1,350	2,200	1.47	1.64
July	7,480	1,140	3,070	2.05	2.36
August	1,240	630	979	.653	.75
September	1,710	450	757	.505	.56
The year	16,400	123	2,320	1.55	21.05

Piscataquis River Near Foxcroft, Maine.

Location.—At Low's highway bridge, about halfway between Guilford and Foxcroft, three-fourth of a mile above the mouth of Black Stream and 3 miles below Mill Stream.

Records available.—August 17, 1902, to September 30, 1915.

Drainage area.—286 square miles.

Gage.—Staff, attached to left abutment of bridge; datum unchanged.

Channel.—Practically permanent; banks high and overflowed only during extreme floods.

Discharge measurements.—At medium and high stages made from the bridge; at low stages made by wading either above or below the bridge where the bed is of fine gravel but the velocity is greater than at the bridge.

Winter flow.—Not usually affected by ice.

Artificial control.—The stream is used to develop power at several manufacturing plants above the station.

Accuracy.—The relation between gage height and discharge at low stages is considerably affected by the irregular use of the water at the mills; during some winters it is also affected by ice; little if any affected by backwater from log jams, as little log driving is now done on the river. A very good rating curve has been developed for medium and low stages, but the curve for high stages is not yet accurately defined.

MONTHLY DISCHARGE OF PISCATAQUIS RIVER AT FOXCROFT, MAINE.

[Drainage area 286 square miles]

Month.	Discharge in Second-Feet.				Run-off — Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	7,910	100	961	3.36	3.87
November	7,010	502	1,240	4.34	4.84
December	782	220	501	1.75	2.02
January	1,110	220	633	2.21	2.55
February	709	164	411	1.44	1.50
March	8,220	100	1,860	6.50	7.49
April	9,240	1,020	2,460	8.60	9.60
May	1,670	136	608	2.12	2.44
June	569	46	192	.672	.75
July	318	51	165	.578	.67
August	318	51	111	.389	.45
September	1,460	46	205	.718	.80
The year	9,240	46	780	2.73	36.98
1913-1914					
October	8,320	72	1,290	4.51	5.20
November	4,240	374	1,080	3.78	4.22
December	1,350	90	493	1.72	1.98
January	938	180	529	1.85	2.13
February	858	374	566	1.98	2.06
March	2,350	123	974	3.40	3.92
April	8,730	470	2,720	9.51	10.61
May	8,530	180	2,570	8.99	10.36
June	470	58	147	.514	.57
July	148	51	90	.314	.36
August	64	19	39	.136	.16
September	81	19	37	.129	.14
The year	8,730	19	878	3.07	41.71
1914-1915					
October	123	15	45	.157	.18
November	638	17	90	.315	.35
December	318	51	125	.437	.50
January	2,280	164	938	3.28	3.78
February	7,810	437	1,580	5.52	5.75
March	5,080	437	1,540	5.38	6.20
April	7,110	374	2,010	7.03	7.84
May	7,510	220	1,270	4.44	5.12
June	374	51	122	.426	.48
July	3,520	100	538	1.88	2.17
August	2,220	148	695	2.43	2.80
September	1,300	148	389	1.36	1.52
The year	7,810	15	774	2.71	36.69

Passadumkeag River at Lowell.

Location.—One-half mile below highway bridge at Lowell.

Drainage area.—301 square miles.

Records available.—From October 1, 1915.

Gage.—Standard chain reads from 0.0-7.0 feet. Staff gage reads from 4.5 to 12.0 feet.

Discharge measurements.—Made from cable 20 feet above gage at low and medium stages and at the highway bridge in Lowell at extreme high water. Wading measurements can be made under the cable at low stages. Channel rocky and free from vegetation, curved for 150′ above station and straight for 150′ below. Current is normal to section and velocity good. Left bank will overflow at 5.0 or 5.5 gage height.

Control.—About 150 yards below gage and is permanent.

Winter flow.—Probably affected by ice forming at the control.

Artificial control.—The dam ½ mile above will affect the flow at the station.

Accuracy.—A rating curve has been developed for low and medium stages, and it is believed that the results obtained will be accurate.

Station established.—September 30, 1915.

Kenduskeag Stream near Bangor, Maine.

Location.—At highway bridge at Sixmile Falls, about 6 miles northwest of Bangor.

Records available.—September 15, 1908, to September 30, 1915.

Drainage area.—191 square miles.

Gage.—Standard chain; datum unchanged.

Channel.—Practically permanent; broken by one pier; banks high and not subject to overflow.

Discharge measurements.—Made from the bridge.

Winter flow.—Affected by ice.

Artificial control.—A number of years ago an artificial cut was made for log driving through a low divide between Souadabscook Stream and Black Stream, the latter a tributary to the Kenduskeag, entering about 7 miles above the gaging station. During high stages of the Souadabscook a portion of its waters finds it way thrugh the artificial cut into the Kenduskeag; at low stages of the Souadabscook all the flow continues down its own channel. Black Stream probably sends its waters only to the Kenduskeag.

ACCURACY.—A good discharge rating curve has been developed.

MONTHLY DISCHARGE OF KENDUSKEAG STREAM AT BANGOR, MAINE.

[Drainage area 191 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	2,820	119	514	2.69	3.10
November	2,180	414	853	4.47	4.99
December	870	398	575	3.01	3.47
January	2,220	678	1,180	6.18	7.12
February	845	200	357	1.87	1.95
March	3,590	199	1,640	8.59	9.90
April	2,260	870	1,380	7.22	8.06
May	700	110	294	1.54	1.78
June	655	64	190	.995	1.11
July	110	30	67	.351	.40
August	86	22	42	.220	.25
September	71	25	44	.230	.26
The year	3,590	22	594	3.11	42.39
1913-1914					
October	1,610	51	432	2.26	2.61
November	538	366	449	2.35	2.62
December	538	223	404	2.12	2.44
January	615	156	232	1.21	1.40
February	795	305	370	1.94	2.02
March	1,120	276	626	3.28	3.78
April	4,500	895	2,350	12.30	13.72
May	1,240	137	459	2.40	2.77
June	335	57	140	.733	.82
July	71	25	42	.220	.25
August	57	18	35	.183	.21
September	45	12	24	.126	.14
The year	4,500	12	464	2.43	32.78
1914-1915					
October	45	7	20.2	0.106	0.12
November	119	25	58.8	.308	.34
December	71	25	47.2	.247	.28
January	1,640	18	458	2.40	2.77
February	4,250	57	608	3.18	3.31
March	2,180	156	456	2.39	2.76
April	1,470	305	659	3.45	3.85
May	3,680	146	825	4.32	4.98
June	211	57	122	.639	.71
July	3,180	119	540	2.83	3.26
August	845	146	326	1.71	1.97
September	262	51	148	.775	.86
The year	4,250	7	355	1.86	25.21

COASTAL BASIN NO. 3.

The following revision of lake areas in Coastal Basin No. 3, in the Fourth Annual Report of the Water Storage Commission, is from recently issued topographic sheets of the United States Geological Survey.

BELFAST QUADRANGLE:

Duck Trap River Water-shed.	Sq. miles.
Tilden Pond, Belmont	0.53
Pitcher Pond, Northport and Lincolnville	0.54
Knights Pond, Northport	0.13
Collman Pond, Lincolnville, (formerly Andrews Pond)	0.33
Megunticook River Water-shed.	
Moody Pond, Lincolnville, (formerly Fletchers Pond)	0.09
Levensaler Pond, Lincolnville	0.06
Megunticook Lake, Camden, Lincolnville, and Hope	1.94
Norton Pond, Lincolnville	0.15
St. George River Water-shed.	
Lake Quantabacook, Searsmont	0.92
Lawry Pond, Searsmont, (formerly Moody Pond)	0.14
Hobbs Pond, Hope	0.40

LIBERTY QUADRANGLE.

St. George River Water-shed.	Sq. miles.
St. George Lake, Liberty (Published 1.60)	1.62
Elevation 505	
Drainage area at outlet	6.5
Cargill Pond, Liberty (not published)	0.09
Elevation 590	

Stevens Pond, Liberty (published 0.63)....... 0.59
Elevation 306
Drainage area at outlet 12.0
True's Pond, Montville (published 0.27) 0.24
Elevation 290
Drainage area at outlet..................... 27.3
Newbert Pond, Appleton (published 0.10)...... 0.13
Mud Pond, Montville (published as "Pond")... 0.012

Medomak River Water-shed.
Washington Pond, Washington (published 0.87) 0.91
Elevation 319
Crystal Pond, Washington (published 0.16)..... 0.13
Elevation 380
Muddy Pond, Washington (not published)..... 0.01

Sheepscot River Water-shed, East Branch.
Sheepscot Lake, Palermo (published 1.86)..... 1.81
Elevation 281
James Pond, Somerville..................... 0.055
Turner's Pond, Somerville and Palermo (not published) 0.22
Bowler Pond, Palermo (formerly Belden Pond) 0.05
Pond, Palermo, (formerly Cedar Pond)....... 0.02
Foster Pond, Palermo...................... 0.05
Bear Pond, Palermo (formerly Accidental Pond) 0.03
Chisholm Pond, Palermo (formerly Turner Pond) 0.08
Elevation 353
Beech Pond, Palermo (formerly Beach Pond).. 0.06

Sheepscot River Watershed, West Branch.
Branch Pond, Palermo...................... 0.45
Elevation 345
Prescot Pond, Palermo (not published)........ 0.04

Kennebec River Water-shed.
Dutton Pond, China (not published).......... 0.07
(Fifteen Mile Creek.)

St. George River at Union, Maine.

Location.—One mile above Union, Maine, one-half mile below the outlet of Sennebec Lake and 200 feet below the tail race of the electric plant of the Dirigo Power Co.

Records available.—December 11, 1913, to December 31, 1914.

Drainage area.—116 square miles.

Gage.—Vertical staff gage bolted securely to a tree on the left bank.

Channel.—Rock and gravel.

Discharge measurements.—Made from a cable about 50 feet above the gage.

Artificial control.—The dam of the Dirigo Power Co. is located about 1000 feet, and the tail race about 300 feet above the station. On the completion of the electric plant, now in course of construction, the regimen of the stream will be more or less affected by night storage.

Accuracy.—A well defined rating curve has been developed and the accuracy is good.

Station established.—December 11, 1913.

Station discontinued.—June 18, 1915.

Monthly Discharge of St. George River at Union, Maine.

[Drainage area, 116 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1913-1914					
October	....	....	....	....	....
November	....	....	....	....	....
December	373	110	210	1.81	2.09
January	102	58	71	.612	.68
February	....	....	58	.500	.52
March	972	208	485	4.18	4.82
April	1,060	373	727	6.27	7.00
May	340	42	205	1.77	2.04
June	102	42	67	.578	.64
July	46	33	40	.345	.40
August	29	18	24	.207	.24
September	33	15	23	.198	.22
The year	....	....	....	....	....
1914-1915					
October	18	3	13.8	0.119	0.14
November	15	10	13.0	0.112	0.12
December	68	13	41.0	0.353	0.41
January	....	....	....	....	....
February	....	....	....	....	....
March	....	....	....	....	....
April	....	....	....	....	....
May	....	....	....	....	....
June	....	....	....	....	....
July	....	....	....	....	....
August	....	....	....	....	....
September	....	....	....	....	....
The year	....	....	....	....	....

Note.—Station discontinued June 18, 1915. Computations not made after December, 1914, as a change of section and control took place early in 1915, and a rating curve for the new conditions was not developed.

KENNEBEC RIVER BASIN.

Moosehead Lake at East Outlet, Maine.

Location.—At the wharf at the east outlet of the lake, about 8 miles from Kineo.

Records available.—April 1, 1895, to September 30, 1915. Tables of daily gage heights are published in Water Supply Papers 351, 381 and 401.

Drainage area.—1,240 square miles.

Gage.—Staff, at end of boat landing; two datums have been used at the east outlet; the original datum is at elevation 1,011.30 feet above mean sea level and approximately 10 feet below the sills of the outlet gates; gage is read to this datum; the second, to which all gage readings published to and including 1911 have been referred, is 10 feet higher; that is, the zero is at the sill of the gates. It is believed that low water may go below the sill of the gates (zero of second datum) and so gage heights in this report are published as read; that is, to the original datum 1,011.30 feet above mean sea level.

Artificial control.—The lake is regulated to a capacity of 23,735,000,000 cubic feet. The dam at the east outlet is controlled by 35 gates; 15 old gates are at gage height 10 feet (original datum) and 20 gates at sill-gate height 8 feet (original datum). At extreme low stages the flow from the lake is controlled not by the gates but by a bar above the dam at an approximate gage height of 9 feet (original datum). The records show only fluctuations in the level of the lake, and are used in the studies of regulation of the lake and in computing the natural flow of the Kennebec at The Forks station.

Storage capacity.—Approximately equal to a discharge of 124 second-feet for one month (30 days) for each tenth foot of depth over the surface of Moosehead Lake.

Coöperation.—Record kept and furnished for publication by the Hollingsworth & Whitney Co.

Kennebec River at the Forks, Maine.

Location.—At wooden highway bridge across river about 2,000 feet above the mouth of Dead River.

Records available.—September 28, 1901, to September 30, 1915.

Drainage area.—1,570 square miles.

Gages.—Standard chain, attached to bridge, a staff gage attached to timber retaining wall on left bank 75 feet above the bridge, and an automatic gage installed June 21, 1912, on the left abutment. Datum of gage unchanged.

Channel.—Practically permanent; unbroken by piers.

Discharge measurements.—Made from the bridge.

Winter flow.—Affected by ice.

Artificial control.—The flow of the Kennebec above The Forks is controlled through Moosehead Lake; Indian Pond, about 12 miles above the station, is under regulation for log driving from about May 1 to July 31 of each year.

Accuracy.—The relation between gage height and discharge is affected by the regulation of the stream for log driving and for the extensive waterpower plants below and, during the winter, by ice. The operation of the gates at Indian Pond Dam (from about May 1 to July 31 of each year) causes fluctuations in daily gage heights at The Forks ranging from 2 feet to more than 5 feet. A good rating curve has been developed for the station. Although set to the same datum in practically the same cross section, the automatic gage does not read the same as the chain gage above about 1.2 feet. A careful determination of the cross section of the water surface at chain-gage height 5.5 feet clearly showed the transverse slope and checked the table of relation at that stage. It should be noted that the left abutment is on the concave side of a distinct bend in the river and that the chain gage is about 9 feet from the left abutment. A discharge rating curve referred to automatic gage heights was developed from the discharge rating curve referred to chain-gage heights by means of the table of gage relation. Discharge for each 2-hour period, was computed from this rating curve and the daily discharge is the mean of the discharge for twelve periods and therefore more accurate than the discharge obtained by entering the rating table with the mean daily gage height.

Monthly Discharge of Kennebec River at The Forks, Maine.

[Drainage area, 1570 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912–1913					
October	1,810	896	1,430	.911	1.05
November	3,500	861	1,520	.968	1.08
December	2,540	1,460	1,830	1.17	1.35
January	2,460	1,840	2,210	1.41	1.63
February	2,570	2,330	2,440	1.55	1.61
March	3,810	1,480	2,560	1.63	1.88
April	12,400	3,300	7,250	4.62	5.16
May	10,100	2,550	4,170	2.66	3.07
June	6,140	2,260	3,480	2.22	2.48
July	3,860	2,450	3,320	2.11	2.43
August	4,080	1,860	2,590	1.65	1.90
September	2,040	602	1,590	1.01	1.13
The year	12,400	602	2,860	1.82	24.77
1913–1914					
October	2,240	602	1,090	.694	.8
November	2,200	602	853	.543	.61
December	2,330	707	1,310	.834	.96
January	4,880	1,960	3,420	2.18	2.51
February	2,080	1,630	1,910	1.22	1.27
March	2,600	255	1,190	.758	.87
April	5,870	1,240	2,590	1.65	1.84
May	17,000	3,320	8,180	5.21	6.01
June	5,020	1,380	3,470	2.21	2.47
July	3,840	1,860	3,040	1.94	2.24
August	3,630	2,110	2,760	1.76	2.03
September	3,520	1,270	1,680	1.07	1.19
The year	17,000	255	2,620	1.67	22.80
1914–1915					
October	1,550	1,090	1,250	0.796	0.92
November	1,180	450	1,040	.662	.74
December	1,430	950	1,190	.758	.87
January	1,430	700	957	.610	.70
February	1,030	770	852	.543	.57
March	1,070	395	787	.501	.58
April	3,320	300	1,440	.918	1.02
May	5,080	1,200	3,570	2.27	2.62
June	3,180	1,820	2,540	1.62	1.81
July	4,320	1,450	3,200	2.04	2.35
Augusta	4,260	635	1,750	1.11	1.28
September	2,550	600	1,830	1.16	1.29
The year	5,080	300	1,710	1.09	14.75

Monthly Discharge of Kennebec River at The Forks, Maine.

[As Corrected for Storage]

[Drainage area 1570 square miles]

Month	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	....	....	1,660	1.06	1.22
November	....	....	3,530	2.25	2.51
December	....	....	1,540	.981	1.13
January	....	....	1,850	1.18	1.36
February	....	....	1,240	.790	.82
March	....	....	3,220	2.05	2.36
April	....	....	8,930	5.69	6.35
May	....	....	4,180	2.66	3.07
June	....	....	2,870	1.83	2.04
July	....	....	1,740	1.11	1.28
August	....	....	455	.290	.33
September	....	....	300	.191	.21
The year period	....	....	2,630	1.67	22.68
1913-1914					
October	....	....	2,270	1.45	1.67
November	....	....	2,260	1.44	1.61
December	....	....	1,780	1.13	1.30
January	....	....	2,050	1.31	1.51
February	....	....	670	.427	.44
March	....	....	1,070	.682	.79
April	....	....	4,610	2.94	3.28
May	....	....	11,400	7.26	8.37
June	....	....	2,410	1.54	1.72
July	....	....	1,430	.911	1.05
August	....	....	570	.363	.42
September	....	....	400	.255	.28
The year	....	....	2,590	1.65	22.44
1914-1915					
October	....	....	720	.459	.53
November	....	....	800	.510	.57
December	....	....	840	.535	.62
January	....	....	665	.424	.49
February	....	....	787	.501	.52
March	....	....	1,370	.873	1.01
April	....	....	4,230	2.69	3.00
May	....	....	5,470	3.48	4.01
June	....	....	1,800	1.15	1.28
July	....	....	2,780	1.77	2.04
August	....	....	1,810	1.15	1.33
September	....	....	1,160	.739	.82
The year	....	....	1,880	1.20	16.22

Kennebec River at Waterville, Maine.

Location.—At the dam and mill of the Hollingsworth & Whitney Co., at Waterville, 2 miles above the mouth of Sebasticook River and about 3½ miles above the mouth of Messalonskee Stream.

Records available.—March 22, 1892, to September 30, 1915.

Drainage area.—4,270 square miles.

Gage.—Rod gages in the pond above the dam and in the tail-race of the mill.

Determination of discharge.—The discharge is computed from the flow over the dam, through the logway, and through 18 wheels of the mill. Most of the wheels were rated at Holyoke, Mass., under practically the same head as that used at Waterville—about 23 feet. Methods and diagrams for estimating the flow have been developed by the company, and the amount lost by leakage and used for washing and various purposes in the mill is estimated. When the flow of the river is less than about 3,500 second-feet all the water is used through the wheels.

Winter flow.—As a rule, not affected by ice. During most years the winter flow passes through the wheels of the mill.

Artificial control.—Numerous power plants and much storage above the station.

Accuracy.—Results are considered fair only, as many wheels are in operation and only one reading a day is made for each wheel, but the record is valuable because of its length and continuity.

Coöperation.—Records are obtained and estimates of daily discharge are furnished by the Hollingsworth & Whitney Co.

MONTHLY DISCHARGE OF KENNEBEC RIVER AT WATERVILLE, MAINE.

[Drainage area 4270 square miles]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	24,600	1,330	5,730	1.34	1.54
November	25,700	4,650	7,330	1.72	1.92
December	7,310	1,630	4,750	1.11	1.28
January	7,260	1,980	4,910	1.15	1.33
February	6,560	933	3,540	.829	.86
March	43,400	985	13,100	3.07	3.54
April	33,100	9,700	23,600	5.53	6.17
May	23,900	3,560	10,900	2.55	2.94
June	14,400	2,570	6,750	1.58	1.76
July	6,510	3,080	4,620	1.08	1.24
August	4,670	855	3,280	.768	.89
September	12,100	554	2,940	.688	.77
The year	43,400	554	7,620	1.78	24.24
1913-1914					
October	26,400	615	8,400	1.97	2.27
November	23,900	2,100	7,670	1.80	2.01
December	9,260	565	4,000	.936	1.08
January	4,700	415	3,500	.819	.94
February	4,590	2,070	3,580	.838	.87
March	11,700	2,060	4,970	1.16	1.34
April	57,000	5,630	20,900	4.89	5.46
May	54,300	8,960	23,600	5.53	6.38
June	11,000	1,240	5,660	1.32	1.47
July	6,000	1,310	4,070	.952	1.10
August	5,360	1,440	3,690	.864	1.00
September	4,400	547	2,500	.586	.65
The year	57,000	415	7,720	1.81	24.57
1914-1915					
October	4,840	840	2,190	0.513	0.59
November	4,840	503	2,170	.508	.57
December	3,900	686	2,190	.513	.59
January	5,260	585	2,560	.600	.69
February	31,600	834	4,820	1.13	1.18
March	16,700	767	6,950	1.63	1.88
April	41,700	3,770	17,800	4.17	4.65
May	44,200	9,090	20,900	4.70	5.42
June	13,900	692	4,700	1.12	1.25
July	39,700	972	8,350	1.96	2.26
August	16,200	641	6,010	1.41	1.63
September	6,240	963	3,290	.770	.86
The year	44,200	503	6,820	1.60	21.57

DEAD RIVER AT THE FORKS, MAINE.

LOCATION.— One and one-half miles west of The Forks.

RECORDS AVAILABLE.—September 29, 1901, to August 15, 1907; March 16, 1910 to September 30, 1915.

DRAINAGE AREA.—878 square miles.

GAGE.—Inclined staff bolted to large bowlder on the left bank, a short distance from observer's house; datum unchanged.

CHANNEL.—Practically permanent; banks medium high; overflowed only at extreme high water.

DISCHARGE MEASUREMENTS.—Made from a car suspended from a cable a short distance above the gage.

WINTER FLOW.—Affected by ice.

ARTIFICIAL CONTROL.—A number of dams on the lakes above; used solely for log driving.

ACCURACY.—Relation between gage height and discharge affected by ice during the winter and by the control of the stream for log driving during May and June. Special note is made of the length and time of the drive and of the maximum and minimum head used.

MONTHLY DISCHARGE OF DEAD RIVER AT THE FORKS, MAINE.

[Drainage area, 878 square miles.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	5,100	510	1,230	1.40	1.61
November	3,730	965	1,570	1.79	2.00
December	1,510	902	1,140	1.30	1.50
January	....	....	641	.73	.84
February	....	....	500	.57	.59
March	....	....	2,690	3.06	3.53
April	9,320	1,620	4,630	5.27	5.88
May	12,100	1,100	3,010	3.43	3.95
June	5,530	510	1,320	1.50	1.67
July	840	415	542	.62	.72
August	415	240	327	.37	.43
September	1,240	160	370	.42	.47
The year	12,100	160	1,500	1.71	23.19
1913-1914					
October	4,580	160	1,720	1.96	2.26
November	5,530	965	1,900	2.16	2.41
December	1,240	510	759	.86	.99
January	2,560	840	1,460	1.66	1.91
February	720	160	381	.434	.45
March	2,750	415	1,630	1.86	2.14
April	8,020	1,240	2,990	3.40	3.79
May	16,200	1,460	7,190	8.19	9.44
June	3,660	415	873	.994	1.11
July	415	160	289	.329	.38
August	902	160	389	.443	.51
September	902	100	231	.263	.29
The year	16,200	100	1,650	1.88	25.68
1914-1915					
October	1,320	100	457	0.521	0.60
November	840	325	483	.550	.61
December	1,030	325	562	.640	.74
January	965	160	365	.416	.48
February	6,140	160	848	.966	1.00
March	5,530	1,700	2,970	3.38	3.90
April	7,130	1,240	3,100	3.53	3.94
May	7,130	370	2,020	2.30	2.65
June	720	325	503	.573	.64
July	6,140	415	2,010	2.29	2.64
Augusta	4,100	415	1,330	1.51	1.74
September	780	325	425	.484	.54
The year	7,130	100	1,260	1.44	19.48

SANDY RIVER NEAR FARMINGTON, MAINE.

LOCATION.—At Fairbanks highway bridge, 3 miles above Farmington.

RECORDS AVAILABLE.—July 11, 1910, to September 30, 1915.

DRAINAGE AREA.—270 square miles.

GAGE.—Standard chain.

CHANNEL.—Practically permanent; left bank high; right bank subject to overflow in extreme freshets; current swift at high and medium stages but sluggish during low water.

DISCHARGE MEASUREMENTS.—Made from the bridge.

WINTER FLOW.—Affected by ice.

ARTIFICIAL CONTROL.—No storage basins above the station; the water-power dam at Phillips may slightly affect the flow at the station.

MONTHLY DISCHARGE OF SANDY RIVER AT FARMINGTON, ME.

[Drainage area, 270 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912–1913					
October	6,720	83	622	2.30	2.65
November	5,520	317	686	2.54	2.83
December	1,640	353	908	3.36	3.87
January	....	....	350	1.30	1.50
February	....	....	150	0.555	.58
March	....	....	1,820	6.74	7.77
April	4,250	517	1,640	6.07	6.77
May	2,690	251	691	2.56	2.95
June	940	83	238	.881	.98
July	787	67	120	.444	.51
August	83	19	51	.189	.22
September	2,420	25	184	.681	.76
The year	....	....	622	2.30	31.39
1913–1914					
October	6,120	83	1,030	3.81	4.39
November	6,500	251	894	3.31	3.69
December	853	221	456	1.69	1.95
January	....	....	270	1.00	1.15
February	....	....	135	.500	.52
March	....	....	405	1.50	1.73
April	7,250	560	1,890	7.00	7.81
May	5,600	283	1,450	5.37	6.19
June	725	83	181	.670	.75
July	431	67	128	.474	.55
August	431	52	119	.441	.51
September	193	38	82	.304	.34
The year	....	....	587	2.17	29.58

NOTE.—Owing to doubt concerning the accuracy of the records of gauge height at this station, the discharge for the year ending Sept. 30, 1915, is not published.

SEBASTICOOK RIVER AT PITTSFIELD, MAINE.

LOCATION.—At steel highway bridge just above the Maine Central Railroad bridge in the town of Pittsfield.

RECORDS AVAILABLE.—July 27, 1908, to September 30, 1915.

DRAINAGE AREA.—320 square miles.

GAGE.—Standard chain; datum unchanged.

CHANNEL.—Practically permanent; banks high and rocky and not subject to overflow; stream confined between the abutments of the bridge.

DISCHARGE MEASUREMENTS.—Made from the highway bridge.

WINTER FLOW.—Not affected by ice, as the rapid fall and proximity of the power plant immediately above the station tend to keep the river open.

ARTIFICIAL CONTROL.—About 800 feet upstream from the station is the dam of the Robert Dobson Co. and the Smith Woolen Co.; about half a mile farther upstream is the dam of the Waverly woolen mill. About 5 miles below the station and 2 miles from Burnham is the dam of the Sebasticook Power Co., but the fall of the stream prevents backwater from the lower dam.

ACCURACY.—The accuracy is more or less affected by fluctuations in stage caused by the operation of the dams above the station for night storage. Conditions favor the accurate determination of discharge, and a fair rating curve has been developed; a few more measurements are needed to closely determine the flow at extreme high and extreme low stages.

MONTHLY DISCHARGE OF SEBASTICOOK RIVER AT PITTSFIELD, MAINE.

[Drainage area, 320 square miles]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	1,040	50	330	1.03	1.19
November	2,200	485	1,040	3.25	3.63
December	706	310	477	1.49	1.72
January	838	352	554	1.73	1.99
February	540	50	348	1.09	1.14
March	3,260	230	1,140	3.56	4.10
April	3,260	792	1,960	6.12	6.83
May	745	125	308	.962	1.11
June	540	71	312	.975	1.09
July	250	50	153	.478	.55
August	193	50	120	.375	.43
September	250	50	143	.447	.50
The year	3,260	50	574	1.79	24.28

NOTE.—Owing to lack of information on stage when the mills above the station are shut down, tables of discharge for 1913-1915 are not published. Daily gauge height tables are published in Water Supply Papers, 381 and 401.

Cobbosseecontee Stream at Gardiner, Maine.

Location.—At the dam of the Gardiner Water Power Co. in the city of Gardiner.

Records available.—June 16, 1890 to September 30, 1915.

Drainage area.—220 square miles. Measured on recently completed topographic sheets. Value given in previous reports about 10 per cent too large. *See Accuracy.*

Gages.—One in pond above dam and one in tailrace of power house.

Determination of flow.—The discharge is determined by considering (1) the flow over the dam, usually nothing except for a short time in the spring; (2) the flow through two gates; and (3) the flow through a 39-inch Victor wheel installed in 1907. The computations of daily discharge are made by the engineers of the S. D. Warren Co. from tables of discharge based on careful experiments.

Winter flow.—Not affected by ice.

Artificial control.—The extensive lakes in the basin are controlled by storage dams and the stream affords a remarkable example of the regularity of flow that can be obtained with proper storage. Except for a short time in the spring no water is wasted.

Accuracy.—Results are considered good for a station of this type. Run-off per square mile and depth in inches on drainage area, as published in earlier reports, should be recomputed by means of new value for drainage area.

Coöperation.—Station maintained by the S. D. Warren Co., which furnished the records of daily discharge for publication.

MONTHLY DISCHARGE OF COBBOSSEECONTEE STREAM AT GARDINER, MAINE.

[Drainage area, 220 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912–1913					
October	210	0	174	.791	.91
November	260	0	211	.959	1.07
December	260	0	210	.955	1.10
January	280	0	232	1.05	1.21
February	280	0	240	1.09	1.14
March	820	0	413	1.88	2.17
April	1,660	0	747	3.40	3.79
May	250	0	220	1.00	1.15
June	842	0	274	1.24	1.38
July	250	0	211	.959	1.11
August	250	0	218	.991	1.14
September	200	0	161	.732	.82
The year	1,660	0	276	1.25	16.99
1913–1914					
October	250	0	192	.873	1.01
November	270	0	208	.945	1.05
December	270	0	234	1.06	1.22
January	270	0	235	1.07	1.23
February	280	0	234	1.06	1.10
March	1,050	0	700	3.18	3.67
April	1,570	545	1,180	5.36	5.98
May	1,040	0	313	1.42	1.64
June	250	0	217	.986	1.10
July	250	0	218	.991	1.14
August	250	0	209	.950	1.09
September	250	0	196	.891	.99
The year	1,570	0	345	1.57	21.22
1914–1915					
October	180	0	157	.714	.82
November	180	0	132	.600	.67
December	1[illegible]0	0	131	.595	.69
January	2[illegible]0	0	148	.673	.78
February	950	0	274	1.25	1.30
March	650	0	244	1.11	1.28
April	250	0	217	.986	1.10
May	250	0	183	.832	.96
June	200	0	169	.768	.86
July	700	0	255	1.16	1.34
August	250	0	210	.955	1.10
September	250	0	217	.986	1.10
The year	950	0	194	.882	12.00

ANDROSCOGGIN RIVER BASIN.

ANDROSCOGGIN RIVER AT ERROL DAM, N. H.

LOCATION.—Errol dam, 1 mile above the town of Errol, N. H.

RECORDS AVAILABLE.—January 1, 1905, to September 30, 1915.

DRAINAGE AREA.—1,095 square miles.

GAGE.—Movable rod gage; readings taken each day from the sill of deep gate No. 6; elevation of zero of gage or sill of gate is 1,231.3 feet above mean sea level.

DISCHARGE.—Computed from discharge through 14 gates in the dam by means of coefficients determined from a few discharge measurements.

The dam is a wooden structure completely housed over, about 175 feet between abutments. Extensive repairs were made on the dam during November and December, 1912. The entire flow passes through gates of different sizes, 14 in all. There is no provision for overflow besides the gates. Beginning at the left end, the gates are as follows:

One gate 10 feet deep by 15 feet wide, seldom used; three gates 10½ feet deep by 15 feet wide, open most of the time; nine gates 15 feet deep by 7 feet wide in the clear (so-called deep gates), open a portion of the time only; one gate 15 feet deep by 5 feet wide, gristmill gate and used only occasionally. The cap of all the 14 gates is one continuous beam and on the same level, thus making the bottom of the various gates at different levels.

A "deadhead" of 2.66 feet exists a short distance above the present dam, this point at present controlling the low flow.

The depth on the deep gates does not indicate the true height of water in Umbagog Lake on account of this "deadhead" formed by the old dam and by the bar at "Quick Water Point," the lowest point of which is about 4 feet above the sill of the present dam.

WINTER FLOW.—Little affected by ice.

ARTIFICIAL CONTROL.—Errol dam controls the storage of Umbagog Lake, the lower of the Rangeley series of lakes, comprising the principal storage of the Androscoggin River and amounting to about 19 billion cubic feet, and also a recently developed storage site on Magalloway River created by the Azicohos dam, which amounts to about 8 billion cubic feet, thus making the total storage about 28 billion cubic feet. Errol dam is located about 5 miles below the outlet of Umbagog Lake and about 3.5 miles below the mouth of Magalloway River, thus making this latter stream one of the feeders of Umbagog Lake.

ACCURACY.—The discharge is derived from coefficients applied to the various gate openings as determined from a number of current meter gagings. The ratings, however, are not as thorough as could be desired, and the results are considered very roughly approximate.

COÖPERATION.—Records are obtained and computations of daily discharge made under the direction of Mr. Walter H. Sawyer, agent for Union Water Power Co., who furnished the data.

Monthly Discharge of Androscoggin River at Errol Dam, New Hampshire.

[Drainage area, 1095 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1923					
October	1,730	976	1,410	1.29	1.49
November	....	....	1,450	1.32	1.47
December	....	....	1,450	1.32	1.52
January	2,520	1,300	2,040	1.86	2.14
February	2,360	1,740	2,050	1.87	1.95
March	5,550	2,050	2,790	2.55	2.94
April	6,700	3,500	4,740	4.33	4.83
May	6,700	1,620	3,060	2.79	3.22
June	5,030	1,820	2,590	2.37	2.64
July	2,140	1,820	1,950	1.78	2.05
August	2,290	1,760	2,040	1.86	2.14
September	1,980	660	1,690	1.54	1.72
The year	....	....	2,270	2.07	28.11
1913-1914					
October	1,730	604	1,300	1.19	1.37
November	1,640	398	1,210	1.11	1.24
December	2,180	1,430	1,790	1.63	1.88
January	1,890	1,770	1,840	1.68	1.94
February	1,930	1,790	1,840	1.68	1.75
March	1,890	1,380	1,650	1.51	1.74
April	1,570	712	1,150	1.05	1.17
May	7,080	596	2,330	2.13	2.46
June	1,750	1,360	1,540	1.40	1.56
July	1,890	1,040	1,560	1.42	1.64
August	1,780	1,260	1,660	1.52	1.75
September	2,070	1,380	1,760	1.61	1.80
The year	7,080	398	1,640	1.50	20.30
1914-1915					
October	1,840	1,340	1,670	1.52	1.75
November	1,880	1,340	1,630	1.49	1.66
December	1,650	1,260	1,510	1.38	1.59
January	1,730	1,380	1,540	1.41	1.63
February	1,620	840	1,410	1.29	1.34
March	1,520	1,020	1,220	1.11	1.28
April	1,340	*80	917	.838	.94
May	1,380	481	1,100	1.00	1.15
June	1,530	983	1,320	1.20	1.34
July	1,280	*80	808	.738	.85
August	1,240	240	840	.767	.88
September	1,670	951	1,450	1.32	1.47
The year	1,880	*80	1,280	1.17	15.88

Note.—* Leakage only.

Androscoggin River, Berlin, N. H.

Location.—Berlin, N. H., at the upper dam of the Berlin Mills Co.

Records available.—October 1, 1913 to September 30, 1915.

Drainage area.—1,350 square miles.

GAGES.—Fixed gages are maintained in the river above the forebay racks and in the tailrace immediately below the outlet of the wheels. These gages are referred to the same datum. To each wheel gate a gage is attached, from which the gate opening can be ascertained.

DISCHARGE.—Computed from records prepared from Holyoke tests of the wheel runners. Water running to waste over the dam is computed by the Francis Formula for discharge over weirs.

WINTER FLOW.—Not affected by ice.

ARTIFICIAL CONTROL.—Under an agreement between the large power users on the Androscoggin River the flow at Berlin, N. H., is maintained at a minimum of 1,550 cubic feet per second and at such a higher point above 1,550 cubic feet per second as is consistent with the constant maintenance of the above mentioned quantity.

The actual fine regulation of the river is carried on at Pontocook Dam, N. H., above which point there is a pond containing about one day's supply.

The course regulation of the river is made at Errol, N. H., about 30 miles above Berlin.

In the event of a rain or a sudden thaw in the winter the gates at Errol are closed, and water is accumulated in Umbagog Lake. If it is found that the area between Pontocook and Berlin is supplying sufficient water to maintain the flow at the desired quantity, the gates in Pontocook are closed and water retained in the pond above that dam. In the event of a sudden cold snap which will check the flow of the river, or in the event of a reduction of the flow by evaporation on hot, windy days, a portion of the water in Pontocook is discharged through the gates, in order that the flow may be kept constant, and the gates in Errol are partially opened to make up the deficiency.

ACCURACY.—The discharge being computed from curves prepared from the Holyoke test of the runners is probably correct within 2%.

COÖPERATION.—The readings are furnished by Mr. Walter H. Sawyer, engineer of the Union Water Power Co., at Lewiston, Me.

Monthly Discharge of Androscoggin River at Berlin, N. H.

[Drainage area, 1350 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1913–1914					
October	2,420	1,600	1,770	1.31	1.51
November	4,770	1,600	1,840	1.36	1.52
December	2,350	1,690	1,920	1.42	1.64
January	2,020	1,690	1,840	1.36	1.57
February	1,820	1,550	1,700	1.26	1.31
March	2,600	1,640	1,950	1.44	1.66
April	10,500	1,500	3,220	2.39	2.67
May	14,300	1,560	4,890	3.62	4.17
June	1,990	1,700	1,810	1.34	1.50
July	2,120	1,620	1,800	1.33	1.53
August	1,850	1,650	1,740	1.29	1.49
September	1,880	1,600	1,750	1.30	1.45
The year	14,300	1,500	2,190	1.62	22.02
1914–1915					
October	1,750	1,600	1,730	1.28	1.48
November	1,800	1,560	1,700	1.26	1.41
December	1,790	1,530	1,640	1.21	1.40
January	1,660	1,520	1,580	1.17	1.35
February	2,600	1,430	1,600	1.18	1.23
March	2,000	1,100	1,430	1.06	1.22
April	4,000	1,000	2,300	1.70	1.90
May	3,850	1,540	1,950	1.44	1.66
June	1,610	1,460	1,540	1.14	1.27
July	4,300	1,470	1,750	1.30	1.50
August	2,110	1,530	1,640	1.21	1.40
September	1,840	1,400	1,690	1.25	1.40
The year	4,300	1,000	1,710	1.27	17.22

Androscoggin River at Rumford Falls, Maine.

Location.—Dam of the Rumford Falls Power Co., at Rumford Falls.

Records available.—May 18, 1892, to September 30, 1915.

Drainage area.—2,090 square miles.

Gage.—One located in pond above dam and one in tailrace of power house.

Discharge.—Computed from discharge over the dam, using the customary Francis weir formula with modified coefficient, and the quantities passing through the various wheels of the power house, which have been thoroughly rated.

Winter flow.—Little affected by ice.

Artificial control.—The storage in the Rangeley system of lakes at the headwaters of Androscoggin River, aggregating 28,000,000,000 cubic feet, is largely under complete control. The stored water is regulated in the interests of the waterpower users below and is under such excellent management that this is one of the best water-power streams in the country.

Accuracy.—Results are believed to be excellent.

Coöperation.—Records are obtained from Mr. Charles A. Mixer, engineer Rumford Falls Power Co.

Monthly Discharge of Androscoggin River at Rumford, Maine.

[Drainage area, 2090 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	12,840	1,850	3,050	1.46	1.68
November	9,170	2,400	3,150	1.51	1.68
December	4,660	1,720	2,790	1.34	1.54
January	4,030	2,520	3,080	1.47	1.70
February	3,450	2,220	2,550	1.22	1.27
March	19,100	1,990	6,630	3.17	3.66
April	14,700	6,120	8,480	4.06	4.53
May	9,140	2,320	5,360	2.56	2.95
June	7,710	1,800	3,650	1.75	1.95
July	3,480	1,510	2,230	1.07	1.23
August	2,350	1,480	2,000	.957	1.10
September	8,490	1,260	2,130	1.02	1.14
The year	19,100	1,260	3,760	1.80	24.43
1913-1914					
October	13,800	1,850	3,700	1.77	2.04
November	22,000	2,400	4,010	1.92	2.14
December	3,320	1,880	2,530	1.21	1.40
January	2,720	1,930	2,360	1.13	1.30
February	2,680	1,920	2,150	1.03	1.07
March	5,930	2,110	3,170	1.51	1.74
April	23,900	2,820	6,910	3.31	3.69
May	16,100	1,900	6,820	3.26	3.76
June	2,960	1,860	2,230	1.07	1.19
July	3,080	1,650	2,140	1.02	1.18
August	3,170	1,600	2,000	.956	1.10
September	2,300	1,550	1,830	.876	.98
The year	23,900	1,550	3,320	1.59	21.59
1914-1915					
October	1,990	1,600	1,760	0.842	0.97
November	3,030	1,540	1,890	.904	1.01
December	3,060	1,340	1,790	.856	.99
January	3,970	1,460	2,000	.957	1.10
February	13,900	1,680	2,800	1.34	1.40
March	3,400	1,470	2,150	1.03	1.19
April	11,800	1,570	4,380	2.10	2.34
May	10,300	1,710	3,140	1.50	1.73
June	2,460	1,470	1,830	.876	.98
July	17,100	1,520	3,390	1.62	1.87
August	4,400	1,290	2,610	1.25	1.44
September	2,880	1,250	1,900	.909	1.01
The year	17,100	1,250	2,470	1.18	16.03

MAGALLOWAY RIVER, AZISCOHOS DAM.

LOCATION.—About 15 miles above the mouth of the Magalloway River. Outlet is into Androscoggin River above Errol Dam.

RECORDS AVAILABLE.—January 1, 1912, to September 30, 1915.

DRAINAGE AREA.—215 square miles.

GAGE.—"Readings giving the head acting on gates are taken from cast iron gages, the upper one being fastened securely to the concrete gate tower, and the lower one to one of the concrete buttresses."

DETERMINATION OF DISCHARGE.—The balanced cylinder gate valves through which the water is discharged are provided with scales so the amount of gate opening may be determined very closely. The discharge of the gates at different gate openings was ascertained by current meter measurements at a specially prepared station about a mile below the dam.

ARTIFICIAL CONTROL.—The lake with a storage capacity of about 9,593,000,000 cubic feet is wholly under artificial control and the discharge represents such amounts as are required for the water power interests below. The operation of the gates is planned to maintain as nearly as possible a constant flow at Berlin, N. H.

COÖPERATION.—Discharge computed and furnished for publication by Walter H. Sawyer, Agent, Union Water Power Co., Lewiston, Maine. He has requested that monthly discharge only be published.

MONTHLY DISCHARGE OF MAGALLOWAY RIVER AT AZISCOHOS DAM, MAINE.

[Drainage area, 215 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	....	....	490	2.28	2.63
November	....	....	906	4.21	4.70
December	....	....	1,290	6.00	6.92
January	1,320	78	695	3.23	3.72
February	1,440	1,100	1,200	5.58	5.81
March	1,610	55	310	1.44	1.66
April	706	78	237	1.10	1.23
May	1,580	94	502	2.33	2.69
June	1,420	93	549	2.55	2.84
July	2,200	45	977	4.54	5.23
August	89	43	84	.391	.45
September	1,500	86	1,090	5.07	5.66
The year	....	....	694	3.23	43.54
1913-1914					
October	1,400	143	913	4.25	4.90
November	1,180	151	309	1.44	1.61
December	1,940	204	1,380	6.42	7.40
January	913	422	667	3.10	3.57
February	422	43	322	1.50	1.56
March	344	46	69	.321	.37
April	70	53	60	.279	.31
May	149	70	94	.437	.50
June	1,010	80	199	.926	1.03
July	605	99	140	.651	.75
August	100	80	91	.423	.49
September	104	57	89	.414	.46
The year	1,940	43	361	1.68	22.95
1914-1915					
October	956	88	264	1.23	1.42
November	1,190	669	974	4.53	5.05
December	894	385	687	3.20	3.69
January	1,200	1,000	1,100	5.12	5.90
February	1,850	898	1,190	5.54	5.77
March 1-13, 23-31	1,890	860	1,540	7.16	5.86
April	1,800	54	573	2.67	2.98
May	1,040	69	127	.591	.68
June	1,320	75	789	3.67	4.10
July	150	74	97	.451	.52
August	147	80	125	.582	.67
September	175	93	113	.526	.59
The *period	1,890	54	607	2.82	37.23

NOTE.—* 356 days.

Little Androscoggin River Near South Paris.

Location.—At Biscoe Falls, 5½ miles above South Paris.

Records available.—September 14, 1913, to September 30, 1915.

Drainage area.—75 square miles.

Gage.—Standard chain on timber fastened to 3 inch W. I. pipe set in concrete.

Channel.—Rock.

Discharge measurements.—Made at low stages by wading in the flume at the old dam; at medium and high stages from the highway bridge 250 feet above.

Artificial control.—Flow depends somewhat on the discharge from dams at Snow's Falls, 1½ miles above the station, and at West Paris, 4 miles above.

Accuracy.—A well defined rating curve has been developed up to 5 feet gage height. On account of uncertainty in the curve above this point the discharge will not be published until further information is obtained.

Station established.—September 14, 1913.

PRESUMPSCOT RIVER BASIN.

PRESUMPSCOT RIVER AT OUTLET OF SEBAGO LAKE, MAINE.

LOCATION.—Outlet dam at Sebago Lake and the hydroelectric plant at Eel Weir Falls, 1 mile below lake outlet.

RECORDS AVAILABLE.—January 1, 1887, to September 30, 1915.

DRAINAGE AREA.—436 square miles.

GAGES.—On the bulkhead of the gatehouse at the outlet dam and in the fore bay and tailrace of the power plant.

DISCHARGE.—Prior to March, 1904, the discharge was deduced from the records of the opening of the gates in the dam, the discharge capacity of which under different conditions of head has been determined and tabulated by Mr. Hiram F. Mills, of Lowell.

In March, 1904, a hydroelectric plant was completed at Eel Weir Falls, the water being brought directly from the outlet dam to the plant by means of a canal about a mile long. This new plant has necessitated a different method of recording the flow from the lake. The water passes through three pairs of 30-inch Hercules wheels, the amount being recorded by three Allen meters, one on each pair. These meters were rated by the result of a test at Holyoke, Mass., of one pair of wheels. Since the station was finished the performance of the wheels and of the recording meters has been checked by current-meter measurements, brake tests of the wheels, and electrical readings of the generator output. It is usually desired to keep a constant flow through the canal, and when demands for power are not sufficient to utilize the entire flow through the wheels, the excess of water is run off through a pair of regulating gates at the power station. A record of the opening of these gates is kept and the flow computed from a coefficient determined from current-meter tests.

At times the flow from the lake may be greater than is safe to carry through the canal, though this has not yet happened. At such times it will be necessary to draw a part of the water through the old regulating gates in the main dam.

WINTER FLOW.—No trouble from ice.

ARTIFICIAL CONTROL.—Sebago Lake, with an area of 46 square miles, is under complete control for storage. It is a magnificent natural storage reservoir and its utilization for this purpose has made the flow of the Presumpscot extremely regular.

ACCURACY.—Results very good for a station of this type.

COÖPERATION.—Records obtained and computations of daily discharge made and furnished by the S. D. Warren Co.

MONTHLY DISCHARGE OF PRESUMPSCOT RIVER AT OUTLET SEBAGO LAKE, MAINE.

[Drainage area 436 square miles]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1912-1913					
October	678	223	611	1.40	1.61
November	680	228	601	1.38	1.54
December	823	233	678	1.56	1.80
January	813	233	644	1.48	1.71
February	823	238	727	1.67	1.74
March	810	80	572	1.31	1.51
April	743	165	590	1.35	1.51
May	670	217	592	1.36	1.57
June	673	228	596	1.37	1.53
July	672	220	592	1.36	1.57
August	673	208	616	1.41	1.63
September	680	245	611	1.40	1.56
The year	823	80	619	1.42	19.28
1913-1914					
October	675	163	586	1.34	1.54
November	842	113	617	1.42	1.58
December	678	202	583	1.34	1.54
January	750	212	592	1.36	1.57
February	728	260	614	1.41	1.47
March	673	195	484	1.11	1.28
April	670	138	449	1.03	1.15
May	748	132	550	1.26	1.45
June	702	260	582	1.33	1.48
July	786	117	567	1.30	1.50
August	772	255	639	1.47	1.70
September	783	330	676	1.55	1.73
The year	842	113	578	1.33	17.99
1914-1915					
October	802	198	661	1.52	1.75
November	676	242	567	1.30	1.45
December	680	257	578	1.33	1.53
January	685	182	527	1.21	1.40
February	678	180	498	1.14	1.19
March	622	170	495	1.14	1.31
April	657	180	457	1.05	1.17
May	485	50.0	361	.828	.95
June	420	56.7	278	.638	.71
July	358	8.3	176	.404	.47
August	540	66.7	388	.890	1.03
September	693	45.0	527	1.21	1.35
The year	802	8.3	459	1.05	14.31

SACO RIVER BASIN.

SACO RIVER AT WEST BUXTON, MAINE.

LOCATION.—At hydroelectric plant of the Portland Electric Co. at West Buxton, Maine.

RECORDS AVAILABLE.—October 19, 1907, to September 30, 1915.

DRAINAGE AREA.—1,550 square miles.

GAGES.—One in pond above dam and one in tailrace of power house.

CHANNEL.—Crest of the concrete dam, about 300 feet long.

DISCHARGE.—The flow over the dam and through the rated wheels of the power plant is determined by means of readings every hour of the gages and gate openings.

WINTER FLOW.—No trouble from ice.

ARTIFICIAL CONTROL.—There are dams on numerous although comparatively small lakes in the basin above the station. Regulation of storage probably has some effect on the regimen of the stream but not to the extent that obtains in the other basins in the State of Maine, where natural storage facilities are better and more fully developed.

ACCURACY.—Reprogle friction type of governors used with little change in gate openings, and fluctuations in load are taken up at the Bonney Eagle development. S. Morgan Smith wheels with Holyoke rating under similar head are used, and results are believed to be good for a station of this type.

COÖPERATION.—Records furnished by the Cumberland County Power & Light Co.

Monthly Discharge of Saco River at West Buxton, Maine.

[Drainage area, 1550 square miles]

Month.	Discharge in Second-Feet. Maximum.	Minimum.	Mean.	Per square mile.	Run-off—Depth in inches on drainage area.
1912-1913					
October	3,930	690	1,550	1.00	1.15
November	4,660	1,400	2,950	1.90	2.12
December	2,540	1,030	1,830	1.18	1.36
January	3,510	2,220	2,830	1.83	2.11
February	2,590	1,120	1,960	1.26	1.31
March	15,800	1,190	6,220	4.01	4.62
April	14,000	4,870	8,140	5.25	5.86
May	5,410	2,350	3,710	2.39	2.76
June	4,760	1,150	2,410	1.55	1.73
July	1,360	763	999	.645	.74
August	1,040	294	682	.440	.51
September	2,650	291	931	.601	.67
The year	15,800	291	2,850	1.84	24.94
1913-1914					
October	5,910	1,680	3,300	2.13	2.46
November	6,800	2,430	4,610	2.97	3.31
December	3,550	1,560	2,470	1.59	1.83
January	2,620	1,010	1,690	1.09	1.26
February	2,870	1,070	1,910	1.23	1.28
March	9,470	929	5,750	3.71	4.28
April	16,000	6,940	10,200	6.62	7.39
May	10,900	3,180	7,120	4.59	5.29
June	4,510	920	2,040	1.32	1.47
July	2,130	907	1,390	.896	1.03
August	1,610	628	1,080	.696	.80
September	1,470	553	925	.596	.66
The year	16,000	553	3,540	2.28	31.06
1914-1915					
October	997	428	692	0.446	0.51
November	1,320	615	861	.556	.62
December	1,290	393	907	.586	.68
January	2,490	533	1,380	.891	1.03
February	9,290	1,300	2,780	1.79	1.86
March	9,120	2,710	4,720	3.04	3.50
April	7,960	2,360	5,120	3.30	3.68
May	6,830	1,410	3,860	2.50	2.88
June	2,150	740	1,340	.865	.97
July	8,690	1,060	4,240	2.74	3.16
August	3,820	1,950	2,820	1.82	2.10
September	2,340	1,190	1,710	1.10	1.23
The year	9,290	393	2,540	1.64	22.22

INDEX.

A.

B.

C.

D.

E

F.

G.

I.

K.

L.

M.

P.

R.

S.