DEPARTMENT OF THE INTERIOR

NITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 264

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1909

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RED UNDER THE DIRECTION OF M. O. LEIGHTON

BY

C. C. COVERT, A. H. HORTON
AND R. H. BOLSTER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

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By C. C. Covert, A. H. Horton, and R. H. Bolster.

INTRODUCTION.

AUTHORITY FOR INVESTIGATIONS.

This volume contains results of flow measurements made on certain streams in the United States. The work was performed by the water-resources branch of the United States Geological Survey, either independently or in cooperation with organizations mentioned herein. These investigations are authorized by the organic law of the Geological Survey (Stat. L., vol. 20, p. 394), which provides, among other things, as follows:

Provided that this officer [the Director] shall have the direction of the Geological Survey and the classification of public lands and examination of the geological structure, mineral resources, and products of the national domain.

Inasmuch as water is the most abundant and most valuable mineral in nature, the investigation of water resources is included under the above provision for investigating mineral resources. The work has been supported since the fiscal year ending June 30, 1895, by appropriations in successive sundry civil bills passed by Congress under the following item:

For gaging the streams and determining the water supply of the United States, and for the investigation of underground currents and artesian wells, and for the preparation of reports upon the best methods of utilizing the water resources.

The various appropriations that have been made for this purpose are as follows:

Annual appropriations for the fiscal year ending June 30—

1895	$12,500
1896	20,000
1897 to 1900, inclusive	50,000
1901 to 1902, inclusive	100,000
1903 to 1906, inclusive	200,000
1907	150,000
1908 to 1910, inclusive	100,000
1911	150,000

SCOPE OF INVESTIGATIONS.

These investigations are not complete, nor do they include all the river systems, or parts thereof, that might purposefully be studied. The scope of the work is limited by the appropriations available. The field covered is the widest and the character of the work is believed to be the best possible under the controlling conditions. The work would undoubtedly have greater scientific importance and ultimately be of more practical value if the money now expended for wide areas were concentrated on a few small drainage basins; but such a course is impossible because general appropriations made by Congress are applicable to all parts of the country. Each part demands its proportionate share of the benefits.

It is essential that records of stream flow shall be kept during a period of years long enough to determine within reasonable limits the entire range of flow from the absolute maximum to the absolute minimum. The length of such a period manifestly differs for different streams. Experience has shown that the records for some streams should cover from five to ten years, and for other streams twenty years or even more, the limit being determined by the relative importance of the stream and the interdependence of the results and other long-time records on adjacent streams.

In the performance of this work an effort is made to reach the highest degree of precision possible with a rational expenditure of time and a judicious expenditure of a small amount of money. In all engineering work there is a point beyond which refinement is needless and wasteful, and this statement applies with especial force to stream-flow measurements. It is confidently believed that the stream-flow data presented in the publications of the Survey are in general sufficiently accurate for all practical purposes. Many of the records are, however, of insufficient length, owing to the unforeseen reduction of appropriations and consequent abandonment of stations. All persons are cautioned to exercise the greatest care in using such incomplete records.

Records have been obtained at more than 1,550 different points in the United States, and in addition the surface water supply of small areas in Seward Peninsula and the Yukon-Tanana region, Alaska, has been investigated. During 1909 regular gaging stations were maintained by the Survey and cooperating organizations at about 850 points in the United States, and many miscellaneous measurements were made at other points. Data were also obtained in regard to precipitation, evaporation, storage reservoirs, river profiles, and water power in many sections of the country, and will be made available in the regular surface water-supply papers and in special papers from time to time.

PURPOSES OF THE WORK.

The results contained in this volume are requisite to meet the immediate demands of many public interests, including navigation, irrigation, domestic water supply, water power, swamp and overflow land drainage, and flood prevention.

Navigation.—The Federal Government has expended more than $250,000,000 for the improvement of inland navigation, and prospective expenditures will approximate several times this amount. It is obvious that the determination of stream flow is necessary to the intelligent solution of the many problems involved.

Irrigation.—The United States is now expending $51,000,000 on federal irrigation systems, and this amount is far exceeded by the private expenditures of this nature in the arid West. The integrity of any irrigation system depends absolutely on the amount of water available. Therefore investigations of stream flow in that portion of the country are not only of first importance in the redemption of the lands, but constitute an insurance of federal and private investments.

Domestic water supply.—The highest use of water is for domestic supply, and although this branch of the subject is of less direct federal interest than the branches already named, it nevertheless has so broad a significance with respect to the general welfare that the Federal Government is ultimately and intimately concerned.

Water power.—The development of the water power of the country is an economic necessity. Our stock of coal is being rapidly depleted and the cost of steam power is increasing accordingly. Industrial growth and, as a consequence, the progress of the United States as a nation will cease if cheap power is not available. Water power affords the only avenue now open. When the electric transmission of power was accomplished the relation of our water powers to national economy changed entirely. Before the day of electric transmission water power was important only at the locality at which it was generated, but it has now become a public utility in which the individual citizen is vitally interested. Inasmuch as the amount of water power that may be made available depends on the flow of rivers, the investigation of flow becomes a prerequisite in the judicious management of this source of energy.

Drainage of swamp and overflowed lands.—More than 70,000,000 acres of the richest land in this country are now practically worthless or of precarious value by reason of overflow and swamp conditions. When this land is drained it becomes exceedingly productive and its value increases many fold. Such reclamation would add to the national assets at least $700,000,000. The study of run-off is the first consideration in connection with drainage projects. If by the drainage of a large area into any particular channel that channel becomes so gorged with water which it had not hitherto been called on to convey that overflow conditions are created in places where previously the land was not subject to inundation, then drainage results merely in an exchange of land values. This is not the purpose of drainage improvement.

Flood prevention.—The damage from floods in the United States probably exceeds on the average $100,000,000 annually, and in the year 1908, according to estimates based on reliable data, the aggregate damage approximated $250,000,000. Such an annual tax on the property of great regions should be reduced in the orderly progress of government. It goes without saying that any consideration of flood prevention must be based on a thorough knowledge of stream flow, both in the contributing areas which furnish the water and along the great lowland rivers.

PUBLICATIONS.

The data on stream flow collected by the United States Geological Survey since its inception have appeared in the annual reports, bulletins, and water-supply papers. Owing to natural processes of evolution and to changes in governmental requirements, the character of the work and the territory covered by these different publications have varied greatly. For the purpose of uniformity in the presentation of reports a general plan has been agreed upon by the United States Reclamation Service, the United States Forest Service, the United States Weather Bureau, and the United States Geological Survey, according to which the area of the United States has been divided into twelve parts whose boundaries coincide with certain natural drainage lines. The areas so described are indicated by the following list of papers on surface water supply for 1909. The dividing line between the North Atlantic and South Atlantic drainage areas lies between York and James rivers.

Papers on surface water supply of the United States, 1909.

Part.	No.	Title.	Part.	No.	Title.
I	261	North Atlantic coast.	VI	266	Missouri River basin.
II	262	South Atlantic coast and eastern Gulf of Mexico	VII	267	Lower Mississippi River basin.
			VIII	268	Western Gulf of Mexico.
III	263	Ohio River basin.	IX	269	Colorado River basin.
IV	264	St. Lawrence River basin.	X	270	Great Basin.
V	265	Upper Mississippi River and Hudson Bay basins.	XI	271	California.
			XII	272	North Pacific coast.

The following table gives the character of data regarding stream flow at regular stations to be found in the various publications of the United States Geological Survey exclusive of all special papers.

Numbers of reports are inclusive and dates also are inclusive so far as the data are available:

Stream-flow data in reports of the United States Geological Survey.

[Ann.=Annual Report; B.=Bulletin; W. S.=Water-Supply Paper.]

Report.	Character of data.	Year.
10th Ann., pt. 2	Descriptive information only	
11th Ann., pt. 2	Monthly discharge	1884 to Sept., 1890.
12th Ann., pt. 2	....do	1884 to June 30, 1891.
13th Ann., pt. 3	Mean discharge in second-feet	1884 to Dec. 31, 1892.
14th Ann., pt. 2	Monthly discharge (long-time records, 1871 to 1893)	1888 to Dec. 31, 1893.
B. 131	Descriptions, measurements, gage heights, and ratings	1893 and 1894.
16th Ann., pt. 2	Descriptive information only	
B. 140	Descriptions, measurements, gage heights, ratings, and monthly discharge (also many data covering earlier years).	1895.
W. S. 11	Gage heights (also gage heights for earlier years)	1896.
18th Ann., pt. 4	Descriptions, measurements, ratings, and monthly discharge (also similar data for earlier years).	1895 and 1896.
W. S. 15	Descriptions, measurements, and gage heights, eastern United States, eastern Mississippi River, and Missouri River above junction with Kansas.	1897.
W. S. 16	Descriptions, measurements, and gage heights, western Mississippi River below junction of Missouri and Platte, and western United States.	1897.
19th Ann., pt. 4	Descriptions, measurements, ratings, and monthly discharge (also some long-time records).	1897.
W. S. 27	Measurements, ratings, and gage heights, eastern United States, eastern Mississippi River, and Missouri River.	1898.
W. S. 28	Measurements, ratings, and gage heights, Arkansas River and western United States.	1898.
20th Ann., pt. 4	Monthly discharge (also for many earlier years)	1898.
W. S. 35 to 39	Descriptions, measurements, gage heights, and ratings	1899.
21st Ann., pt 4	Monthly discharge	1899.
W. S. 47 to 52	Descriptions, measurements, gage heights, and ratings	1900.
22d Ann., pt. 4	Monthly discharge	1900.
W. S. 65, 66	Descriptions, measurements, gage heights, and ratings	1901.
W. S. 75	Monthly discharge	1901.
W. S. 82 to 85	Complete data	1902.
W. S. 97 to 100	....do	1903.
W. S. 124 to 135	....do	1904.
W. S. 165 to 178	....do	1905.
W. S. 201 to 214	Complete data, except descriptions	1906.
W. S. 241 to 252	Complete data	1907-8.
W. S. 261 to 272	....do	1909.

NOTE.—No data regarding stream flow are given in the 15th and 17th annual reports.

The records at most of the stations discussed in these reports extend over a series of years. An index of the reports containing records prior to 1904 has been published in Water-Supply Paper 119. The first table which follows gives, by years and drainage basins, the numbers of the papers on surface water supply published from 1899 to 1909. Wherever the data for a drainage basin appear in two papers the number of one is placed in parentheses and the portion of the basin covered by that paper is indicated in the second table. For example, in 1904 the data for Missouri River were published in Water-Supply Papers 130 and 131, and the portion of the records contained in Water-Supply Paper 131, as indicated by the second table, is that relating to Platte and Kansas rivers.

Numbers of water-supply papers containing results of stream measurements, 1899–1909.

	1899.[a]	1900.[b]	1901.	1902.	1903.	1904.	1905.	1906.	1907–8.	1909.
Atlantic coast and eastern Gulf of Mexico:										
New England rivers.	35	47	65, 75	82	97	124	165	201	241	261
Hudson River to Delaware River, inclusive	35	47,(48)	65, 75	82	97	125	166	202	241	261
Susquehanna River to York River, inclusive	35	48	65, 75	82	97	126	167	203	241	261
James River to Yadkin River, inclusive	(35),36	48	65, 75	(82),83	(97),98	126	167	203	242	262
Santee River to Pearl River, inclusive	36	48	65, 75	83	98	127	168	204	242	262
St. Lawrence River	36	49	65, 75	(82),83	97	129	170	206	244	264
Hudson Bay	....	....	66, 75	85	100	130	171	207	245	265
Mississippi River:										
Ohio River	36	48,(49)	65, 75	83	98	128	169	205	243	263
Upper Mississippi River.	36	49	65, 75	83	98,(99)	128, (130)	171	207	245	265
Missouri River	(36),37	49,(50)	66, 75	84	99	130, (131)	172	208	246	266
Lower Mississippi River.	37	50	(65), 66, 75	(83),84	(98),99	(128), 131	(169), 173	(205), 209	247	267
Western Gulf of Mexico.	37	50	66, 75	84	99	132	174	210	248	268
Pacific coast and Great Basin:										
Colorado River	(37),38	51	66, 75	85	100	133, (134)	175, (177)	211, (213)	249, (251)	269, (271)
Great Basin	38,(39)	50	66, 75	85	100	133, (134)	176, (177)	212, (213)	250, (251)	270, (271)
South Pacific coast to Klamath River, inclusive	(38),39	51	66, 75	85	100	134	177	213	251	271
North Pacific coast.	38	51	66, 75	85	100	135	(177), 178	214	252	272

[a] Rating tables and index to Water-Supply Papers 35–39 contained in Water-Supply Paper 39.

[b] Rating tables and index to Water-Supply Papers 47–52 and data on precipitation, wells, and irrigation in California and Utah contained in Water-Supply Paper 52.

Numbers of water-supply papers containing data covering portions of drainage basins.

No.	River basin.	Tributaries included.
35	James	
36	Missouri	Gallatin.
37	Colorado	Green, Gunnison, Grand above junction with Gunnison.
38	Sacramento	Except Kings and Kern.
39	Great Basin	Mohave.
48	Delaware	Wissahickon and Schuylkill.
49	Ohio	Scioto.
50	Missouri	Loup and Platte near Columbus, Nebr. All tributaries below junction with Platte.
65	Lower Mississippi	Yazoo.
82	James	
	St. Lawrence	Lake Ontario, tributaries to St. Lawrence River proper.
83	Lower Mississippi	Yazoo.
97	James	
98	Lower Mississippi	Do.
99	Upper Mississippi	Tributaries from the west.
128	Lower Mississippi	Yazoo.
130	Upper Mississippi	Tributaries from the west.
131	Missouri	Platte, Kansas.
134	Colorado	Data near Yuma, Ariz., repeated.
	Great Basin	Susan, Owens, Mohave.
169	Lower Mississippi	Yazoo.
177	Colorado	Below junction with Gila.
	Great Basin	Susan repeated, Owens, Mohave.
	North Pacific coast	Rogue, Umpqua, Siletz.
205	Lower Mississippi	Yazoo, Homochitto.
213	Colorado	Data at Hardyville repeated; at Yuma, Salton Sea.
	Great Basin	Owens, Mohave.
251	Colorado	Yuma and Salton Sea stations repeated.
271	Great Basin	Owens River basin.

The order of treatment of stations in any basin in these papers is downstream. The main stem of any river is determined on the basis of drainage area, local changes in name and lake surface being disregarded. After all stations from the source to the mouth of the main stem of the river have been given, the tributaries are taken up in regular order from source to mouth. The tributaries are treated the same as the main stream, all stations in each tributary basin being given before taking up the next one below.

The exceptions to this rule occur in the records for Mississippi River, which are given in four parts, as indicated above, and in the records for large lakes, where it is often clearer to take up the streams in regular order around the rim of the lake than to cross back and forth over the lake surface.

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 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, miner's inches, 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 acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the following table of equivalents.

"Gallons per minute" is generally used in connection with pumping and city water supply.

The "miner's inch" is the rate of discharge of water that passes through an orifice 1 inch square under a head which varies locally. It is commonly used by miners and irrigators throughout the West and is defined by statute in each State in which it is used.

"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.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work.

CONVENIENT EQUIVALENTS.

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

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
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 equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 California miner's inches equals 18.7 United States gallons per second.
100 California miner's inches equals 96.0 Colorado miner's inches.
100 California miner's inches for one day equals 4.96 acre-feet.
100 Colorado miner's inches equals 2.60 second-feet.
100 Colorado miner's inches equals 19.5 United States gallons per second.
100 Colorado miner's inches equals 104 California miner's inches.
100 Colorado miner's inches for one day equals 5.17 acre-feet.
100 United States gallons per minute equals 0.223 second-foot.
100 United States gallons per minute for one day equals 0.442 acre-foot.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 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 equals 7.48 gallons.
1 cubic foot of water weighs 62.5 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.
$1\frac{1}{3}$ 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.

EXPLANATION OF TABLES.

For each drainage basin there is given a brief description of general conditions covering such features as area, source, tributaries, topography, geology, conditions of forestation, rainfall, ice conditions, irrigation, storage, power possibilities, and other special features of importance or interest.

For each regular current-meter gaging station are given in general, and so far as available, the following data: Description of station, list of discharge measurements, table of daily gage heights, table of daily discharges, table of monthly and yearly discharges and run-off. For stations located at weirs or dams the gage height table is omitted.

In addition to statements regarding the location and installation of current-meter stations the descriptions give information in regard to any conditions which may affect the constancy of the relation of gage height to discharge, covering such points as ice, logging, shifting conditions of flow, and backwater; also information regarding diversions which decrease the total flow at the measuring section. Statements are also made regarding the accuracy and reliability of the data.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, name of hydrographer, width and area of cross section, gage height, and discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day. At most stations the gage is read in the morning and in the evening. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. All gage heights during ice conditions, backwater from obstructions, etc., are published as recorded, with suitable footnotes. The rating is not applicable for such periods unless the proper correction to the gage heights is known and applied. Attention is called to the fact that the zero of the gage is placed at an arbitrary datum and has no relation to zero flow or the bottom of the river. In general, the zero is located somewhat below the lowest known flow, so that negative readings shall not occur.

The discharge measurements and gage heights are the base data from which rating tables, daily-discharge tables, and monthly-discharge tables are computed.

The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable. It is not published in this report but can be determined from the daily gage heights and daily discharges for the purpose of verifying the published results as follows:

First plot the discharge measurements for the current and earlier years on cross-section paper with gage heights in feet as ordinates and discharge in second-feet as abscissas. Then tabulate a number of gage heights taken from the daily gage-height table for the complete range of stage given and the corresponding discharges for the days selected from the daily-discharge table and plot the values on the cross-section paper. The last points plotted will define the rating curve used and will lie among the plotted discharge measurements. After drawing the rating curve, a table can be developed by scaling off the discharge in second-feet for each tenth foot of gage height. These values should be so adjusted that the first differences shall always be increasing or constant, except for known back-water conditions.

The table of daily discharges gives the discharges in second-feet as determined from the rating tables corresponding to the observed gage heights.

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 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 for each second during the month. On this the computations for the remaining columns, which are defined on page 13 are based.

FIELD METHODS OF MEASURING STREAM FLOW.

There are three distinct methods of determining the flow of open-channel streams: (1) By measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir or dam; (3) by measurements of the velocity of the current and of the area of the cross section. The method chosen depends on the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

Slope method.—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v=c\sqrt{Rs}$. This has been utilized by Kutter, both in developing his formula for c and in determining the values of the coefficient n which appears therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for n to be used in Kutter's formula. The most common use of this method is in estimating the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions. It is seldom used by the United States Geological Survey. For full information regarding this method the reader is referred to the various text-books on hydraulics.

Weir method.—Relatively few stations are maintained at weirs or dams by the United States Geological Survey. Standard types of sharp-crested and broad-crested weirs within the limits for which accurate coefficients have been experimentally obtained give very accurate records of discharge if properly maintained. At practically all broad-crested weirs, however, there is a diversion of water either through or around the dam, usually for the purpose of development of water power. The flow is often complicated, and the records are subject to errors from such sources as leakage through the dam, backwater at high stages, uncertainty regarding coefficient, irregularity of crest, obstructions from logs or ice, use of flashboards, old turbines with imperfect ratings, and many others depending on the type of development and the uses of the diverted water.

In general, records of discharge at dam are usually accurate enough for practical use if no others are available. It has been the general experience of the United States Geological Survey, however, that records at current-meter gaging stations under unobstructed channel conditions are more accurate than those collected at dams, and where the conditions are reasonably favorable are practically as good as those obtained at sharp-crested weirs.[a]

Velocity method.—Streams in general present throughout their courses, to a greater or less extent, all conditions of permanent, semipermanent, and varying conditions of flow. In accordance with the location of the measuring section with respect to these physical conditions, current-meter gaging stations may in general be divided into four classes—(1) those with permanent conditions of flow;

[a] The determination of discharge over the different types of weirs and dams is treated fully in "Weir experiments, coefficients, and formulas" (Water-Supply Paper 200) and in the various text-books on hydraulics. "Turbine water-wheel tests and power tables" (Water-Supply Paper 180) treats of the discharge through turbines when used as meters. The edition of the latter paper is nearly exhausted. It can, however, be consulted at most of the larger libraries of the country, or can be obtained from the Superintendent of Documents, Washington, D. C., at a cost of 20 cents.

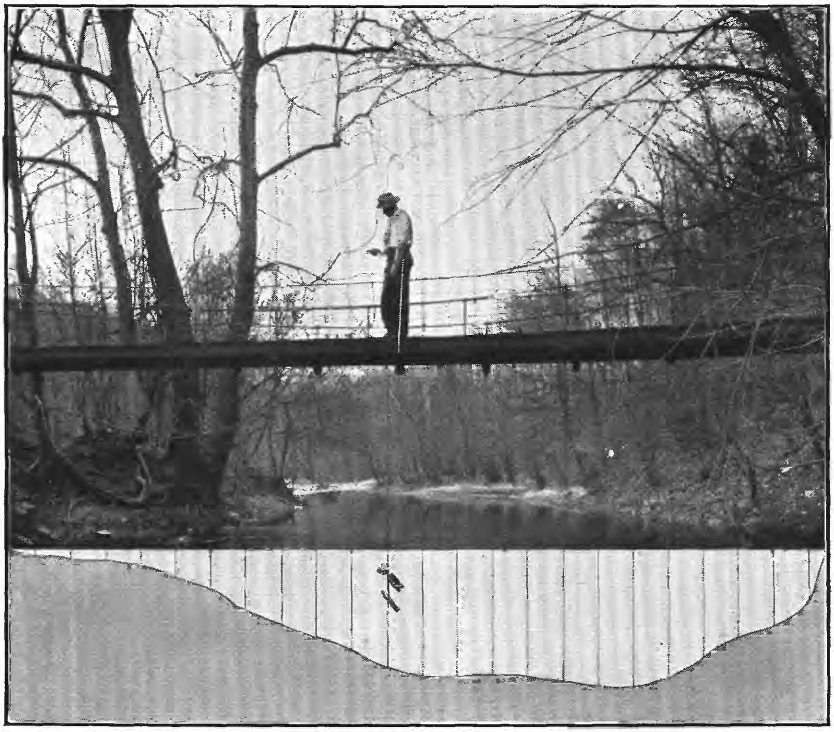
(2) those with beds which change only during extreme high water; (3) those with beds which change frequently but which do not cause a variation of more than about 5 per cent of the discharge curves from year to year; and (4) those with constantly shifting beds. In determining the daily flow different office methods are necessary for each class. The field data on which the determinations are based and the methods of collecting them are, however, in general the same.

Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements, in order that the data may have the required degree of accuracy. They are located, as far as possible, at such points that the relation between gage height and discharge will always remain constant for any given stage. The experience of engineers of the Geological Survey has been that permanency of conditions of flow is the prime requisite of any current-meter gaging station when maintained for several years unless funds are available to cover all changes in conditions of flow. A straight, smooth section without cross currents, backwater, boils, etc., at any stage is highly desirable, but on most streams is not attainable except at the cost of a cable equipment. Rough, permanent sections, if measurements are properly made by experienced engineers, taking measuring points at a distance apart of 2 to 5 per cent or less of the total width, will within reasonable limits yield better results for a given outlay of money than semipermanent or shifting sections with smooth, uniform current. So far as possible stations are located where the banks are high and not subject to overflow at high stages and out of the influence of tributary streams, dams, or other artificial obstructions which might affect the relation between gage height and discharge.

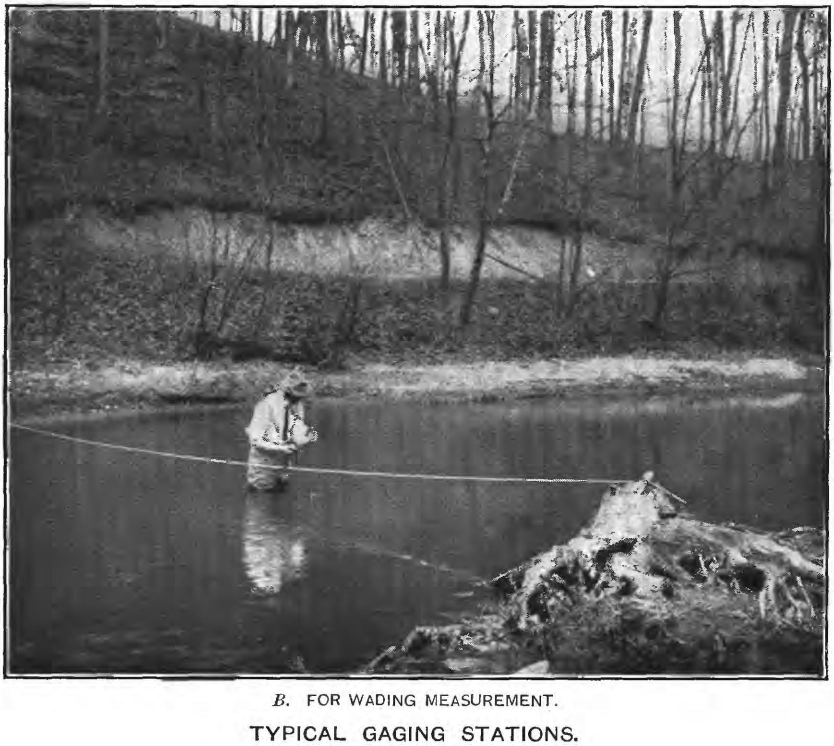
A gaging station consists essentially of a gage for determining the daily fluctuations of stage of the river and some structure or apparatus from which discharge measurements are made—usually a bridge or cable.

The two factors required to determine the discharge of a stream past a section perpendicular to the mean direction of the current are the area of the cross section and the mean velocity of flow normal to that section.

In making a measurement with a current meter a number of points, called measuring points, are measured off above and in the plane of the measuring section at which observations of depth and velocity are taken. (See Pl. I, *A*.) These points are spaced equally for those parts of the section where the flow is uniform and smooth and are spaced unequally for other parts, according to the discretion and judgment of the engineer. In general the points should not be spaced farther apart than 5 per cent of the distance between piers,



A. FOR BRIDGE MEASUREMENT.



B. FOR WADING MEASUREMENT.

TYPICAL GAGING STATIONS.

nor farther apart than the approximate mean depth of the section at the time of measurement.

The measuring points divide the total cross section into elementary strips at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the two ends times the width of the strip times the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.[a]

Depths for the determination of the area are usually obtained by sounding with the current meter and cable. In rough sections or swift current an ordinary weight and cable are used, particular care being taken that all observations shall be in the plane of the cross section.

Two methods of determining the velocity of flow of a stream are in general use—the float method and the current-meter method.

The float method, with its various modifications of surface, subsurface, and tube or rod floats, is now considered obsolete in the ordinary practice of the United States Geological Survey. The use of this method is limited to special conditions where it is impracticable to use the current meter, such as in places where large quantities of ice or débris which may damage the meter are flowing with the current, and for miscellaneous measurements or other work where a high degree of accuracy is not necessary. Tube floats are very satisfactory for use in canals with regular bottoms and even flow of current. Measurements by the float method are made as follows: The velocity of flow of the stream is obtained by observing the time which it takes floats set free at different points across the stream to pass between two range lines about 200 feet apart. The area used is the mean value obtained from several cross sections measured between the two range lines. The chief disadvantages of this method are difficulty in obtaining the correct value of mean area for the course used and uncertainty regarding the proper coefficient to apply to the observed velocity.[b]

The Price current meter is now used almost to the exclusion of other types of meters by the United States Geological Survey in the determination of the velocity of flow of water in open channels, a use for which it is adapted under practically all conditions.[c] Plate

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

[b] Further information regarding this method is given in Water-Supply Paper 95 and in the various textbooks covering the general subject of stream flow. The edition of this paper is nearly exhausted. It can, however, be consulted at most of the larger libraries of the country, or can be obtained from the Superintendent of Documents, Washington, D. C., at a cost of 15 cents.

[c] See Hoyt, J. C., and others, Use and care of the current meter as practiced by the U. S. Geological Survey: Trans. Am. Soc. Civil Eng., 1910, vol. 66, p. 70.

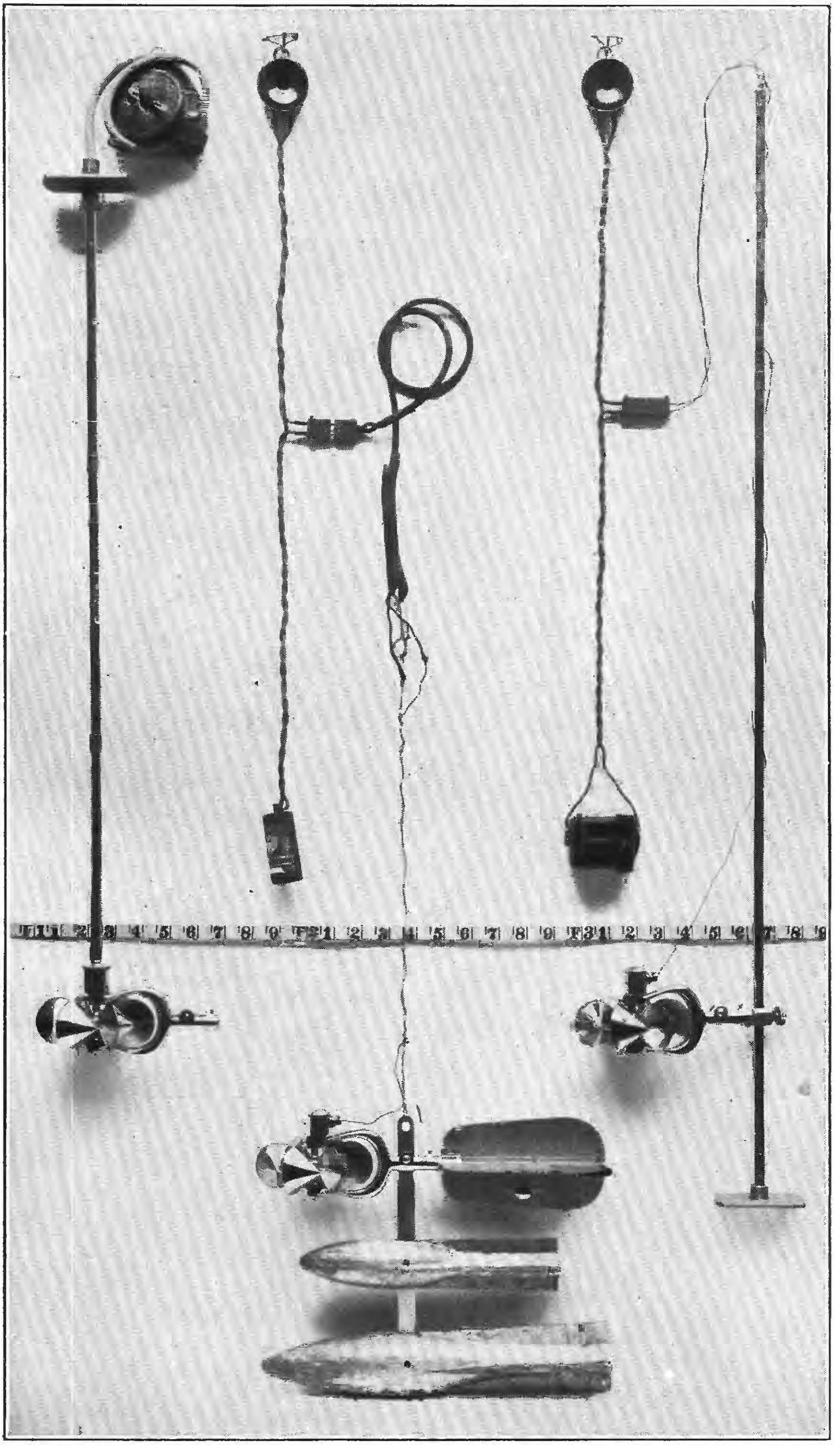
II shows in the center the new type of penta-recording current meter equipped for measurements at bridge and cable stations; on the left the same type of meter is shown equipped for wading measurements to record by the acoustic method; the meter shown on the right is equipped to record electrically. (See Pl. I, *B*.) Briefly, the meter consists of six cups attached to a vertical shaft which revolves in a conical hardened steel point when immersed in moving water. The number of revolutions is indicated electrically. The rating or relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval. The 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 principal multiple-point methods in general use are the vertical velocity curve and 0.2 and 0.8 depth.

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 known, 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 and to measurements under ice.

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. (See Pl. I, *A*.) On the assumption that the vertical velocity curve is a common parabola with horizontal axis, the mean of the 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 a completed measurement seldom varies as much as 1 per cent from the value given by the vertical velocity curve method. Moreover, the indications are that it holds nearly as well



SMALL PRICE CURRENT METERS.

for ice-covered rivers. It is very 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 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 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, 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.

The determination of the flow of an ice-covered stream is difficult, owing to diversity and instability of conditions during the winter period and also to lack of definite information in regard to the laws of flow of water under ice. The method now employed is to make frequent discharge measurements during the frozen periods by the 0.2 and 0.8 and the vertical velocity curve methods, and to keep an accurate record of the conditions, such as the gage height to the surface of the water as it rises in a hole cut in the ice, and the thickness and character of the ice. From these data an approximate estimate of the daily flow can be made by constructing a rating curve (really a series of curves) similar to that used for open channels, but considering, in addition to gage heights and discharge, the varying thickness of ice.[a]

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 full notes, 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 discharges, and from these applications the tables of monthly discharge and run-off are computed.

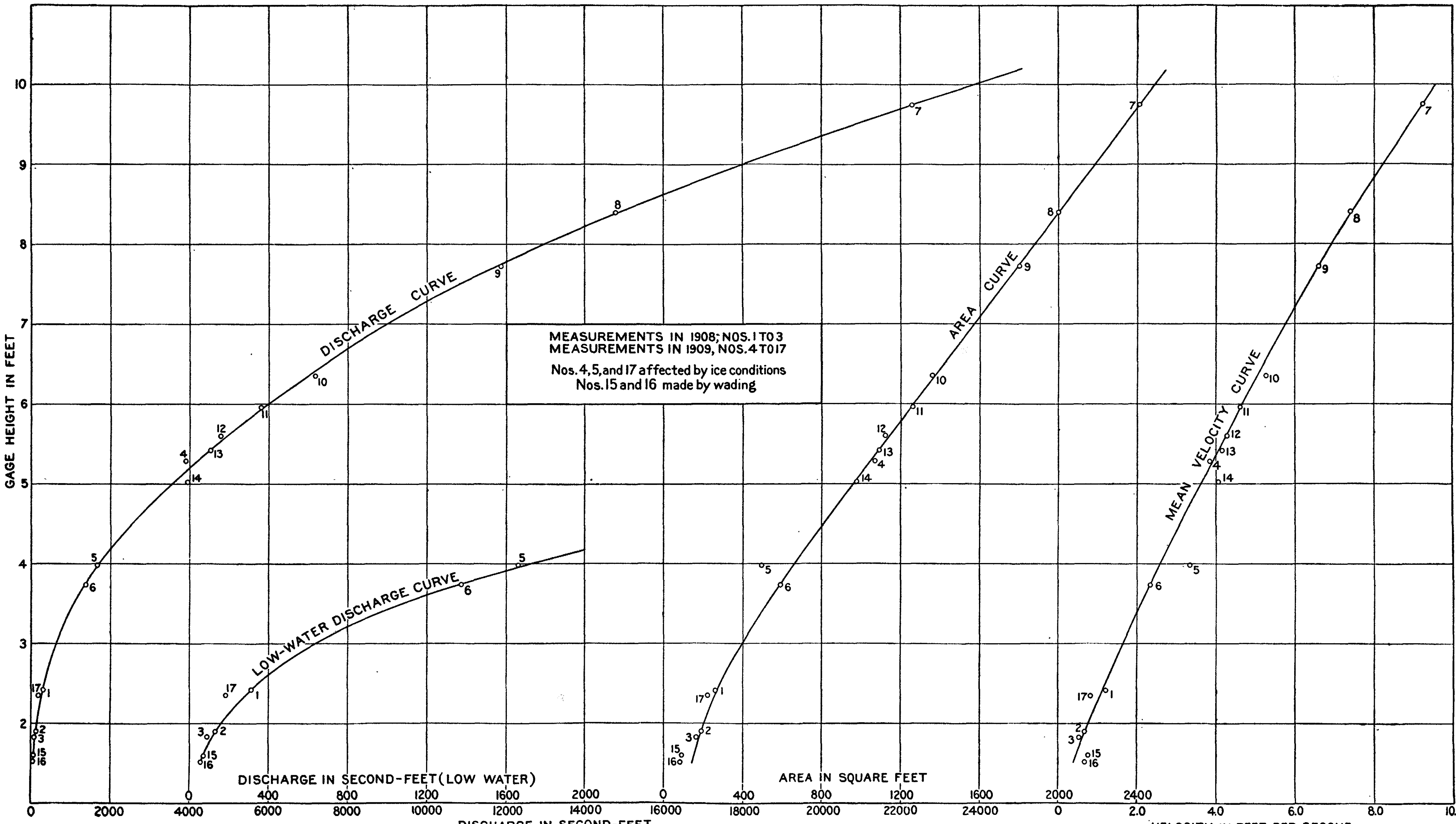
Rating curves are drawn and studied with special reference to the class of channel conditions which they represent. (See p. 17.) The discharge measurements for all classes of stations when plotted with gage heights in feet as ordinates and discharges in second-feet as abscissas define rating curves which are more or less generally parabolic in form. In many cases 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, and for checking purposes to avoid errors in the form of the discharge curve and to determine and eliminate erroneous measurements. Plate III shows a typical rating curve.

For every published 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 as stated in the footnote of each table is not applicable for known conditions of ice, log jams, or other similar obstructions; (*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.

[a] For information in regard to flow under ice cover, see Water-Supply Paper 187.



DISCHARGE, AREA, AND MEAN VELOCITY CURVES FOR GENESEE RIVER AT ST. HELENA, N. Y.

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. Stations of this type are found in the north Atlantic coast drainage basins.

Class 2 is confined mainly to 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. Stations of this type are found in the upper Missouri River drainage basin.

Class 3 includes most of the current-meter gaging stations maintained by the United States Geological Survey. If sufficient measurements could be made at stations of this class results would be obtained nearly equaling those of class 1, but owing to the limited funds at the disposal of the Survey this is manifestly impossible, nor is it necesssary for the uses to which discharge data are applied. The critical points are, as a rule, at relatively high or low stages. Percentage error, however, is greater at low stages. 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 past 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 their ordinates, or gage heights. This law of the parallelism of ratings is the fundamental basis of all ratings and estimates at stations with semipermanent 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 and 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 the old conditions.

(*c*) In the case of uniform change along the crest of a weir or rocky controlling point, 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 with respect to their ordinates.

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 example, on small streams—there may result a wide departure from the law of parallelism of ratings. 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, boils, 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. Stations of this type are found in the south Atlantic coast and eastern Gulf of Mexico drainage basins.

Class 4 comprises stations that have soft, muddy, or sandy beds. Good results can be obtained from such sections only by frequent discharge measurements, the frequency varying 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 with respect to their ordinates. 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. Stations of this type are found in the Platte, Arkansas, Rio Grande, and lower Colorado drainage basins.

The computations have, as a rule, been carried to three significant figures. Computation machines, Crelle's tables, 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 is feasible, by means of comparison with adjacent streams. The attempt is made to complete years or periods of discharge, thus eliminating fragmentary and disjointed records. Full notes accompanying such estimates follow the daily and monthly discharge tables.

For most of the northern stations estimates have been made on the monthly discharge during frozen periods. These are based on measurements under ice conditions wherever available, daily records of temperature and precipitation obtained from the United States Weather Bureau climate and crop reports, observers' notes of conditions, and a careful and thorough intercomparison of results with adjacent streams. Although every care possible is used in making these estimates they are often very rough, the data for some of them being so poor that the estimates are liable to as much as 25 to 50 per cent error. It is believed, however, that estimates of this character are better than none at all, and serve the purpose of indicating in a relative way the proportionate amount of flow during the frozen period. These estimates are, as a rule, included in the annual discharge. The large error of the individual months has a relatively small effect on the annual total, and it is for many purposes desirable to have the yearly discharge computed, even though some error is involved in doing so.

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 stations at dams, where uncertainty regarding the coefficient and complicated conditions of flow prevail.

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 gage reading a day does not always give the mean height for that day. 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.

The effort is made to visit every station at least once each year for the purpose of making a measurement to determine the constancy of conditions of flow since the last measurement made during the preceding year, and also to check the elevation of the gage. On account of lack of funds or for other causes some stations were not visited during the current year. If conditions of flow have been reasonably permanent up to the time of the last preceding measurement, it is considered best to publish values of discharge on the basis of the latest verified rating curve rather than to omit them altogether, although it should be distinctly understood that such records are at times subject to considerable error. This is also true, although to a less degree, of the period of records since the date of the last measurement of the current year. As a rule the accuracy notes are based on the assumption that the rating curve used is strictly applicable to the current year.

In order to give engineers and others information regarding the probable accuracy of the computed results footnotes are added to the discharge tables, stating the probable accuracy of the rating tables used, and an accuracy column is inserted in the monthly discharge table. For the rating tables "well defined" indicates in general that the rating is probably accurate within 5 per cent; "fairly well defined," within 10 per cent; "poorly defined" or "approximate," within 15 to 25 per cent. These notes are very general and are based on the plotting of the individual measurements with reference to the mean rating curve.

The accuracy column in the monthly discharge table does not apply to the maximum or minimum nor to any individual day, but to the monthly mean. It is based on the accuracy of the rating, the probable reliability of the observer, and knowledge of local conditions. In this column A indicates that the mean monthly flow is probably accurate within 5 per cent; B, within 10 per cent; C, within 15 per cent; D, within 25 per cent. Special conditions are covered by footnotes.

USE OF THE DATA.

In general, the policy is followed of making available for the public the base data which are collected in the field each year by the Survey engineers. This is done to comply with the law, and also for the express purpose of giving to any engineer the opportunity of examining the computed results and of changing and adjusting them as may seem best to him. Although it is believed that the rating tables and computed monthly discharges are as good as the base data up to and including the current year will warrant, it should always be borne in mind that the additional data collected at each station from year to year nearly always throw new light on data already collected and published, and hence allow more or less improvement in the computed results of earlier years. It is therefore expected that the engineer who makes serious use of the data given in these papers will verify all ratings and make such adjustments in earlier years as may seem necessary. The work of compiling, studying, revising, and republishing data for different drainage basins for five or ten year periods or more is carried on by the United States Geological Survey so far as the funds for such work are available.

The values in the table of monthly discharge are so arranged as to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates. This is particularly true of the maximum and minimum figures, which in the very nature of the method of collecting these data are liable to large errors. The maximum value should be increased considerably for many stations in considering designs for spillways, and the minimum value should be considered for a group of, say, seven days and not for one day. The daily discharges are published to allow a more detailed study of the variation in flow and to determine the periods of deficient flow.

COOPERATIVE DATA.

Cooperative data of various kinds and data regarding the run-off at many stations maintained wholly by private funds are incorporated in the surface water-supply reports of the United States Geological Survey.

Many stations throughout the country are maintained for specific purposes by private persons, who supply the records gratuitously to the United States Geological Survey for publication. When such records are supplied by responsible persons and appear to be reasonably accurate they are verified, so far as possible, and estimated values of accuracy are given. Records clearly known to be worthless or misleading are not published. As it is, however, impossible to verify completely all such records furnished—because of lack of funds or for other causes—they are published for what they are worth, because they are of value as a matter of record and afford at least approximate information regarding stream flow at the particular localities. The survey does not, however, assume any responsibility for inaccuracies found in such records, although most of them are believed to be reasonably good.

COOPERATION AND ACKNOWLEDGMENTS.

LAKE SUPERIOR DRAINAGE BASIN.

The work in Minnesota during 1909 has been done with state cooperation under the terms of an act of the legislature of 1909, as embodied in the following sections:

SECTION 1. The state drainage commission of the State of Minnesota is hereby authorized and directed to cause to be made a topographical survey of the several watersheds of the State for the purpose of securing data from which complete plans for a uniform system of drainage may be prepared.

SEC. 6. The drainage commission of the State of Minnesota is hereby authorized to cooperate with the United States in the execution of drainage or topographical surveys in any county in this State, whenever said drainage commission deems it expedient and in the best interest of the State so to do.

The work has been carried on in conjunction with the state drainage commission, George A. Ralph, chief engineer. Special acknowledgment is due the Great Northern Power Company for records on St. Louis River near Thompson, Minn.

LAKE MICHIGAN, LAKE HURON, AND LAKE ERIE DRAINAGE BASINS.

Assistance has been rendered or records furnished by the following, to whom special acknowledgment is due: State Geological Survey of Michigan; R. M. Roberts, city engineer, Saginaw, Mich.; L. W. Anderson, city engineer, Grand Rapids, Mich.; Washtenaw Light and Power Company, Ann Arbor, Mich.; Fletcher Paper Company, Alpena, Mich.; Commonwealth Power Company, Jackson, Mich.; Penn Iron Mining Company, Vulcan, Mich.; Oliver Iron Mining Company, Iron Mountain, Mich.; D. W. Mead, Madison, Wis.; Gardner S. Williams, Ann Arbor, Mich.; William G. Fargo, Jackson, Mich.

LAKE ONTARIO AND ST. LAWRENCE RIVER DRAINAGE BASINS IN NEW YORK.

Assistance has been rendered or records furnished by the following, to whom special acknowledgment is due: United States Engineer Corps; Hon. Frank M. Williams, state engineer and surveyor, representing New York state cooperation; state water supply commission of New York, Hon. Henry H. Persons, president; E. A. Fisher, city engineer, and board of park commissioners, Rochester; George Beebe, chief engineer and superintendent bureau of water, Syracuse; Plattsburg Gas and Electric Company, Plattsburg.

New York state cooperation, under the direction of the state engineer and surveyor, has been carried on by cooperative agreements authorized by an act of the state legislature, being paragraph 11 of chapter 420, laws of 1900.

Cooperation with the state water supply commission was made possible by the provisions of the "Fuller bill," chapter 569, laws of 1907, and carried on under agreements between the state water supply commission and the United States Geological Survey.

ST. LAWRENCE RIVER DRAINAGE BASIN IN VERMONT.

The work in Vermont during 1909 has been done in cooperation with the State of Vermont, George H. Prouty, governor, under the provisions of the following act of the general assembly:

An act to provide for investigation of the water resources of the State of Vermont and to make the records of such investigation available to the authorities of the State, and to all the people thereof.

It is hereby enacted by the general assembly of the State of Vermont:

SECTION 1. That, as the Director of the United States Geological Survey is authorized to cooperate with the properly constituted authorities in the several States in making investigation of and reports upon the water resources of these States, the governor of the State of Vermont is hereby empowered to enter into contract with the Director of the United States Geological Survey for the purpose of making such investigation and report for this State, provided that such work shall include, first, the completion of the surveys of river basins already partially investigated; and provided further, that the Director shall agree to expend for this purpose, and from funds placed at his disposal by the Government of the United States, sums equal to those hereinafter appropriated.

SEC. 2. That, for the purpose set forth in section 1 of this act, the sum of $1,000 for the year 1909, and a like sum for the year 1910, is hereby appropriated to be expended by the State, in accordance with the laws relating to, and the regulations of, the United States Geological Survey in such case provided, payment to be made on vouchers audited and approved by the Director of said Survey, when presented to the auditor of accounts.

Assistance has been rendered or records furnished by the following, to whom special acknowledgment is due: Newport Electric Light Company; Prof. C. S. Carleton, of Norwich University; Lane Manufacturing Company; Morrisville water and light commissioners; Colton Manufacturing Company; Corry, Deavitt and Frost Electric Company; Sweat-Comings Manufacturing Company.

DIVISION OF WORK.

The field data in the Lake Superior drainage basin were collected under the direction of Robert Follansbee, district engineer, assisted by G. A. Gray and C. B. Gibson.

The field data in the Lake Michigan, Lake Huron, and Lake Erie drainage basins were collected under the direction of A. H. Horton, district engineer, assisted by G. A. Gray and William M. O'Neill.

The field data for New York were collected under the direction of C. C. Covert, district engineer, assisted by W. G. Hoyt.

The field data in the St. Lawrence River drainage basin in Vermont were collected under the direction of H. K. Barrows, district engineer, assisted by D. M. Wood.

The ratings, special estimates, and studies of the completed data were made by A. H. Horton, C. C. Covert, T. W. Norcross, D. M. Wood, R. H. Bolster, and G. C. Stevens. The computations and the preparation of the data for publication were made under the direction of R. H. Bolster, assistant engineer, by G. C. Stevens, H. D. Padgett, R. C. Rice, J. G. Mathers, and M. I. Walters. The manuscript was edited by Mrs. B. D. Wood.

LAKE SUPERIOR DRAINAGE BASIN.

GENERAL FEATURES.

The area tributary to Lake Superior in the United States comprises the northeastern part of Minnesota, a small strip in northern Wisconsin, and nearly one-half of the Northern Peninsula of Michigan. Except at the west end the slopes to the lake are very narrow and are drained by short streams of sharp descent. St. Louis River, which enters at the head of the lake, is the largest and most important stream.

ST. LOUIS RIVER DRAINAGE BASIN.

DESCRIPTION.

St. Louis River drains an area 3,440 square miles in extent, located in the northeastern part of Minnesota, chiefly in southern St. Louis County. The river rises in a small lake on the extreme western edge of Lake County, Minn., in T. 59 N., R. 11 W. Its general course is at first southwestward, but after passing through Seven Beaver Lake, which has an area of several miles, it flows southward until it reaches a point about 6 miles above the St. Louis-Carlton County line, where it turns to the east, southeast, and finally northeast, emptying into the extreme west end of Lake Superior. Its principal tributaries are Partridge, Embarrass, and Floodwood rivers from the west and Whiteface and Cloquet rivers from the east.

Throughout its course above Thompson the river flows through a comparatively shallow valley eroded in the glacial drift which covers the greater part of the basin; for the remainder of its course it plunges through a deep gorge, descending nearly 500 feet within a few miles. This gorge is cut chiefly through the drift sheet, as the underlying slates have been eroded to only a slight extent.

The northern boundary of the drainage basin is in general the line of hills rising from 300 to 500 feet above the plain and known as the Mesabi Range. Through a break in the hills Embarrass River flows, draining a considerable area north of the range.

The greater portion of the drainage basin above the mouth of Cloquet River is a vast swampy region containing much muskeg, through which the flow of the rivers is slow and obstructed. The northern and southern borders of this swampy tract are formed by the gradual elevation of the till-covered surface. In this flat country the immediate underlying drift consists of washed and wind-blown sand. The eastern portion of the drainage basin is rougher than the western portion, although it contains areas of muskeg.

The basin is for the most part more or less heavily timbered and logging is carried on actively at the present time. Logging dams have been erected at the following points for the purpose of storing the waters for log driving during the spring and summer months: On St. Louis River, in sec. 4, T. 57 N., R. 14 W.; on Embarrass River, in sec. 6, T. 58 N., R. 15 W.; on Partridge River, in sec. 6, T. 58 N., R. 14 W.; on Paleface River, in sec. 36, T. 56 N., R. 16 W.; on Whiteface River, in sec. 2, T. 54 N., R. 16 W.; on Bug Creek, in sec. 21, T. 54 N., R. 16 W.; on Ushkabwakka River, in sec. 14, T. 52 N., R. 16 W.; on Cloquet River, in sec. 19, T. 53 N., R. 13 W., and sec. 15, T. 52 N., R. 15 W.; on West Branch of Cloquet River, in sec. 15, T. 55 N., R. 13 W.; on branch of Cloquet River, in sec. 12, T. 55 N., R. 13 W.; on Little Cloquet River, in sec. 18, T. 54 N., R.

12 W., sec. 25, T. 54 N., R. 13 W., and sec. 36, T. 54 N., R. 13 W.; on branch of Cloquet River in sec. 17, T. 53 N., R. 13 W.

The Weather Bureau has maintained a number of rainfall stations in this section of the country, the records of which give the following summary:

Precipitation in St. Louis River basin.

Station.	Length of record.	Mean annual precipitation.
		Inches.
Mount Iron	1904-1908	29.1
Pokegama Dam	1888-1908	27.7
Sandy Lake	1893-1908	26.8
Duluth	1871-1908	29.8

From December to April the rivers are completely frozen over and snow remains on the ground for considerable periods.

The many logging dams in the basin create storage reservoirs for controlling the flow of the rivers, and additional storage may be made available by constructing low dams across the outlets of other lakes. Wild Rice Lake, in T. 51 N., R. 15 W., which is used as a reservoir in connection with the development of power on the lower St. Louis, has an area of 5 square miles with a draft of 5 feet, making its storage capacity 25 square-mile-feet.

As the St. Louis has a good fall throughout its length, power can be developed at many places. Below Thompson is a plant which utilizes nearly 400 feet of fall and develops 30,000 horsepower. A very much smaller power is developed at Cloquet. These are the only utilized sites in the drainage basin.

As logging is the chief industry in this portion of the State, very little land is cleared and cultivated. The many swamps make much of the country impassable during the summer months except by canoes, and owing to the sparseness of the population very little drainage work has been done. About 117,000 acres have been ditched in St. Louis County.

The following gaging stations have been maintained in this basin:

St. Louis River near Thompson, Minn., 1909.
Whiteface River at Meadowlands, Minn., 1909.
Cloquet River at Independence, Minn., 1909.

ST. LOUIS RIVER NEAR THOMPSON, MINN.

This station, which is located just below the tail race of the Great Northern power house, near Thompson, Minn., in T. 48 N., R. 26 E., was established October 5, 1909, in cooperation with the Great Northern Power Company, by which the daily gage readings are furnished. The river has a fall of over 400 feet within a distance of a few miles and the records of flow are therefore of value in connection with water-power development.

No important tributary enters within several miles of the station. The drainage area above this point is 3,420 square miles.

Discharge measurements are made from a car and cable 1,500 feet below the staff gage, which is located just below the tail water of the power house. The opening and shutting of the turbine gates cause fluctuations in gage heights, and in order to determine approximately the mean gage height four readings are made each day, at 8 and 11 a. m. and 2 and 5 p. m., the average of these readings being taken as the mean for the day.

The records do not show the natural flow of the river at all times, owing to reservoirs above which regulate the flow to a certain extent. The dam at Thompson is designed to hold twenty-four hours' supply of water for the power plant, and the discharge from a large part of the entire drainage area above the gaging station is controlled by logging dams. The logging dams in general are closed during the winter months to store the flow in order to drive the logs down the stream in the spring, and when the drives are finished the dams are left open until it is time to store the water for the next season's drive.

The flow at this station is practically unaffected by ice, the river remaining open during the winter.

As the gage section has not yet been completely rated, estimates of flow are for the present withheld.

Discharge measurements of St. Louis River near Thompson, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
October 5	Follansbee and Gray	240	1,430	2.56	2,610
November 2	G. A. Gray	250	1,700	3.33	3,960

Daily gage height, in feet, of St. Louis River near Thompson, Minn., for 1909.

[N. Van Valkenburgh, observer.]

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1		3.38	2.91	11	2.00	2.12	3.05	21	2.71	2.70	2.10
2		3.27	3.27	12	1.55	1.69	2.88	22	3.06	2.36	1.72
3		3.16	3.54	13	1.49	1.52	2.70	23	3.31	2.12	1.64
4		3.23	3.55	14	1.59	1.92	2.61	24	3.28	1.70	1.86
5	2.45	3.73	3.55	15	2.56	2.16	2.68	25	3.52	2.18	1.80
6	2.08	3.35	3.51	16	2.51	2.75	2.63	26	3.75	2.28	1.72
7	1.71	2.94	3.14	17	2.64	2.29	2.28	27	3.75	2.92	1.78
8	1.95	2.60	3.12	18	3.12	2.10	2.00	28	3.68	2.98	1.84
9	2.30	2.37	2.61	19	2.70	2.32	2.02	29	3.80	2.69	1.60
10	2.26	2.20	2.86	20	3.08	2.80	2.11	30	3.58	2.94	1.76
								31	3.42		1.51

WHITEFACE RIVER AT MEADOWLANDS, MINN.

This station, which is located at the highway bridge at Meadowlands, Minn., in sec. 14, T. 53 N., R. 19 W., was established June 7, 1909, to determine the water power available on Whiteface River.

The nearest tributary is a very small stream entering from the east one-half mile above. The drainage area above this point is 442 square miles.

Discharge measurements are made from the bridge at which the staff gage is located, except during periods of low water, when they are made by wading at the rapids nearly 2 miles below the station.

Whiteface River is used extensively for log driving, and the flow is to a large extent controlled by logging dams above. The opening and shutting of the gates of these dams causes a fluctuation in gage height of several feet at the gaging station, and the records of extreme stage are therefore of little value. In fact, none of the gage records are better than fair, although three readings a day are taken.

As the station has not been completely rated, no estimates of flow have been made.

Discharge measurements of Whiteface River at Meadowlands, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 7	Hoyt and Gibson	104	661	[a] 6.52	708
August 5	G. A. Gray	104	588	[b] 5.71	341
August 24	do	104	643	[c] 6.09	677
October 3	do	104	470	5.09	309

[a] Gage height lowered 0.35 foot during measurement.
[b] Gage height lowered 0.18 foot during measurement.
[c] Gage height rose 0.18 foot during measurement.

Daily gage height, in feet, of Whiteface River at Meadowlands, Minn., for 1909.

[A. F. Johnson, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		2.77	8.07	5.63	5.35	5.67
2		2.70	7.63	5.45	5.15	5.50
3		2.70	7.37	5.12	5.10	4.90
4		2.70	6.50	5.20	6.10	5.33
5		2.70	5.62	4.90	4.83	5.77
6		2.60	5.82	4.43	4.87	5.47
7	6.10	2.60	5.03	4.27	4.70	5.47
8	5.80	2.60	5.10	4.13	4.80	5.07
9	5.17	2.60	6.03	4.10	4.67	5.73
10	5.30	2.60	7.03	4.10	4.80	4.83
11	5.13	2.77	12.23	4.07	4.70	4.70
12	4.00	3.07	11.73	4.00	5.40	4.70
13	4.33	3.70	10.83	4.23	5.50	4.80
14	6.10	3.70	11.20	4.67	5.80	5.30
15	4.00	3.73	11.97	5.12	5.87	5.47

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
16	4.00	3.74	11.20	4.70	5.90	5.33
17	4.00	3.34	10.95	4.45	5.88	5.33
18	6.67	4.67	10.53	4.35	5.77	4.83
19	3.63	6.17	9.93	4.35	5.97	5.03
20	3.10	4.17	7.50	5.20	5.60	5.37
21	3.10	6.30	7.10	5.60	5.50	5.30
22	3.00	11.00	6.87	6.35	6.10	5.37
23	6.47	11.10	6.87	7.00	6.23	5.30
24	5.00	11.50	5.97	6.75	6.20	5.53
25	5.27	11.10	5.70	6.05	6.43	5.77
26	4.13	10.53	5.60	6.30	6.33	5.67
27	3.77	9.55	5.57	6.55	6.33	5.70
28	3.57	8.27	5.40	6.35	6.47	5.87
29	3.10	8.53	5.70	6.15	6.03	5.67
30	3.00	7.17	6.03	5.75	5.63	5.77
31		8.55	6.03		5.53	

NOTE.—The flow is controlled by a logging dam on the headwaters, so that the stage may change several feet in one day. Also, logs may jam below the station, causing backwater.

CLOQUET RIVER AT INDEPENDENCE, MINN.

This station, which is located at the highway bridge at Independence, Minn., 6 miles north of Burnett, a station on the Duluth, Missabe and Northern Railway, was established June 28, 1909, as part of the general plan of investigating the water resources in Minnesota.

The station is located just below a small tributary entering from the north, in sec. 26, T. 52 N., R. 17 W. The drainage area above the station is 698 square miles.

Cloquet River is used extensively for log driving, and the run-off from by far the greater part of the drainage area above Independence is controlled by logging dams. This control causes violent fluctuations in the gage height during the day, amounting at times to several feet, and consequently the mean daily gage height, which is the mean of three readings taken morning, noon, and night, can be considered only approximate. In fact, the flow is controlled to such an extent that daily discharge data have little value, the chief purpose of the records being to show the approximate mean monthly discharge and total discharge. In addition to the fluctuations log jams forming below the station may cause backwater, but the same condition is true of the entire stream, making it impossible to select a satisfactory station upon it. Owing to the northern latitude ice conditions are severe at this station.

Since the establishment of the staff gage, which is located at the bridge section, the datum has remain unchanged.

As the station has not been completely rated no estimates of flow have been made.

Discharge measurements of Cloquet River at Independence, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 28	G. A. Gray	168	566	6.78	1,720
July 15	Robert Follansbee	122	156	4.01	94.8
August 6	G. A. Gray	164	445	5.90	840
August 23	do	168	565	6.61	1,440
October 4	do	167	553	6.50	1,430

Daily gage height, in feet, of Cloquet River at Independence, Minn., for 1909.

[Fred Haakensen, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		3.98	6.49	6.09	5.98	6.90	16		4.16	7.94	4.39	6.80	4.90
2		3.90	6.40	4.84		6.10	17		4.10	7.81	4.36	7.20	5.80
3		3.89	7.38	4.46		6.90	18		4.16	7.62	4.30	7.60	5.50
4		3.90	7.28	5.08	6.40	7.90	19		6.64	8.00	4.42	7.40	5.60
5		3.88	7.76	4.58	5.60	7.50	20		6.85	7.32	4.38	6.50	5.10
6		3.85	5.84	4.39	5.00	6.80	21		7.45	7.34	4.85	6.30	5.00
7		3.84	4.73	4.28	5.40	6.40	22		8.60	7.51	5.62	6.60	5.20
8		3.81	7.06	4.20	6.10	6.10	23		8.80	6.88	6.34	6.30	5.20
9		3.80	5.10	4.16	5.60	5.90	24		8.26	6.25	7.38	6.80	5.30
10		3.78	4.65	4.14	5.20	5.90	25		8.54	4.74	8.26	6.70	5.60
11		3.78	6.61	4.10	4.90	5.10	26		9.12	6.52	7.75	7.20	5.90
12		3.86	6.94	4.14	4.80	4.70	27		9.06	6.10	7.70	7.40	5.90
13		3.92	7.46	4.26	6.00	4.60	28	6.70	8.11	6.94	7.25	7.90	5.30
14		4.00	8.24	4.34	5.90	4.60	29	6.22	6.10	6.89	7.01	7.80	5.30
15		4.00	7.95	4.35	7.20	4.80	30	5.50	6.55	6.80	6.18	7.90	5.50
							31		6.64	6.45		7.40	

LAKE MICHIGAN DRAINAGE BASIN.

GENERAL FEATURES.

The Lake Michigan drainage basin comprises a comparatively narrow strip of flat or gently rolling land in the northwestern part of Indiana and the northeastern part of Illinois on the south shore of the lake and the eastern part of Wisconsin and the eastern part of the Northern Peninsula of Michigan on the western and northern shores; on the eastern shore there is a wide strip of the western part of the Southern Peninsula of Michigan. The principal streams entering the lake from the west are Escanaba, Menominee, Peshtigo, Oconto, and Fox rivers; from the east, St. Joseph, Kalamazoo, Grand, Muskegon, and Manistee rivers.

The following pages give the results of data collected during 1909 in the Lake Michigan drainage basin.

ESCANABA RIVER DRAINAGE BASIN.

DESCRIPTION.

Escanaba River rises in the western part of Marquette County, near Lake Michigamme, and takes a general southeasterly course to Little Bay de Noquette, an arm of Lake Michigan, which it enters near Escanaba, Mich. Its length is about 90 miles and its drainage area, which lies in the central part of the Northern Peninsula of Michigan, comprises about 890 square miles.

The basin is long and narrow and comparatively regular in outline, the average width of its lower half being less than 10 miles, its extreme width about 25 miles, and its length about 70 miles. In its upper course the river flows through an area of crystalline rocks, but farther down the rocks are sandstones and limestones. The headwaters of the river have an elevation of about 1,600 feet above sea level, and at its mouth the elevation is 580 feet, making a total descent of about 1,000 feet, or an average fall of over 10 feet to the mile.

The tributaries of the river are small, the West Branch being the only one of importance.

The mean annual rainfall in this part of Michigan is about 32 inches. The winters are severe; the snowfall is heavy and lasts for considerable periods, and ice covers the streams to a thickness of about 2 feet for three to four months.

Lumbering is yet an active industry in this basin, although the greater part of the best timber has been cut off, and the river is still used extensively for logging. The change in the forest conditions has probably not affected the run-off of the stream.

Storage sites have not been sought, but suitable locations for reservoirs could doubtless be found, as the basin contains some lakes and swamps.

Little is known of the available water power, but as the average fall is high favorable sites are probably numerous. A few power sites not far from the mouth of the river have been developed, and at least one of these plants is of comparatively recent installation.

The only gaging station maintained in this basin is that on the Escanaba near Escanaba, 1903–1909.

ESCANABA RIVER NEAR ESCANABA, MICH.

This station, which is located at a highway bridge between Escanaba and Gladstone, Mich., about 9 miles north of Escanaba and 4 miles above the mouth of the river, was established August 25, 1903, to obtain data applicable to water-power and water-supply problems. Discharge measurements were made at this station in April, May, and July, 1903, but daily gage heights were not obtained until August 25, 1903. The station was discontinued March 31, 1909, and reestablished June 1, 1909.

The chain gage is attached to the bridge from which all measurements are made. Although the current is swift at the measuring section, gage heights are affected by ice, which in some years covers the stream to a depth of 2 feet for four months, and during the logging season the gage heights are sometimes affected by log jams.

This station was last inspected July 16, 1908. The accuracy of the daily and monthly discharges given below therefore depends on the permanency of flow and of elevation of the gage since that date. Conditions of flow are believed to be permanent. The gage reader at this station was paid by the Geological Survey of Michigan for the greater portion of 1909.

Daily gage height, in feet, of Escanaba River near Escanaba, Mich., for 1909.

[Felix Beauchamp, observer.]

Day.	Jan.	Feb.	Mar.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				3.3	2.1	2.2	1.9	1.9	2.2	3.2
2	2.9			3.3	2.0	2.2	1.9	2.0	2.4	3.3
3				3.2	2.0	2.2	1.8	1.9	2.8	3.1
4				3.2	2.0	2.2	1.9	1.9	2.8	3.0
5				3.2	2.1	2.2	1.8	1.9	2.6	3.2
6		2.9	2.8	3.1	2.1	2.1	1.7	1.8	2.6	3.3
7				3.0	2.1	2.1	1.8	1.9	2.5	3.3
8				3.0	2.0	2.1	1.8	1.9	2.4	3.1
9	2.9			2.9	2.0	2.1	1.8	1.9	2.4	3.1
10				2.9	2.0	2.2	1.7	1.9	2.3	3.0
11				2.9	2.0	2.2	1.8	1.9	2.3	2.9
12				2.8	2.1	2.2	1.9	2.0	2.4	2.9
13		2.9	2.9	2.8	2.1	2.1	1.9	2.0	2.5	3.0
14				2.7	2.2	2.1	2.0	2.0	2.5	5.5
15				2.7	2.2	2.1	2.0	2.0	3.3	5.7
16	2.8			2.6	2.2	2.1	2.3	2.0	3.5	5.6
17				2.6	2.3	2.2	2.3	2.0	3.3	5.7
18				2.6	2.4	2.2	2.3	2.1	3.3	5.1
19				2.7	2.4	2.1	2.2	2.1	3.1	
20		2.8	3.1	2.7	2.5	2.1	2.1	2.1	3.0	
21				2.6	2.6	2.0	2.0	2.0	3.0	
22				2.5	2.7	2.0	2.0	2.0	2.8	
23	2.7			2.5	2.9	2.0	1.9	2.1	2.8	
24				2.4	2.9	2.0	2.0	2.2	2.7	
25				2.4	2.8	2.1	2.0	2.2	2.8	4.5
26				2.3	2.7	2.1	1.9	2.2	2.7	
27		2.9	3.2	2.3	2.5	2.0	1.8	2.2	2.7	
28				2.2	2.5	2.0	1.9	2.1	3.1	
29				2.1	2.3	1.9	1.9	2.1	3.2	
30	2.8			2.1	2.2	1.9	1.8	2.1	3.3	
31					2.2	1.8		2.1		

NOTE.—Ice conditions existed from January 1 to March 31, or later, and December 14 to 31. Ice thickness January to March varied from 0.7 to 2.0 feet; in December it varied from 0.45 to 0.8 foot.

Daily discharge, in second-feet, of Escanaba River near Escanaba, Mich., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,420	350	410	250	250	410	1,300
2	1,420	300	410	250	300	550	1,420
3	1,300	300	410	205	250	880	1,180
4	1,300	300	410	250	250	880	1,070
5	1,300	350	410	205	250	710	1,300
6	1,180	350	350	165	205	710	1,420
7	1,070	350	350	205	250	630	1,420
8	1,070	300	350	205	250	550	1,180
9	970	300	350	205	250	550	1,180
10	970	300	410	165	250	480	1,070
11	970	300	410	205	250	480	970
12	880	350	410	250	300	550	970
13	880	350	350	250	300	630	1,070
14	790	410	350	300	300	630	800
15	790	410	350	300	300	1,420	800
16	710	410	350	480	300	1,680	600
17	710	480	410	480	300	1,420	600
18	710	550	410	480	350	1,420	600
19	790	550	350	410	350	1,180	600
20	790	630	350	350	350	1,070	600
21	710	710	300	300	300	1,070	400
22	630	790	300	300	300	880	400
23	630	970	300	250	350	880	400
24	550	970	300	300	410	790	400
25	550	880	350	300	410	880	400
26	480	790	350	250	410	790	300
27	480	630	300	205	410	790	300
28	410	630	300	250	350	1,180	300
29	350	480	250	250	350	1,300	300
30	350	410	250	205	350	1,420	300
31	....	410	205	....	350	....	300

NOTE.—Discharge estimated for ice period December 14–31. Daily discharges for open-channel period based on a rating curve well defined between 300 and 1,680 second-feet.

Monthly discharge of Escanaba River near Escanaba, Mich., for 1909.

[Drainage area, 800 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
June	1,420	350	839	1.05	1.17	B.
July	970	300	494	.618	.71	B.
August	410	205	349	.436	.50	B.
September	480	165	274	.342	.38	C.
October	410	205	310	.388	.45	B.
November	1,680	410	894	1.12	1.25	B.
December	1,420	....	773	.966	1.11	D.

MENOMINEE RIVER DRAINAGE BASIN.

DESCRIPTION.

Menominee River, throughout its length of about 104 miles, forms part of the boundary line between northern Michigan and Wisconsin, and its drainage basin therefore lies in both States. The river is formed by the junction of Michigamme and Brule rivers, and flows southeastward, emptying into Green Bay, an arm of Lake Michigan, near Menominee, Mich. Its total drainage area is about 4,000 square miles.

Michigamme River might well be called the main stream, as it is the largest and longest of the three tributaries that make up the main river. Downstream from the Michigamme, on the right or west bank, the following important tributaries enter: Paint River, which is called a tributary of Brule River, although it is much the larger stream of the two; and Brule, Pine, and Pemebonwon rivers: on the left or east bank are Sturgeon and Little Cedar rivers.

Michigamme River is said to rise in Lake Michigamme, the largest lake in the Menominee drainage basin, but the lake has a feeder which may be considered the continuation of the river and which rises within 12 miles of Lake Superior. The length of the Michigamme to its extreme source is about 72 miles; to Lake Michigamme about 51 miles. It is noteworthy that four of the largest tributaries enter the main stream above Iron Mountain, Mich., about six-tenths of the total drainage area being above this point. This characteristic increases the value of the stream for water-power development.

The drainage basin is fairly regular in outline, being narrow in its lower portion and widest at the sources of the tributaries which form the river. The surface is in general covered deeply by glacial drift, but the Menominee and all its tributaries flow over hard crystalline rocks as far south as the mouth of Pike River, or fully two-thirds its length. Below the mouth of the Pike the river flows over sandstones and limestones. Most of the rapids and falls occur in the area of crystalline rocks above the mouth of Pike River, although there are several rapids and falls below this point. The country through which the river flows is almost mountainous in character, many high ridges giving diversity to the surface.

The Wisconsin tributaries rise in a high, flat plateau, abounding in lakes and swamps, among which Flambeau and Wisconsin rivers also head. Some of these rivers head in lakes only a few rods apart, and even in the same swamps in which the tributaries of the Menominee head. These lakes and swamps have an elevation of nearly 1,600 feet above sea level, or about 1,000 feet above Lake Michigan. The Michigan branches flow from a similar region of equal or higher elevation. The numerous lakes and swamps make the flow of the river uniform and steady.

The elevation of the headwater streams is, as stated, about 1,600 feet above sea level; at the junction of Brule and Michigamme rivers the elevation is about 1,300 feet; at the highway bridge near Iron Mountain, Mich., the elevation is about 1,050 feet; and at the mouth of the river it is 580 feet.

Forest conditions in this basin are similar to those in the other basins in Wisconsin and Michigan. Lumbering, while declining since 1892, is still active. Probably all the first-class timber has been cut, and that which is being cut at the present time is the smaller and less valuable timber that was left. The forest conditions, as far as their effect upon run-off conditions is concerned, are not greatly different from what they were originally, as the region is not thickly settled, and a second growth soon springs up after the lumbermen.

The mean annual rainfall is about 32 inches. The winters are severe, the snowfall being heavy and remaining on the ground for long periods and the streams being ice-covered from three to four months.

The feasibility of storage has not been fully investigated, but the large number of lakes and swamps must afford many excellent reservoir sites. At the present time lumbermen store water for running logs, and the enlargement of many of these dams would undoubtedly give good-sized reservoirs.

Some excellent water-power sites have been developed on the main stream and its tributaries, but many others, some of which have hardly been seen except by the lumbermen, are awaiting development. With opportunities for storage with which to produce a uniform and increased low-water flow, and with the favorable arrangement of its drainage basin, this river will in time be one of the biggest power producers in this section.

This river is still used for running logs, and the lumbermen's dams for holding water for flooding modify the normal flow of the stream considerably. Dams on the stream for power development should be so built as not to interfere with log running.

Iron is mined at many places in the upper two-thirds of the basin, and the section is fairly well covered with railroads.

The following gaging stations have been maintained in this drainage basin:

Menominee River near Iron Mountain, Mich., 1902–1909.
Menominee River at Lower Quinnesec Falls, Wis., 1898–9.
Menominee River at Koss, Mich., 1907–1909.
Iron River at Riverton Mine, Mich., 1900–1905

MENOMINEE RIVER NEAR IRON MOUNTAIN, MICH.

This station, which is located at the Homestead highway bridge across Menominee River, about 3½ miles south of Iron Mountain, Mich., was established September 4, 1902, to obtain data for studying water power, water supply, and pollution problems. This station was discontinued March 31, 1909, and reestablished June 5, 1909.

Pine River is tributary to the Menominee about 5 miles above the station.

The gage was formerly located on the right abutment of the bridge, from which all measurements are made, but on November 18, 1904, a chain gage was attached to the bridge in order to obtain gage readings during the winter months, as ice formed at the gage on the abutment.

The winters are severe in this locality, but as the current is swift the river is rarely entirely closed at this section. As is shown by the discharge measurements, however, there is backwater effect from ice below the station.

The stream is used extensively for logging and is subject to artificial control at times. Log jams often occur below the station and produce backwater at the gage. Except as above stated the station is an excellent one.

This station was last inspected July 15, 1908. The accuracy of the daily and monthly discharges therefore depends on the permanency of conditions of flow and of elevation of the gage. Conditions of flow are believed to be permanent.

The gage reader's salary during part of 1909 was paid by the Penn Iron Mining Company, Vulcan, Mich., and the Oliver Iron Mining Company, Iron Mountain, Mich.

Daily gage height, in feet, of Menominee River near Iron Mountain, Mich., for 1909.

[A. J. St. Arnauld, observer.]

Day.	Jan.	Feb.	Mar.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	1.6	1.8	....	1.7	3.9	2.2	1.5	2.6	4.9
2	1.6	1.6	1.8	....	1.6	2.8	2.2	1.5	3.4	4.7
3	1.6	1.6	1.8	....	1.9	2.7	2.2	1.5	4.6	4.7
4	1.6	1.6	1.8	....	1.7	2.8	2.2	1.6	4.9	4.4
5	1.6	1.6	1.8	5.4	1.4	3.0	2.7	1.3	4.0	4.6
6	1.6	1.6	1.8	....	1.2	3.3	2.6	1.5	3.7	4.9
7	1.6	1.6	1.8	6.5	1.6	2.5	1.3	1.6	3.5	5.4
8	1.6	1.6	1.8	6.9	1.3	3.1	1.3	1.3	3.3	5.4
9	1.6	1.6	1.8	6.8	1.0	2.3	1.0	1.1	3.1	5.0
10	1.6	1.6	1.8	6.4	1.6	1.8	.9	1.2	2.8	5.2
11	1.7	1.6	1.8	6.6	3.8	2.0	1.6	1.4	2.8	5.1
12	1.6	1.6	1.8	6.2	1.3	2.5	1.9	1.4	2.9	4.4
13	1.6	1.6	1.9	5.9	1.3	2.8	1.3	1.4	2.9	4.1
14	1.6	1.6	1.9	5.2	1.6	2.8	1.6	1.7	3.9	3.6
15	1.7	1.6	2.0	4.8	2.3	3.4	2.7	1.7	6.4	3.6
16	1.7	1.6	2.0	4.3	2.1	2.8	3.6	1.7	6.4	3.6
17	1.7	1.6	2.0	2.3	2.3	2.9	3.5	2.0	6.0	3.6
18	1.7	1.6	2.0	4.6	3.4	2.9	3.4	2.5	6.0	3.6
19	1.7	1.6	2.1	4.6	1.0	2.8	3.0	2.0	5.6	3.3
20	1.7	1.6	2.1	4.3	1.4	2.2	2.6	1.9	5.4	3.0
21	1.7	1.6	2.1	4.3	3.8	2.2	2.5	1.9	5.6	2.9
22	1.7	1.6	2.1	3.2	6.8	2.8	2.2	1.9	5.2	2.8
23	1.7	1.7	2.1	3.2	9.1	2.4	1.9	2.1	4.2	2.6
24	1.8	1.7	2.1	1.6	8.7	2.3	1.9	2.6	4.2	2.6
25	2.0	1.7	2.1	1.6	9.6	2.3	1.6	2.4	4.1	2.6
26	2.4	1.7	2.0	1.6	7.8	2.3	1.8	2.3	4.1	2.6
27	2.3	1.8	2.0	1.8	6.5	2.2	1.7	2.1	4.1	2.9
28	2.2	1.8	1.9	1.7	6.8	2.2	1.4	2.0	4.6	2.9
29	2.2	....	1.9	1.7	3.8	2.5	1.4	2.0	5.6	2.7
30	2.0	....	2.0	1.7	3.6	2.3	1.4	2.0	5.1	2.7
31	1.8	....	2.0	....	3.0	2.1	....	2.3	....	2.5

NOTE.—Ice conditions existed during January, February, March, and December 16–31.

Daily discharge, in second-feet, of Menominee River near Iron Mountain, Mich., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1,340	2,840	1,640	1,220	1,900	3,660
2		1,280	2,040	1,640	1,220	2,460	3,490
3		1,460	1,970	1,640	1,220	3,400	3,490
4		1,340	2,040	1,640	1,280	3,600	3,240
5	4,110	1,170	2,180	1,970	1,120	2,920	3,400
6	4,640	1,060	2,390	1,900	1,220	2,690	3,600
7	5,160	1,280	1,840	1,120	1,280	2,540	4,110
8	5,560	1,120	2,250	1,120	1,120	2,390	4,110
9	5,460	950	1,700	950	1,000	2,250	3,750
10	5,060	1,280	1,400	895	1,060	2,040	3,930
11	5,260	2,760	1,520	1,280	1,170	2,040	3,840
12	4,870	1,120	1,840	1,460	1,170	2,110	3,240
13	4,580	1,120	2,040	1,120	1,170	2,110	3,000
14	3,930	1,280	2,040	1,280	1,340	2,840	2,620
15	3,580	1,700	2,460	1,970	1,340	5,060	2,620
16	3,160	1,580	2,040	2,620	1,340	5,060	2,200
17	1,700	1,700	2,110	2,540	1,520	4,680	1,800
18	3,400	2,460	2,110	2,460	1,840	4,680	1,800
19	3,400	950	2,040	2,180	1,520	4,300	1,600
20	3,160	1,170	1,640	1,900	1,460	4,110	1,600
21	3,160	2,760	1,640	1,840	1,460	4,300	1,600
22	2,320	5,460	2,040	1,640	1,460	3,930	1,600
23	2,320	8,000	1,770	1,460	1,580	3,080	1,600
24	1,280	7,440	1,700	1,460	1,900	3,080	1,600
25	1,280	8,590	1,700	1,280	1,770	3,000	1,600
26	1,280	6,520	1,700	1,400	1,700	3,000	1,400
27	1,400	5,160	1,640	1,340	1,580	3,000	1,400
28	1,340	5,460	1,640	1,170	1,520	3,400	1,400
29	1,340	2,760	1,840	1,170	1,520	4,300	1,200
30	1,340	2,620	1,700	1,170	1.520	3,840	1,200
31		2,180	1,580		1,700		1,200

NOTE.—Flow was affected by ice conditions December 16–31 and discharge estimated. The daily discharges during free-flow periods are based on a rating well defined above a discharge of 1,520 second-feet.

Monthly discharge of Menominee River near Iron Mountain, Mich., for 1909.

[Drainage area, 2,420 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			900	0.372	0.43	D.
February			800	.331	.34	D.
March			1,100	.455	.52	D.
June 5–30	5,560	1,280	3,230	1.33	1.29	C.
July	8,590	950	2,740	1.13	1.30	C.
August	2,840	1,400	1,920	.793	.91	C.
September	2,620	895	1,580	.653	.73	C.
October	1,900	1,000	1,400	.579	.67	C.
November	5,060	1,900	3,270	1.35	1.51	C.
December	4,110		2,480	1.02	1.18	D.

NOTE.—The monthly means for January, February, and March were estimated by comparison with the Koss station and study of gage heights and weather reports.

MENOMINEE RIVER AT KOSS, MICH.

This station, which is located at the Wisconsin and Michigan Railroad bridge at Koss, Mich., was established July 21, 1907, to obtain data for studying water power, water supply, and pollution problems. This station was discontinued March 31, 1909.

This stream is used for logging, and log jams occur frequently at the station and immediately below. The winter conditions are severe, ice forming about 2 feet thick at times. The records are reliable and accurate except as affected by the above conditions.

The chain gage is attached to the bridge from which all discharge measurements are made. The datum of the gage has remained unchanged.

Discharge measurements of Menominee River at Koss, Mich., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 24	W. M. O'Neill	316	1,510	7.41	1,270
March 12	G. A. Gray	285	1,350	7.80	1,390

NOTE.—Measurements made under ice conditions.

Gage heights, in feet, of Menominee River at Koss, Mich., for 1909.

[J. F. Bronoil, observer.]

	Feet.		Feet.
January 7	7.3	February 18	7.2
January 14	7.1	February 25	7.5
January 21	6.9	March 5	7.6
January 28	7.3	March 11	7.9
February 4	7.1	March 18	7.9
February 11	6.9	March 25	8.1

NOTE.—Ice conditions existed from January 1 to about March 25. Gage heights are to water surface. The ice varied in thickness from 0.7 foot to 1.2 feet.

Monthly discharge of Menominee River at Koss, Mich., for 1909.

[Drainage area, 3,780 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			1,560	0.413	0.48	D.
February			1,310	.347	.36	D.
March			1,920	.508	.59	D.

NOTE.—Ice conditions existed from January 1 to about March 25. Discharge estimated on the basis of two measurements under ice conditions and observer's notes.

PESHTIGO RIVER DRAINAGE BASIN.

DESCRIPTION.

Peshtigo River rises in the western part of Forest County, northeastern Wisconsin, flows southeastward across the southwestern part of Marinette County, and empties into Green Bay, an arm of Lake Michigan, at the extreme southeast corner of Marinette County, about 7 miles south of Marinette. The drainage area measured above the mouth comprises about 1,123 square miles.

The drainage basin is narrow and fairly regular in outline, being about 80 miles long and 14 miles in average width. The river itself is about 150 miles long. Its tributaries are small. Among the larger ones are Rat, Thunder, and Little rivers, entering on the west or right bank, and Eagle Nest and Noque Bay rivers, entering on the east or left bank. In the upper two-thirds of its course the river flows through an area of ancient crystalline rocks; in the lower third it crosses successively beds of sandstone and limestone. The most important falls and rapids are in the crystalline area.

The river rises in the highest land in northern Wisconsin. At North Grandon railroad crossing, near its sources, the elevation of the river is 1,620 feet above sea level, at the mouth the elevation is 580 feet, making a total fall of 1,040 feet in about 140 miles, or an average fall of about 7 feet to the mile. This high average gradient gives rise to more and larger rapids than any other river in Wisconsin, and, together with the high and rocky banks, insures numerous water powers.

As in other parts of Wisconsin, practically all the original growth of timber has been cut off and has been replaced by second growth and brush. A considerable area is being brought under cultivation. It is not thought that these changes in forestry conditions have appreciably altered the flow of the streams, but a marked effect on the run-off may be expected to follow the draining of the numerous swamps and lakes at the sources of the river.

The mean annual rainfall is about 32 inches. Winter conditions are severe, the river being ice bound for about three months of each year.

The opportunities for storage have not been investigated, but excellent sites for reservoirs must be afforded by the numerous lakes and swamps in the basin.

The stream presents abundant opportunities for water-power users. It has been estimated that about 32,000 horsepower awaits development on this river at various points.

The stream is still used to some extent for logging but the run of logs is small. A good share of the timber is being used for pulp.

The following gaging stations have been maintained in this drainage basin:

Peshtigo River near Crivitz, Wis., 1906–1909.
Peshtigo River at Crivitz, Wis., 1906.

PESHTIGO RIVER SURVEY.

In order to determine the availability of the Peshtigo for power development, a survey was made during 1906 from the mouth to Rat River.

The results of this survey have been published on separate sheets showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The sheets may be obtained by applying to the Director of the Geological Survey.

PESHTIGO RIVER NEAR CRIVITZ, WIS.[a]

This station, which is located at Herman's farm in the SE. ¼ NW. ¼ sec. 26, T. 32 N., R. 19 E., about 4½ miles west of Crivitz, Wis., was established September 7, 1906, to obtain data for studying water-power problems.

The gage heights at this station were furnished by D. W. Mead and have not been verified by engineers of the United States Geological Survey. Discharge measurements are made from a boat held in position by a stay line stretched across the river. A staff gage in two sections is located on the bank near the measuring section.

No important tributaries enter near the station. The drainage area above the section is about 670 square miles.

Winter conditions are severe, ice forming to a thickness of 1 to 2 feet and lasting about three months. The gage heights may also be affected to a slight extent by logging operations.

The following discharge measurement was made under ice conditions by G. A. Gray:

March 15, 1909: Width, 113 feet; area, 225 square feet; gage height, 1.65 feet; discharge, 318 second-feet.

Daily gage height, in feet, of Peshtigo River near Crivitz, Wis., for 1909.

[Rose Herman, observer.]

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.5	2.75	3.1	2.2	4.1	3.65	2.4	2.45	2.15	2.2	2.45	3.15
2	2.5	2.75	3.1	2.3	4.3	3.55	2.5	2.45	2.15	2.2	2.65	3.05
3	2.5	2.75	3.2	2.6	3.8	4.0	2.5	2.4	2.2	2.2	2.8	3.0
4	2.5	2.75	3.15	2.5	3.1	5.3	2.5	2.5	2.2	2.2	2.8	2.95
5	2.5	2.75	3.2	2.5	3.9	3.25	2.4	2.4	2.15	2.15	2.8	3.0
6	2.5	2.85	3.2	3.0	3.8	3.0	2.4	2.4	2.15	2.15	2.75	3.1
7	2.65	2.9	3.1	3.15	4.1	4.05	2.35	2.35	2.1	2.15	2.7	3.0
8	2.65	2.9	3.2	3.1	5.05	4.8	2.3	2.3	2.1	2.15	2.6	2.7
9	2.65	2.9	3.2	3.1	5.3	5.0	2.3	2.25	2.15	2.15	2.55	3.0
10	2.65	2.9	3.3	2.75	5.35	4.8	2.3	2.2	2.2	2.15	2.5	3.1
11	2.6	2.9	3.25	2.75	5.05	3.4	2.05	2.25	2.15	2.2	2.5	3.1
12	2.6	2.9	3.0	2.8	4.8	4.2	2.6	2.4	2.15	2.2	2.5	3.0
13	2.75	2.9	3.0	2.9	5.0	3.2	2.6	2.45	2.25	2.15	2.8	3.0
14	2.7	2.8	2.85	3.0	5.1	2.8	2.6	2.4	2.4	2.15	3.0	2.7
15	2.7	2.8	2.7	3.15	5.2	4.0	2.7	2.4	2.55	2.2	3.15	2.7
16	2.7	2.8	2.45	3.2	5.3	3.35	2.6	2.35	2.65	2.2	3.45	2.7
17	2.75	2.8	2.3	2.75	5.35	3.3	2.55	2.25	2.7	2.2	3.5	2.65
18	2.75	2.9	2.25	2.85	5.4	2.4	2.5	2.25	2.8	2.2	3.4	2.65
19	2.7	3.0	2.25	3.3	5.4	3.7	2.4	2.25	2.8	2.2	3.4	2.6
20	2.8	3.0	2.2	3.1	5.3	3.2	2.4	2.2	2.7	2.2	3.2	2.6
21	2.8	3.0	2.15	3.15	4.9	2.8	2.35	2.15	2.6	2.25	3.15	2.7
22	2.9	3.1	2.15	4.0	4.3	2.8	2.35	2.1	2.55	2.2	2.95	2.6
23	2.9	3.1	2.15	3.1	4.2	2.8	3.4	2.1	2.5	2.2	2.9	2.4
24	2.9	3.2	2.15	3.0	3.95	2.85	4.1	2.1	2.4	2.3	2.9	2.2
25	2.9	3.2	2.15	3.5	3.6	2.8	4.3	2.1	2.35	2.3	3.0	2.3
26	2.9	3.2	2.1	2.9	3.65	2.7	4.1	2.1	2.35	2.3	3.0	2.2
27	2.7	3.15	2.2	3.75	4.1	2.15	3.7	2.1	2.25	2.3	2.95	2.1
28	2.85	3.1	2.2	4.15	3.8	3.1	3.2	2.25	2.25	2.3	2.95	2.1
29	2.8	......	2.2	4.0	3.5	2.6	3.0	2.2	2.25	2.25	3.0	2.1
30	2.75	......	2.15	4.3	3.1	2.5	2.7	2.2	2.2	2.25	2.9	2.1
31	2.75	......	2.15	......	3.0	......	2.55	2.2	......	2.25	......	2.25

NOTE.—Probable ice conditions January to March and in the latter part of December.

[a] Information in regard to this station prior to 1908 is contained in Bulletin 20 of the Wisconsin Geological and Natural History Survey, entitled "The water powers of Wisconsin," by Leonard S. Smith.

OCONTO RIVER DRAINAGE BASIN.

DESCRIPTION.

Oconto River rises in the plateau region of northeastern Wisconsin in a number of small lakes and swamps in the southern part of Forest County, flows in a southeasterly direction across Oconto County until it passes the southern boundary of that county, then turns abruptly to the east and flows into Green Bay at Oconto, Wis. Its mouth is about 10 miles southwest of the mouth of Peshtigo River.

Its drainage basin, which is somewhat irregular in outline, is about 70 miles long, following the general course of the river, has an average width of about 15 miles, and comprises 950 square miles. The total length of the river is about 90 miles. The most important tributaries are South Branch and on the left or east bank Peshtigo Brook and Little River.

The elevation of the headwaters is about 1,530 feet above sea level; at the mouth the elevation is 580 feet; the total fall therefore is 950 feet, or an average fall of over 10 feet to the mile.

In the upper 35 miles of its course the river flows over crystalline rocks, and in this stretch is found about two-thirds of the total fall. On leaving the crystalline rocks the river flows nearly due south for 20 miles over sandstones and in its eastward stretch it crosses limestones.

As in other parts of Wisconsin, almost all the original forest growth has been lumbered and a second growth is taking its place on those areas that are not being brought under cultivation. It is doubtful if the change in the forestry conditions has had any harmful effect on the run-off at the present time.

The mean annual rainfall is about 32 inches. The winters are severe. The snowfall is comparatively heavy and remains on the ground for long periods. Ice forms from a foot to 2 feet in thickness and lasts for about three months.

The feasibility of storage has not yet been investigated, but as lakes and swamps are numerous excellent sites for reservoirs must exist.

The stream affords many valuable water-power sites whose development is only awaiting a demand for power.

The river is used to some extent for running logs, but the runs are small and the timber is not large; a great deal of it is used for manufacturing pulp.

The following gaging stations have been maintained in this drainage basin:

Oconto River near Gillett, Wis., 1906–1909.
Oconto River at Stiles, Wis., 1906.

OCONTO RIVER NEAR GILLETT, WIS.[a]

This station, which is located at a highway bridge about 2½ miles south of Gillett, Wis., was established June 27, 1906, to obtain data for studying water-power, water-supply, and pollution problems. It was discontinued March 31, 1909.

No important tributaries enter near the gaging station.

The winters are severe, ice forming to a thickness of about 2 feet and lasting for about three months. The gage heights may also be affected for short periods by logging operations.

The datum of the chain gage, which is attached to the bridge from which all discharge measurements are made, has remained unchanged. The records, except as noted above, are reliable and accurate.

Discharge measurements of Oconto River near Gillett, Wis., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 22	W. M. O'Neill	100	289	6.28	296
March 13	G. A. Gray	58	232	6.78	283

NOTE.—Measurements made under ice conditions.

Gage heights, in feet, of Oconto River near Gillett, Wis., for 1909.

[J. M. Aukerson, observer.]

Date	Feet.	Date	Feet.
January 5	6.6	February 18	6.5
January 12	6.4	March 1	6.5
January 19	6.2	March 11	6.8
January 22	6.3	March 20	6.7
January 30	6.2	April 1	6.2
February 12	6.1		

NOTE.—Ice conditions existed from January 1 to latter part of March. Gage heights are to water surface. Ice thickness varied from 1 foot to 1.9 feet. River was open on April 1.

Monthly discharge of Oconto River near Gillett, Wis., for 1909.

[Drainage area, 814 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			293	0.360	0.42	D.
February			289	.355	.37	C.
March			331	.407	.47	C.

NOTE.—Ice conditions existed from January 1 to latter part of March. Monthly estimates are based on two discharge measurements under ice conditions and on observer's notes.

[a] Information in regard to this station prior to 1908 is contained in Bulletin 20 of the Wisconsin Geological and Natural History Survey, entitled "The water powers of Wisconsin," by Leonard S. Smith.

WOLF RIVER DRAINAGE BASIN.

DESCRIPTION.

Wolf River rises in a number of small lakes in the western part of Forest County, in northeastern Wisconsin, flows in a general southerly direction and unites with upper Fox River at a point about 10 miles west of Lake Winnebago. Though nominally a branch of Fox River it is really the master stream, as its discharge is more than three times that of the Fox.

The river is about 180 miles long and its drainage area comprises about 3,600 square miles. All the largest tributaries are from the west, the more important ones (beginning at the source) being West Wolf, Red, Embarrass, Little Wolf, and Waupaca rivers.

The drainage basin is somewhat regular in outline—about 110 miles long with an average width of about 35 miles. Glacial action has modified the basins of many of the streams of northern Wisconsin, and the basin of Wolf River shows very prominently the effect of this action, as there is considerable evidence that formerly this river flowed westward and joined the Mississippi River through the present Wisconsin River valley between Portage and Prairie du Chien.

In the upper half of its course the river flows over crystalline rocks and its descent is very rapid. At the Chicago and Northwestern Railroad crossing, 2 miles west of Lenox, the river has an elevation of 1,560 feet; in the 80 miles between this point and Shawano the river descends about 770 feet, or nearly 10 feet to the mile. This steep slope causes many rapids and falls. Shawano marks the point of transition from ancient crystalline rocks to sandstones, and here the river also crosses the old coast line of Lake Michigan and enters the region of red clay. Below Shawano, which is the head of navigation, the stream is sluggish, its descent being only 42 feet to Lake Winnebago, a distance of 80 miles. The banks are low, and in high water the adjoining flats are covered with water for several miles from the river.

The forestry conditions are similar to those elsewhere in Wisconsin. Lumbering has been carried on very extensively and all the best timber has been cut off. At the present time the run of logs is small, and a great proportion of the timber is used for making paper pulp. Above Shawano the drainage basin is thinly settled, and the forestry conditions, as far as they affect the run-off of the river, are little changed, as a second growth has sprung up after the operations of the lumbermen.

The mean annual rainfall in this part of Wisconsin is about 32 inches. The winters are severe; snowfall is comparatively heavy and lasts for considerable periods. Ice forms on the river from 1 to 2 feet in thickness and remains for about three months.

The feasibility of storage has not been investigated, but the lakes and swamps in the basin must afford opportunities for making reservoirs. The lumbermen have built many dams for holding water for flooding logs, and by increasing the height of these dams large reservoirs could undoubtedly be created.

Excellent sites for water power exist and their development awaits only a demand for power. A few power plants have already been put in operation.

The following stations have been maintained in this drainage basin:

Wolf River, at Keshena, Wis., 1907–1909.
Wolf River, at White House Bridge, near Shawano, Wis., 1906–7.
Wolf River, at Darrows Bridge, near Shawano, Wis., 1906.
Wolf River, at Northport, Wis., 1905.
Wolf River, at Winneconne, Wis., 1902–3.
Little Wolf River, near Northport, Wis., 1907–1909.

WOLF RIVER AT KESHENA, WIS.[a]

This station, which is located at the highway bridge at Keshena, Wis., was established May 9, 1907, to obtain data for studying water power, water supply, and pollution problems. It was discontinued March 31, 1909.

West Wolf River enters about 3 miles above the station.

The winter conditions are severe, ice forming about 2 feet thick near the section. The stream is used considerably for logging, and there is a power plant above the station that may modify the flow in extreme low water.

A staff gage is attached to the left abutment of the bridge from which all measurements are made. The datum of the gage has remained unchanged. The records, except as noted above, are reliable and accurate.

Discharge measurements of Wolf River at Keshena, Wis., 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 20	W. M. O'Neill	158	476	2.49	474
March 14	G. A. Gray	153	382	2.42	385

NOTE.—Measurements made under ice conditions.

[a] Information in regard to this station prior to 1908 is contained in Bulletin 20 of the Wisconsin Geological and Natural History Survey, entitled "The water powers of Wisconsin," by Leonard S. Smith.

Daily gage height, in feet, of Wolf River at Keshena, Wis., for 1909.

[Neil Gauthier, observer.]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	1.78	2.12	2.45	11	2.30	2.20	2.50	21	2.22	2.38	2.38
2	1.80	2.10	2.45	12	2.10	2.18	2.42	22	2.18	2.35	2.42
3	1.82	2.35	2.45	13	2.20	2.20	2.45	23	2.20	2.35	2.28
4	1.82	2.18	2.50	14	2.22	2.22	2.42	24	2.32	2.42	2.22
5	1.88	2.12	2.48	15	2.22	2.28	2.50	25	2.42	2.42	2.22
6	1.90	2.10	2.48	16	2.20	2.25	2.40	26	2.22	2.52	2.12
7	1.95	2.18	2.42	17	2.12	2.38	2.48	27	2.20	2.45	2.25
8	1.92	2.20	2.45	18	2.10	2.38	2.38	28	2.18	2.48	2.30
9	2.00	2.18	2.48	19	2.18	2.38	2.32	29	2.12		1.98
10	2.05	2.15	2.48	20	2.20	2.42	2.38	30	2.10		1.98
								31	2.12		1.90

NOTE.—Ice conditions existed from January 1 to March 31. Gage heights are to water surface. Ice thickness, January 18, 1.1 feet; February 2, 0.7 foot.

Monthly discharge of Wolf River at Keshena, Wis., for 1909.

[Drainage area, 797 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			420	0.527	0.61	D.
February			448	.562	.59	C.
March			431	.541	.62	C.

NOTE.—Ice conditions January 1 to March 31. Monthly estimates based on two discharge measurements under ice conditions and on observer's notes.

LITTLE WOLF RIVER NEAR NORTHPORT, WIS.[a]

This station, which is located at the highway bridge known as Phillips bridge, about 3 miles southwest of Northport, Wis., in the southeastern part of sec. 8, T. 22 N., R. 14 E., was established October 13, 1907, to obtain data for use in studying water-power problems. The station was established and is maintained by D. W. Mead, who furnished the records. The records have not been verified by engineers of the Survey.

The station is about 3 miles from Wolf River.

The drainage area above the section is about 460 square miles.

The ice conditions are those that prevail generally throughout the basin, the stream being covered with ice 1 to 2 feet thick for a period of about three months.

A staff gage is attached to the right abutment of bridge from which discharge measurements are made. The datum of the gage has remained unchanged.

[a] Information in regard to this stream is contained in Bulletin 20 of the Wisconsin Geological and Natural History Survey, entitled "The water powers of Wisconsin," by Leonard S. Smith.

Daily gage height, in feet, of Little Wolf River near Northport, Wis., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.4	2.7	4.7	3.6	3.3	1.7	1.2	1.4	1.2	1.4	1.8
2	2.0	2.4	2.7	4.3	3.7	3.6	1.4	1.3	1.3	1.3	1.4	2.0
3	2.0	2.5	2.8	3.3	4.0	3.4	1.4	1.3	1.3	1.3	1.5	2.1
4	2.0	2.5	3.1	3.7	4.2	3.3	1.5	1.3	1.4	1.2	1.4	2.2
5	1.9	2.6	3.0	3.3	3.9	3.0	1.5	1.3	1.3	1.2	1.4	2.9
6	1.9	3.0	2.9	3.3	4.0	3.3	1.4	1.5	1.2	1.2	1.4	3.0
7	2.0	2.5	2.8	3.6	4.2	4.5	1.5	1.3	1.2	1.2	1.5	2.8
8	2.0	2.4	3.2	3.9	4.2	5.1	1.5	1.4	1.3	1.2	1.4	2.9
9	1.9	2.5	3.4	4.1	4.0	5.0	1.4	1.2	1.3	1.2	1.4	3.2
10	2.0	2.6	3.0	3.9	4.2	4.9	1.4	1.3	1.2	1.2	1.3	3.3
11	2.0	2.6	2.8	3.4	4.0	4.4	1.5	1.3	1.3	1.3	1.4	......
12	2.1	2.5	3.0	3.2	3.7	4.7	1.4	1.4	1.3	1.4	1.4	2.9
13	2.1	2.5	3.5	3.4	3.4	3.6	1.6	1.5	1.5	1.2	1.4	3.0
14	2.2	2.5	3.0	3.3	3.2	3.7	1.7	1.6	1.6	1.3	2.4	2.8
15	2.2	2.6	2.8	3.4	3.5	3.8	1.5	1.8	2.4	1.3	2.6	2.7
16	2.2	3.2	2.9	3.6	4.0	3.6	1.3	1.5	1.4	1.4	2.0	2.7
17	2.3	2.9	3.0	3.5	4.2	3.8	1.3	1.4	1.6	1.3	1.8	2.7
18	2.2	2.5	2.8	3.5	4.4	3.2	1.1	1.4	1.4	1.3	1.8	2.6
19	2.2	2.5	2.9	3.7	4.1	3.2	1.2	1.4	1.4	1.4	1.4	3.0
20	2.2	2.8	3.5	3.5	3.7	3.2	1.2	1.3	1.3	2.3	2.0	2.6
21	2.3	2.7	3.5	3.6	3.9	3.4	1.2	1.3	1.3	1.4	1.7	2.5
22	2.4	2.6	3.1	3.5	3.6	2.2	1.1	1.4	1.3	1.4	1.8	2.5
23	2.5	3.0	3.4	3.4	3.5	2.3	1.2	1.3	1.4	1.3	1.7	2.4
24	2.9	2.6	3.7	3.6	3.4	2.2	1.3	1.3	1.4	1.3	1.7	2.4
25	3.3	2.7	4.0	3.3	3.3	2.7	1.2	1.3	1.3	1.2	1.8	2.4
26	3.4	2.7	4.9	3.2	3.4	3.1	1.2	1.4	1.4	1.3	1.9	2.6
27	2.9	3.2	4.7	2.9	3.5	3.3	1.3	1.3	1.2	1.3	1.8	2.5
28	2.8	3.0	4.4	3.0	3.8	3.2	1.2	1.4	1.2	1.3	1.8	2.5
29	2.7	......	4.1	3.6	3.6	3.2	1.2	1.5	1.2	1.4	1.7	2.6
30	2.4	......	4.5	3.4	3.6	1.8	1.2	1.4	1.2	1.3	1.8	2.5
31	2.5	......	4.3	......	3.6	......	1.3	1.5	......	1.3	......	2.5

NOTE.—Probable ice conditions January, February, March, and the latter part of December.

GRAND RIVER DRAINAGE BASIN.

DESCRIPTION.

Grand River rises in the southern part of Jackson County, in the southeast-central part of Michigan, flows northward to Lansing, thence northwestward to the central part of Ionia County, and finally westward to Grand Haven, Mich., where it enters Lake Michigan. Its length by general course is about 200 miles, but following the bends and angles the distance is at least 300 miles. The principal tributaries beginning at the source are: From the right, Portage, Red Cedar, Lookingglass, Maple, Flat, and Rogue rivers; from the left there is only one of any importance—Thornapple River. The total drainage area is about 5,570 square miles, which makes it the largest stream in Michigan.

The drainage basin is fairly regular in outline and shape. It lies at the southern border of the pine belt and is for the most part cleared and is now thickly settled, having become a rich agricultural region. The area is comparatively flat, being overlain with glacial drift with outcroppings of rock at rare intervals. At Grand Rapids, which is at the head of navigation, the stream passes over a limestone ledge, making a considerable fall at Grand Ledge. About 12 miles west of

Lansing there is a similar descent over sandstone. Below Grand Rapids the flow is very sluggish. In the upper half of this stretch the immediate banks of the river are locally high, forming natural levees; below Lamont bayous and swamps are common between the river banks and the foothills bordering the valley. The valley of the river proper is narrow; gravel bluffs from 50 to 60 feet high stand close to the stream in some places. The northwestern and southeastern portions of the drainage basin are thickly interspersed with small lakes, a number of which have no surface outlet.

The elevation of the sources of the river is about 1,000 feet; at Lansing the elevation is about 820 feet; at Grand Rapids it is about 590 feet; at the mouth of the river the elevation is 581 feet; the total descent is therefore about 400 feet, which produces a rather low average fall.

The basin contains no noteworthy forested areas, all timber having been cut off some time ago.

The mean annual rainfall is from 30 to 35 inches. The winters are comparatively mild; in general the snowfall is not heavy and ice does not form very thick.

Possible storage sites have not been investigated, but it is thought that some of the lakes and swamps might be converted into good-sized reservoirs by means of dams of ordinary height.

The stream is of considerable value for water power, and some sites are still undeveloped. At the present time about 5,000 horsepower is developed at the larger plants on the main stream and tributaries.

The following gaging stations have been maintained in this drainage basin:

Grand River at North Lansing, Mich., 1901-1906.
Grand River at Grand Rapids, Mich., 1901-1909.[a]
Red Cedar River at Agricultural College, Mich., 1902-3.
Crockery Creek at Slocums Grove, Mich., 1902-3.

GRAND RIVER AT GRAND RAPIDS, MICH.

This station, which is located at the Fulton Street Bridge in Grand Rapids, Mich., was established March 12, 1901, to obtain data for studying water-supply, flood-control, pollution, and navigation problems.

The drainage area above the station is about 4,900 square miles.

Ice forms in winter and changes the relationship between gage heights and discharge. Power plants above the section modify the low-water flow.

In November, 1907, a new staff gage, with zero corresponding to the city datum, was attached to the bridge from which discharge

[a] Also gage-height records on Grand River at the Chicago and West Michigan Railroad bridge, Grand Rapids, Mich., 1897-1900.

measurements are made. Readings taken on this gage were first reported in December, 1907. The zero of the gage in use prior to November, 1907, was 0.55 foot below the city datum; all gage readings, however, have been corrected to the city datum, and all published gage heights are therefore referred to the same datum. The records are reliable and accurate. Only two or three measurements have been taken at this station since 1905. These measurements appear to indicate that the 1905 discharge table does not hold after that year and therefore estimates of the flow have not been computed for later years. This station was last inspected October 21, 1908.

The records are furnished by the city engineer of Grand Rapids and have not been verified by engineers of the United States Geological Survey.

Daily gage height, in feet, of Grand River at Grand Rapids, Mich., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	0.35	7.88	3.00	10.05	1.85	0.40	-0.30	-0.52	-0.35	-0.30	1.25
2	......	.25	8.05	2.80	12.60	2.00	.20	- .35	- .50	- .30	- .32	1.15
3	......	.55	7.98	2.55	14.35	1.90	.20	- .38	- .50	......	- .38	1.08
4	-0.10	.80	6.88	......	14.85	1.88	......	- .40	- .50	- .45	- .32	.75
5	.40	.90	5.95	2.15	14.25	2.82	......	- .08	......	- .45	- .20	......
6	.20	4.05	5.08	2.40	13.12	......	.50	- .50	......	- .32	- .12	.82
7	.00	......	......	2.92	11.75	3.28	- .15	- .32	- .45	- .50	......	.80
8	- .30	5.50	4.65	3.00	10.42	3.92	- .15	......	- .80	- .50	- .20	.90
9	- .30	3.90	4.60	3.00	......	4.15	- .12	- .20	- .60	- .50	- .25	.98
10	......	2.75	4.75	3.05	8.70	5.42	.00	- .20	- .65	......	- .30	1.00
11	- .30	3.25	4.75	......	8.05	5.38	......	- .28	- .65	- .28	- .22	.55
12	- .05	3.80	4.85	2.32	7.40	5.15	- .30	- .45	......	- .32	- .18	......
13	.10	4.05	4.70	3.55	6.90	......	- .40	- .42	- .55	- .30	- .10	.55
14	.10	......	......	3.95	6.30	3.70	- .25	- .55	- .75	- .30	......	.80
15	.00	5.80	4.20	3.95	5.65	3.48	- .35	......	- .60	- .20	- .10	2.65
16	- .20	6.20	3.80	4.10	......	3.32	- .48	- .48	- .65	- .10	.00	2.75
17	......	5.70	3.85	4.40	5.25	3.08	- .20	- .48	- .60	......	.05	2.90
18	- .45	5.20	3.45	......	5.45	2.15	......	- .55	- .60	- .20	15	2.60
19	- .50	4.35	2.90	6.70	5.45	1.98	- .42	- .50	......	- .35	.32	......
20	- .50	4.40	2.95	7.35	4.82	......	- .62	- .40	- .50	- .30	.35	2.70
21	.50	......	......	7.95	4.10	1.40	- .50	- .55	- .62	- .35	......	3.30
22	.20	......	2.30	8.80	3.50	1.30	- .30	......	- .48	- .40	1.40	3.35
23	1.00	5.25	2.55	8.95	......	.95	- .40	- .65	- .35	- .35	1.40	3.30
24	......	6.55	2.60	8.60	2.60	.75	- .55	- .65	- .22	......	1.52	3.20
25	1.92	7.10	3.00	......	2.30	.70	......	- .78	- .30	- .45	......	......
26	1.95	7.60	3.10	6.90	2.18	1.00	- .40	- .68	......	- .35	1.52	......
27	2.10	7.78	3.35	5.65	1.80	......	- .50	- .70	- .30	- .35	1.50	3.10
28	1.35	......	......	5.30	1.82	.82	- .40	- .60	- .35	- .40	......	3.10
29	.55	......	3.80	5.60	1.58	.98	- .45	......	- .40	- .35	1.48	2.90
30	- .25	......	3.60	8.85	......	.88	- .40	- .45	- .45	- .40	1.30	2.80
31	......	......	3.45	......	......	......	- .35	- .45	......	......	......	2.80

MANISTEE RIVER DRAINAGE BASIN.

DESCRIPTION.

Manistee River rises in several lakes along the boundary line between Antrim and Otsego counties, in the north-central part of Michigan, flows southwestward across Kalkaska, Wexford, and Manistee counties, and empties into Lake Michigan at Manistee, Mich. It has but two important tributaries, both of which enter in the lower part of the river—Big Bear on the right bank and the South Branch of the Manistee on the left bank. The length of the river is about 110 miles, not taking into account the numerous bends and angles; but following its windings its total length must be about 200 miles, for it is very crooked. The total drainage area is about 2,120 square miles.

The basin is somewhat irregular in shape, the upper part being narrow and the widest portion being found in the lower third. The soil of the area is sandy, and the stream receives a large proportion of its supply from springs along the banks of the main river and its tributaries. The country is flat or rolling. The elevation of the sources of the river is about 1,200 feet and the elevation of the mouth is 581 feet, a total fall of 620 feet.

Practically all the better timber has been cut from this drainage basin, although lumbering is still carried on to some extent.

The mean annual rainfall is about 35 inches. The winters are not severe; there is a fairly heavy fall of snow, and ice forms on the river about 1 foot in thickness during severe cold spells. The large amount of spring water helps to keep the river open.

Storage problems have not been studied, but as the basin contains many lakes it must afford conditions for creating reservoirs to conserve and regulate the flow.

The opportunities for water power have not been fully investigated. Good sites, however, must be available at various places, as the fall of the river is considerable, and the flow is well sustained during dry spells by the numerous springs.

The stream is used considerably for logging, but the lumber interests are becoming less every year.

One gaging station has been maintained in this drainage basin, Manistee River near Sherman, Mich., 1903–1909.

MANISTEE RIVER NEAR SHERMAN, MICH.

This station, which is located at North Bridge, about 1 mile from Sherman, Mich., was established July 10, 1903, to obtain data for studying water power, water supply, and pollution problems.

Wheeler Creek enters immediately below the station.

The river freezes over in winter, making necessary special studies to determine the winter flow. The constancy of flow of this stream, as shown by the tables given below, is remarkable and is due to springs and ground-water flow. The maximum recorded mean flow for any month from 1903 to 1908 is only 2½ times the minimum recorded mean flow. It has consequently been possible to estimate the discharge during the frozen periods fairly closely by taking advantage of these facts and by utilizing climatologic data.

The stream is used for logging, and at times there are sunken logs in the bed of the stream which may affect the gage heights slightly.

The chain gage is attached to the bridge, from which all discharge measurements are made. The datum of the gage has remained unchanged.

The records are reliable and accurate prior to the last inspection of the station, October 23, 1908, except as conditions noted above may affect the readings. The accuracy of the daily and monthly discharges given below depends on the permanency of conditions of flow and of elevation of the gage since that date. Conditions of flow are, however, believed to be permanent.

The gage reader's salary has been paid for part of 1909 by William G. Fargo, Jackson, Mich.

Daily gage height, in feet, of Manistee River near Sherman, Mich., for 1909.

[F. G. Bullock, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.1	2.0	2.2	......	4.1	3.0	2.2	2.1	2.0	2.1	2.2	2.25
2	2.0	2.4	2.2	......	4.2	2.9	2.55	2.1	2.1	2.1	2.28	2.25
3	2.2	2.4	2.2	......	4.4	2.9	2.6	2.05	2.1	2.2	2.18	2.25
4	2.25	2.62	2.15	......	4.2	2.9	2.5	2.05	2.1	2.18	2.15	2.2
5	2.25	2.6	2.15	......	4.0	2.9	2.5	2.05	2.1	2.15	2.05	2.15
6	......	2.6	2.15	......	4.0	2.9	2.5	2.0	2.2	2.15	2.05	2.15
7	......	2.4	2.15	......	3.9	2.7	2.4	2.0	2.2	2.1	2.1	2.15
8	......	2.4	2.15	4.7	3.9	2.7	2.4	1.95	2.1	2.1	2.1	2.15
9	......	2.4	2.15	4.55	3.9	2.5	2.3	1.95	2.1	2.1	2.18	2.2
10	......	2.35	2.15	4.5	3.9	2.5	2.3	2.1	2.1	2.0	2.12	2.2
11	......	2.5	2.15	4.3	3.9	2.5	2.4	2.1	2.1	2.0	2.15	2.2
12	3.32	2.5	2.15	4.7	3.9	2.8	2.4	2.1	2.1	2.0	2.15	2.2
13	3.6	2.4	2.15	5.6	3.9	2.6	2.3	2.05	2.3	1.98	2.15	2.28
14	3.6	2.4	2.15	5.9	3.9	2.6	2.3	2.05	2.35	1.98	2.2	2.3
15	3.6	2.4	2.15	5.7	4.3	2.6	2.3	2.1	2.35	1.9	2.2	2.35
16	3.6	2.4	2.15	5.3	4.5	2.6	2.2	2.1	2.35	1.9	2.28	2.35
17	3.6	2.28	2.3	5.2	4.38	2.6	2.2	2.05	2.35	1.9	2.4	2.35
18	3.4	2.2	2.3	4.9	4.3	2.9	2.2	2.05	2.35	1.95	2.45	2.35
19	......	2.3	2.3	4.6	4.15	2.9	2.15	2.05	2.4	1.95	2.45	2.4
20	......	2.3	2.3	4.5	3.8	2.8	2.15	2.05	2.4	2.08	2.45	2.45
21	......	2.3	2.5	4.5	3.7	2.7	2.15	2.05	2.4	2.18	2.5	2.45
22	......	2.4	2.5	4.5	3.8	2.5	2.15	2.0	2.3	2.2	2.4	2.45
23	3.25	2.4	2.5	4.3	3.6	2.5	2.15	2.0	2.3	2.15	2.35	2.45
24	3.6	2.3	2.5	4.3	3.5	2.4	2.15	2.0	2.3	2.1	2.35	2.45
25	3.6	2.2	2.5	4.2	3.5	2.2	2.2	2.0	2.25	2.05	2.35	2.45
26	3.4	2.18	2.5	4.2	3.5	2.2	2.25	2.0	2.25	2.0	2.35	2.45
27	3.2	2.2	2.5	4.0	3.45	2.2	2.25	1.9	2.2	2.0	2.35	2.4
28	2.95	2.2	2.5	4.0	3.3	2.2	2.2	1.9	2.2	1.9	2.3	2.4
29	2.6	......	2.7	3.9	3.3	2.2	2.2	1.9	2.1	1.9	2.3	2.4
30	2.4	......	2.7	3.9	3.1	2.2	2.2	1.95	2.1	1.95	2.3	2.4
31	2.4	......	2.7	......	3.1	......	2.1	1.95	......	2.1	......	2.45

NOTE.—Ice conditions existed January 6–22. River frozen over January 6–11 and 19–22. No record April 1–7.

Daily discharge, in second-feet, of Manistee River near Sherman, Mich., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	917	883	952	1,200	1,730	1,250	952	917	883	917	952	970
2	883	1,020	952	1,200	1,770	1,210	1,080	917	917	917	980	970
3	952	1,020	952	1,100	1,870	1,210	1,100	900	917	952	945	970
4	970	1,100	934	1,100	1,770	1,210	1,060	900	917	945	934	952
5	970	1,100	934	1,100	1,680	1,210	1,060	900	917	934	900	934
6	800	1,100	934	1,500	1,680	1,210	1,060	883	952	934	900	934
7	800	1,020	934	1,800	1,640	1,140	1,020	883	952	917	917	934
8	800	1,020	934	2,010	1,640	1,140	1,020	866	917	917	917	934
9	800	1,020	934	1,940	1,640	1,060	987	866	917	917	945	952
10	800	1,000	934	1,910	1,640	1,060	987	917	917	883	924	952
11	800	1,060	934	1,820	1,640	1,060	1,020	917	917	883	934	952
12	900	1,060	934	2,010	1,640	1,170	1,020	917	917	883	934	952
13	900	1,020	934	2,470	1,640	1,100	987	900	987	876	934	980
14	900	1,020	934	2,630	1,640	1,100	987	900	1,000	876	952	987
15	900	1,020	934	2,520	1,820	1,100	987	917	1,000	850	952	1,000
16	900	1,020	934	2,310	1,910	1,100	952	917	1,000	850	980	1,000
17	900	980	987	2,260	1,860	1,100	952	900	1,000	850	1,020	1,000
18	900	952	987	2,110	1,820	1,210	952	900	1,000	866	1,040	1,000
19	900	987	987	1,960	1,750	1,210	934	900	1,020	866	1,040	1,020
20	900	987	987	1,910	1,590	1,170	934	900	1,020	910	1,040	1,040
21	900	987	1,060	1,910	1,550	1,140	934	900	1,020	945	1,060	1,040
22	900	1,020	1,060	1,910	1,590	1,060	934	883	987	952	1,020	1,040
23	1,360	1,020	1,060	1,820	1,500	1,060	934	883	987	934	1,000	1,040
24	1,500	987	1,060	1,820	1,460	1,020	934	883	987	917	1,000	1,040
25	1,500	952	1,060	1,770	1,460	952	952	883	970	900	1,000	1,040
26	1,420	945	1,060	1,770	1,460	952	970	883	970	883	1,000	1,040
27	1,330	952	1,060	1,680	1,440	952	970	850	952	883	1,000	1,020
28	1,230	952	1,060	1,680	1,380	952	952	850	952	850	987	1,020
29	1,100	....	1,140	1,640	1,380	952	952	850	917	850	987	1,020
30	1,020	....	1,140	1,640	1,290	952	952	866	917	866	987	1,020
31	1,020	....	1,140	....	1,290	....	917	866	....	917	....	1,040

NOTE.—Flow affected by ice conditions January 6–22 and discharge estimated. Also estimated for April 1–7. The daily discharges for free-flow periods are based upon a rating well defined between 883 and 1,680 second-feet.

Monthly discharge of Manistee River near Sherman, Mich., for 1909.

[Drainage area, 900 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	1,500	....	996	1.11	1.28	C.
February	1,100	883	1,010	1.12	1.17	B.
March	1,140	934	995	1.11	1.28	B.
April	2,630	....	1,820	2.02	2.25	C.
May	1,910	1,290	1,620	1.80	2.08	B.
June	1,250	952	1,100	1.22	1.36	B.
July	1,100	917	982	1.09	1.26	B.
August	917	850	891	.990	1.14	B.
September	1,020	883	958	1.06	1.18	B.
October	952	850	898	.998	1.15	B.
November	1,060	900	973	1.08	1.20	B.
December	1,040	934	993	1.10	1.27	B.
The year	2,630	....	1,100	1.22	16.62	

LAKE HURON DRAINAGE BASIN.

GENERAL FEATURES.

The area tributary to Lake Huron in the United States comprises the eastern part of the Southern Peninsula of Michigan. South of Saginaw Bay the Lake Huron slope is very narrow and the brooks and runnels by which it is drained are only a few miles in length. The so-called Thumb of the Mitten is drained chiefly by three short northward-flowing streams, known as Willow, Pinnepog, and Pigeon rivers, which lie in a flat, marshy region. The Saginaw River system is tributary to the bay at its head, while northward from the bay are Rifle, Au Sable, and Thunder Bay rivers, streams having considerable fall, excellent ground storage, and well-sustained flow. Cheboygan River also belongs in the Lake Huron drainage basin.

AU SABLE RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Au Sable River lies in the northeastern part of Michigan. The river rises in the heart of the plateau region in the central part of northern Michigan, in the southern part of Otsego County, flows southward along the western side of Crawford County to Grayling, then turns and flows eastward across Crawford and Oscoda counties, thence southeastward, and joins Lake Huron at Au Sable. The South Branch and the North Branch are the principal tributaries. The river is about 100 miles in length, not following the bends, and its total drainage area comprises about 2,010 square miles.

Along the lower 20 miles of the river the drainage basin is narrow, having an average width of about 5 miles; but farther up it is somewhat regular in shape, being about 40 miles long by about 30 miles wide. The drainage basin is underlain by shales which have been so deeply covered with glacial drift that rock outcrops are very rare. The upper end of the narrow part of the basin is rolling and hilly; the lower part is level and undulating. In its wider portion the basin consists chiefly of sand and gravel plains with undrained hollows. The elevation of the sources of the river is about 1,250 feet; at Bamfield, about 40 miles from the mouth, following the river, the elevation is about 850 feet; the elevation of the mouth is 581 feet.

This district was at one time noted for its white pine, but the area is now almost entirely cleared of its valuable native timber and is in great part covered with scrub conifers. The mean annual rainfall is about 30 to 35 inches. It is possible that deforestation has increased the flow of this stream by allowing the rainfall to be entirely absorbed by the sand and gravel soil. The water thus absorbed reappears as springs. The springs, which occur wherever the streams have cut down through the sand and gravel to the underlying clay, help maintain the flow of the stream in dry periods and have a tendency to keep the river open during the winter months, although the winter conditions are severe, snowfall being comparatively heavy and ice of considerable thickness forming on the streams.

The arrangement of this basin is very favorable for water-power developments, as three-fourths of the drainage area lies above the narrow portion in which the sites are found. Along this section the bed of the stream is of firm clay and in many places the river is flanked by high terraced clay cliffs rising 60 to 100 feet above it. Extensive investigations are now being made preparatory to developing the power.

The river is still used for logging, but the run of logs is small.

One gaging station has been maintained in this drainage basin: Au Sable River at Bamfield, Mich., 1902–1909.

AU SABLE RIVER AT BAMFIELD, MICH.[a]

This station, which is located at the steel highway bridge at Bamfield, Mich., was established August 27, 1902, to obtain data for use in water-power studies.

The measuring section was formerly located at a wooden bridge about 400 feet above the new steel bridge from which measurements are now made. The steel bridge was begun in March, 1907, and finished in July, 1907. The staff gage, which is fastened to a pier of the old bridge, is unchanged and the section at the gage has not been altered in any way. A slight backwater effect has, however, been caused at the section where the gage is located by changes made in the channel below the gage at the time of the erection of the new steel bridge. The monthly discharges from March, 1907, to December, 1908, as published in Water-Supply Paper 244, are about 4 per cent or less in excess of their true values according to stage.

It is probable that the river is used for log driving only in the spring of the year, for during the summer and fall the gage heights are fairly uniform. As sunken logs are removed from the river twice each year they have little if any effect on the gage readings.

Winters are severe in this locality; the river generally freezes over but does not remain closed longer than one or two months. Any increase in gage height during the winter months, unless caused by a thaw, is generally caused by backwater from ice jams formed by anchor ice.

[a] See list of miscellaneous discharge measurements made on Au Sable River at Rogers Bank, Mich. No established relation has yet been determined between the gage at Bamfield and that at Rogers Bank.

Except as stated above, the records are reliable and accurate. Because of the change in channel conditions, the 1909 estimates are withheld until more data are available.

The gage reader's salary for part of 1909 was paid by William G. Fargo, Jackson, Mich.

Discharge measurements of Au Sable River at Bamfield, Mich., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 12[a]	W. M. O'Neill	86	408	1.19	1,050
January 14[a]	do	86	396	1.22	856
February 16[b]	C. C. Covert	120	631	[c]3.73	1,010
February 17[b]	do	120	598	[d]3.79	984
March 13	do	87	406	1.25	1,180
Do	do	87	391	1.21	1,140

[a] Ice along shores.
[b] Frozen over.
[c] Gage height to bottom of ice, 3.26 feet.
[d] Gage height to bottom of ice, 3.19 feet.

Daily gage height, in feet, of Au Sable River at Bamfield, Mich., for 1909.

[Mrs. W. H. Bamfield, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.97	1.40	1.22	1.62	3.12	2.18	1.48	1.58	1.15	1.11	1.22	1.95
2	.95	4.05	1.19	2.00	3.20	2.12	1.54	1.49	1.25	1.20	1.39	1.85
3	1.00	4.28	1.22	2.34	3.14	2.00	1.40	1.35	1.25	1.18	1.32	1.56
4	1.15	3.85	1.20	2.35	3.35	1.98	1.48	1.42	1.38	1.34	1.31	1.57
5	1.05	2.10	1.18	2.66	3.45	1.94	1.44	1.45	1.22	1.28	1.22	1.54
6	1.10	2.48	1.18	3.69	3.43	1.89	1.32	1.42	1.11	1.14	1.19	1.66
7	1.10	1.55	1.19	4.35	3.31	1.95	1.25	1.39	1.09	1.08	1.21	1.66
8	1.20	1.50	1.24	4.10	3.10	1.92	1.20	1.32	.96	1.00	1.20	1.74
9	1.40	1.74	1.24	3.82	3.02	1.85	1.20	1.31	1.06	1.02	1.24	1.54
10	1.80	1.49	1.33	3.45	2.94	1.80	1.30	1.23	1.14	1.06	1.39	1.54
11	1.65	1.50	1.38	2.12	2.80	1.80	1.28	1.30	1.50	1.31	1.21	1.59
12	1.20	1.40	1.20	3.22	2.68	1.70	1.30	1.20	1.18	1.16	1.28	1.54
13	.95	1.40	1.22	3.68	2.60	1.81	1.28	1.25	1.18	1.00	1.40	1.62
14	1.25	1.45	1.24	4.39	2.51	1.94	1.29	1.19	1.10	1.20	1.50	1.69
15	1.55	3.46	1.21	3.95	2.84	2.02	1.30	1.19	1.02	1.19	1.49	1.74
16	1.30	3.74	1.22	3.70	3.33	1.95	1.28	1.19	1.10	1.55	1.54	1.80
17	1.20	3.88	1.24	3.56	3.16	1.96	1.11	1.10	1.07	1.31	1.50	1.69
18	1.32	4.12	1.24	3.36	3.30	2.28	1.11	1.13	1.10	1.35	1.60	1.60
19	1.60	4.38	1.28	3.42	3.13	2.06	1.40	1.15	1.04	1.35	1.70	1.78
20	1.25	3.90	1.20	3.56	2.61	1.94	1.25	1.09	1.02	1.40	1.54	1.90
21	1.18	4.00	1.23	3.46	2.50	1.90	1.46	1.00	1.08	1.42	1.66	2.00
22	1.36	2.28	1.25	3.60	2.39	1.72	1.65	1.05	1.21	1.47	1.82	2.00
23	1.60	1.22	1.25	3.65	2.38	1.62	2.50	1.08	1.49	1.55	1.69	1.69
24	2.10	1.33	1.30	3.54	2.22	1.55	2.90	1.20	1.42	1.62	1.61	1.50
25	2.29	1.37	1.35	3.02	2.14	1.50	2.55	1.18	1.48	1.50	1.58	1.40
26	1.98	1.29	1.40	2.88	2.06	1.45	2.32	1.20	1.40	1.40	1.48	1.44
27	1.90	1.34	1.46	2.85	1.95	1.25	1.90	1.12	1.34	1.20	1.72	1.42
28	1.75	1.26	1.51	2.90	2.17	1.11	1.74	1.21	1.30	1.24	1.99	1.36
29	1.65		1.52	2.86	2.20	1.19	1.82	1.30	1.21	1.20	2.00	1.30
30	1.42		1.50	2.95	2.22	1.48	1.91	1.16	1.23	1.20	1.93	1.39
31	1.20		1.46		2.14		1.80	1.12		1.24		1.52

NOTE.—Ice conditions existed January 6-20 and January 30 to February 22; also during the latter part of December.

SAGINAW RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of the Saginaw River lies in the north-central part of Michigan, surrounding Saginaw Bay. The Saginaw is formed by three rivers—Tittabawassee River, which is the most northern; Shiawassee River, which extends to the south; and the Cass, which drains the eastern part of the basin. Tittabawassee River rises in the southwestern part of Ogemaw County, flows southward to the central part of Midland County near Midland, then southeastward, and joins Saginaw River a few miles above the city of Saginaw; it receives the waters of Tobacco, Salt, and Pine rivers, and Chippewa River, which discharges to the Pine. Shiawassee River rises in the central part of Livingston County and flows northward into Saginaw River. This river is really the main stream of the drainage basin, as it is a direct continuation of Saginaw River. Its principal tributaries are Bad and Flint rivers. Cass River, the smallest of the three tributaries that form the Saginaw, is formed by the union of the North and South branches. Considering the South Branch as the main stream, the river rises in the western part of Sanilac County, flows northward until it crosses into Tuscola County, then southwestward into the Saginaw about opposite the mouth of the Tittabawassee. It has no important tributaries.

Saginaw River proper is only 20 miles long, the Tittabawassee and the Shiawassee are about 80 miles in length, and the Cass is about 75 miles long. None of these measurements takes into account the short bends and angles. The total drainage area of Saginaw River comprises about 6,260 square miles; of this area about 2,620 square miles belong to the Tittabawassee, about 2,420 square miles to the Shiawassee, and about 994 square miles to the Cass.

This drainage basin, like most of the river basins in Michigan, is covered with glacial drift, and presents a flat surface varied only by the valleys which the larger streams have cut from 10 to 30 feet below the plain. The depth of the surface deposits is not everywhere uniform, varying from a thin film to a layer 500 feet thick, but being in most places about 80 to 100 feet in thickness. To the southeast the drift coating is very thin, the maximum being about 40 feet, but toward the west it becomes thicker.

The sources of the Tittabawassee lie about 900 feet above sea level; at Midland the elevation is about 600 feet; Saginaw Bay is about 581 feet above sea level. The elevation of the sources of the Shiawassee is about 920 feet; at Coruna the elevation is about 740 feet. The sources of the Cass are at an elevation of about 800 feet; at Vassar the elevation is about 610 feet. The slope of the Saginaw River is so small that fluctuations in the elevation of Saginaw Bay caused by strong winds sometimes reverse the current in the river.

This section of Michigan has been about cleared of its timber, and the entire area is largely under cultivation, but some lumbering is still being done on the Tittabawassee.

The mean annual rainfall is from 25 to 30 inches. The winter conditions are comparatively severe in the northern half of the basin; the snowfall is heavy, and ice of considerable thickness forms on the streams; in the southern half of the basin the winters are somewhat milder. The climate and temperature of the entire lower peninsula of Michigan is much modified by the bodies of water that surround it.

The feasibility of storage has not been investigated. The land in the drainage basins of the Shiawassee and Cass and in the lower part of the Tittabawassee is becoming of such agricultural value and swamp areas are being reclaimed to such an extent that there is little opportunity for storage. The map, however, shows several lakes at the sources of the Shiawassee and Tittabawassee that may be utilized as reservoirs for conserving the flow of these two streams.

The Shiawassee and Tittabawassee and their tributaries afford some opportunities for water-power development, but dry-season flow of the Cass is so small that such opportunities are lacking.

The following gaging stations have been maintained in this drainage basin:

Flint River at Flint, Mich., 1903–4.
Cass River at Frankenmuth, Mich., 1908–9.
Cass River at Bridgeport, Mich., 1908.
Tittabawassee River at Freeland, Mich., 1903–1909.

CASS RIVER AT FRANKENMUTH, MICH.

This station, which is located at the highway bridge at Frankenmuth, Mich., was established February 18, 1908, to obtain data for studying water-supply and pollution problems, and was discontinued March 31, 1909.

Perrys Creek enters from the south about 5 miles above the station.

The low-water flow is controlled by a power plant above the station. The discharge is affected by ice during the winter periods.

The first staff gage was attached to a pile practically at the measuring section; later a staff gage on one of the piers of the bridge was used.

Reports of discharge measurements made at this station in 1909 were furnished by R. M. Roberts, city engineer of Saginaw, Mich. It is believed that the measurements are reliable and accurate. The gage heights are referred to the city datum of Saginaw, Mich.

Discharge measurements of Cass River at Frankenmuth, Mich., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 20	G. A. Lowry	141	776	8.50	818
March 21	....do	144	1,040	10.50	1,330
April 20	....do	168	2,290	18.00	6,140
April 22	....do	168	1,900	15.70	3,390
April 23	....do	168	1,620	14.00	2,550
April 24	....do	154	1,260	11.90	1,720

Daily gage height, in feet, of Cass River at Frankenmuth, Mich., for 1909.

[Conrad Schriener, observer.]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	5.2	6.9	13.1	11	5.5	8.3	12.9	21	5.7	8.4	8.5
2	5.5	6.5	12.6	12	5.4	7.9	12.7	22	5.4	9.0	8.4
3	5.35	6.6	12.1	13	5.55	7.7	12.4	23	6.6	9.9	8.4
4	6.0	6.4	11.7	14	5.5	7.4	11.3	24	8.2	11.3	8.2
5	5.55	6.2	11.4	15	5.55	7.0	11.4	25	10.3	13.3	10.4
6	5.45	8.2	11.8	16	5.6	7.0	12.0	26	9.7	14.0	14.3
7	5.7	9.9	11.6	17	5.4	6.8	11.9	27	8.25	14.5	13.3
8	5.8	10.3	11.6	18	5.85	7.0	10.2	28	7.25	13.9	13.4
9	5.6	9.7	13.3	19	6.0	6.6	......	29	7.3	......	12.7
10	5.4	8.9	13.1	20	5.8	7.5	8.5	30	7.4	......	11.4
								31	7.45	......	10.5

NOTE.—Ice conditions existed during portions of January and February.

Daily discharge, in second-feet, of Cass River at Frankenmuth, Mich., for 1909.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	50	200	2,400	11	50	400	2,300	21	80	614	638
2	50	150	2,140	12	50	300	2,190	22	80	765	614
3	50	100	1,900	13	50	300	2,040	23	252	1,030	614
4	50	100	1,710	14	50	200	1,540	24	566	1,540	566
5	50	100	1,580	15	50	200	1,580	25	1,160	2,510	1,200
6	50	566	1,760	16	50	200	1,850	26	963	2,910	3,100
7	50	1,030	1,670	17	50	200	1,800	27	578	3,230	2,510
8	50	1,160	1,670	18	50	200	1,130	28	366	2,850	2,560
9	50	963	2,510	19	50	200	884	29	375	......	2,190
10	50	500	2,400	20	50	400	638	30	300	......	1,580
								31	250	......	1,230

NOTE.—The flow was affected by ice conditions during the periods January 1-22, January 30 to February 5, February 10-20, and discharge estimated from study of gage heights and weather reports. Discharge interpolated for March 19. The daily discharges for open-channel periods are based on a rating well defined between 252 and 3,230 second-feet.

Monthly discharge of Cass River at Frankenmuth, Mich., for 1909.

[Drainage area, 863 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	1,160	....	193	0.224	0.26	D.
February	3,230	....	818	.948	.99	D.
March	3,100	566	1,690	1.96	2.26	B.

TITTABAWASSEE RIVER AT FREELAND, MICH.

This station, which is located at the highway bridge at Freeland, Mich., was established August 22, 1903, to obtain data for studying water-power, water-supply, and pollution problems. It was discontinued August 3, 1906, and was reestablished October 28, 1906.

The drainage area above the station is about 2,550 square miles.

Ice forms at the measuring section, and special studies are necessary to determine the flow during the frozen period.

The records are reliable and accurate. A chain gage is attached to the bridge from which all measurements are made. The datum of the gage has remained unchanged.

This station was last inspected by engineers of the United States Geological Survey on October 28, 1908. Conditions of flow are believed to be permanent. On account of the erratic plotting of measurements and the questionable correction for obliquity of current at different stages, it is deemed advisable to withhold estimates until more data are available.

The following discharge measurement was made by Richard R. Ryan:

April 17, 1909: Gage height, 7.84 feet; discharge, 6,170 second-feet. A correction of 89 per cent was made for obliquity of current.

Daily gage height, in feet, of Tittabawassee River at Freeland, Mich., for 1909.

[W. E. Dennison, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.62		6.00	12.68	3.85	2.27	1.75	1.45	1.76	1.73	2.50
2	2.47	4.60		5.62	14.30	3.80	2.35	1.80	1.50	1.75	1.80	2.45
3		5.00		5.48	13.65	3.75	2.41	1.84	1.53	1.74	2.00	2.40
4		5.43		5.82	11.95	6.40	2.33	1.90	1.52	1.77	2.00	2.23
5		6.00		6.50	10.30	8.03	2.30	1.95	1.50	1.80	2.20	2.12
6		6.95		7.12	8.21	7.90	2.25	1.98	1.51	2.00	2.21	2.20
7		7.00	5.62	7.92	7.90	6.20	2.20	1.94	1.50	2.15	2.20	2.21
8		7.02	6.20	8.00	7.40	5.05	2.10	1.93	1.48	2.12	2.13	2.20
9		6.83	6.81	7.70	7.00	4.63	2.00	1.92	1.45	2.10	2.10	2.51
10	2.55	6.42	7.60	7.00	6.60	4.31	1.95	1.90	1.47	2.05	2.31	2.82
11		6.00	7.15	6.56	7.70	4.00	1.92	1.84	1.46	2.00	2.24	3.00
12		5.40	7.00	5.85	7.00	3.61	1.91	1.78	1.45	1.98	2.27	3.15
13		4.83	6.85	6.00	6.70	3.31	1.86	1.72	1.47	1.91	2.30	3.12
14		4.25	6.68	6.82	5.87	3.30	1.80	1.70	1.50	1.78	2.31	3.10
15			6.42	7.61	5.05	3.21	1.71	1.64	1.50	1.70	2.34	3.14
16			6.00	6.72	5.15	3.17	1.68	1.60	1.48	1.87	2.38	3.11
17	2.55		6.25	7.30	5.00	3.00	1.60	1.61	1.47	1.90	2.31	3.02
18			6.46	8.21	4.61	2.90	1.60	1.63	1.45	1.86	2.30	3.00
19			6.35	10.38	4.20	2.76	1.55	1.65	1.45	1.90	2.35	3.05
20			6.21	13.32	3.90	2.71	1.53	1.60	1.46	1.92	2.38	3.10
21		8.16	6.02	14.00	3.72	2.68	1.51	1.59	1.48	1.97	2.40	3.12
22	2.85		6.72	13.30	3.51	2.53	1.50	1.56	1.50	1.93	2.42	3.05
23	3.45		6.90	12.00	3.30	2.41	1.50	1.53	1.58	1.91	2.40	3.00
24	6.50		7.30	10.31	3.21	2.35	1.51	1.50	1.73	1.90	2.43	3.00
25	7.00		7.65	8.23	3.15	2.21	1.50	1.46	2.00	1.97	2.46	2.96
26	8.65		7.53	7.30	3.00	2.14	1.50	1.45	2.10	1.86	2.50	2.97
27	8.00		7.00	6.55	2.91	2.00	1.48	1.43	2.10	1.82	2.50	2.97
28	7.58	8.25	6.65	5.63	2.90	2.00	1.48	1.40	2.00	1.80	2.51	2.94
29	6.80		6.60	5.53	2.87	2.12	1.50	1.37	1.82	1.70	2.50	2.90
30	5.55		6.51	7.42	2.85	2.20	1.62	1.36	1.79	1.75	2.52	2.85
31	4.80		6.43		2.85		1.70	1.40		1.70		2.82

NOTE.—Ice conditions January 1 to about March 1. The ice thickness varied from 0.75 foot to 1.1 feet during this period.

LAKE ERIE DRAINAGE BASIN.

GENERAL FEATURES.

That portion of the Lake Erie drainage basin that lies within the United States, exclusive of Lakes Superior, Michigan, and Huron, covers the northern third of Ohio, a small corner of northeastern Indiana, and a similar area in southeastern Michigan. South of the lake the drainage area is narrow, the divide lying in places scarcely 50 miles back from the lake shore. To the west the width of the area is greater, and the Maumee, which enters the lake near Toledo, is the largest stream of northern Ohio. The average altitude of the basin above Lake Erie is 500 feet, but the head of the Maumee at Fort Wayne, Ind., is only 170 feet above the lake. The surface is level or gently rolling.

The principal streams are Huron and Raisin rivers, which enter the lake from the Michigan corner, and Maumee, Black, and Cuyahoga rivers, which enter from Ohio. Of these, the Maumee, formed by the junction of St. Marys and St. Joseph rivers at Fort Wayne, Ind., is the most important.

HURON RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Huron River lies in the southeastern part of Michigan. The river rises in several small lakes near Pontiac, in Oakland County, flows southwestward until it enters Washtenaw County, and then turns to the southeast and joins Lake Erie near the mouth of Detroit River. Its length, not following the bends of the river, is about 80 miles, and its total drainage area comprises about 1,060 square miles. The only important tributary is Mill Creek, which enters on the right bank at Dexter, Mich.

The drainage basin is irregular in shape, having its greatest length, about 50 miles, parallel to and lying at a distance of 25 to 30 miles from Detroit River. This basin is connected with Lake Erie by a long narrow valley averaging not more than 5 miles in width, extending from a point near Ypsilanti southeastward to Lake Erie, a distance of 28 miles. In this portion of its course a large part of the total fall of the river occurs.

The northern part of the catchment area is rolling and its topography is complex. The stream flows through a series of lakes, and north of Dover the basin is largely composed of lakes and surrounding marshes. In the vicinity of Ann Arbor the topography is very rolling. Below Ypsilanti the country is flat.

The sources of the river have an elevation of about 900 feet above sea level; at Portage Lake, where the river turns and flows southeastward, the elevation is 850 feet; at Ypsilanti the elevation is 690 feet; at the mouth of the river the elevation is 573 feet.

There are no forested areas in this section. The mean annual rainfall is about 35 inches. The winters are comparatively mild; the snowfall is not heavy and ice does not form very thick.

Storage problems have not been studied, but the numerous lakes and swamps afford a natural storage and produce a steady flow.

The conditions for water power on this stream are nearly ideal, as almost the entire catchment area is situated above the portion of the river that is most suited for the location of dams. A few sites below Ann Arbor have been developed, and opportunities for further development exist in this stretch of the river.

The following gaging stations have been maintained in this drainage basin:

Huron River at Dover, Mich., 1904.
Huron River at Dexter, Mich., 1904–1909.
Huron River at Geddes, Mich., 1904–1909.
Huron River at French Landing, Mich., 1904–5.
Huron River at Flat Rock, Mich., 1904–1909.

HURON RIVER AT DEXTER, MICH.

This station, which is located at the highway bridge at Dexter, Mich., was established September 1, 1904, to obtain data for use in studying water-power, water-supply, and pollution problems.

Mill Creek enters a short distance above the station.

On March 12, 1908, the staff gage which was in use until that time was carried out by the ice; a chain gage was installed March 26, 1908, at the same datum as the staff gage. As the current is swift at the section, little ice forms and the gage heights are only slightly affected thereby. The datum of the gage has remained unchanged. The high water that carried away the gage produced a permanent change in the bed of the river and altered the relation between the gage heights and discharge which existed prior to March 12, 1908.

A small headrace runs to an abandoned mill on the left bank, but at ordinary and low stages there is little or no flow in this canal; at high stages a small amount of water may pass around the gage through this raceway.

The service of the gage reader at this station is paid by the Washtenaw Light and Power Company, Ann Arbor.

The discharge measurements taken at this station plot very erratically, and any estimates of discharges attempted on the basis of the records which follow should be used with great caution. This station was last inspected October 16, 1909.

Daily gage height, in feet, of Huron River at Dexter, Mich., for 1909.

[Elisha White, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.1	0.5	1.9	0.55	3.2	0.45	-0.1	-0.3	-0.32	-0.25	-0.3	0.48
2	.08	.48	1.9	.52	3.05	.42	- .1	- .3	- .3	- .25	- .1	.42
3	.05	.38	1.82	.5	2.85	.4	- .08	- .3	- .3	- .28	- .1	.35
4	.0	.28	1.58	.5	2.65	.35	- .05	- .05	- .28	- .3	- .1	.3
5	.0	.2	1.48	.5	2.5	.32	- .08	.0	- .3	- .3	- .1	.3
6	.0	.7	1.4	.5	2.48	.3	- .15	- .08	- .3	- .3	- .1	.3
7	.0	.9	1.38	.55	2.38	.45	- .18	- .15	- .3	- .3	- .1	.28
8	.0	.82	1.3	.6	2.25	.65	- .2	- .2	- .3	- .3	- .1	.22
9	.0	.65	1.3	.55	2.05	.68	- .2	- .25	- .3	- .3	.0	.15
10	.0	.5	1.55	.5	1.98	.68	- .22	- .25	- .1	- .3	.0	.15
11	.0	.5	1.6	.45	1.85	.68	- .25	.0	- .1	- .3	- .05	.1
12	.0	.5	1.48	.4	1.82	.58	- .25	- .05	- .15	- .3	- .05	.1
13	.2	.5	1.28	.45	1.58	.5	- .25	- .2	- .2	- .3	- .05	.3
14	.2	.5	1.18	.5	1.55	.45	- .28	- .2	- .2	- .3	- .05	.6
15	.2	.5	1.1	.5	1.6	.42	- .3	- .2	- .22	- .3	- .02	.68
16	.3	.45	1.08	.5	1.55	.32	- .2	- .2	- .25	- .3	.0	.58
17	.3	.6	.92	.45	1.4	.25	- .28	- .22	- .3	- .3	.15	.48
18	.3	.55	.82	.45	1.22	.48	- .3	- .25	- .3	- .3	.15	.4
19	.28	.5	.8	.48	1.12	.32	- .3	- .25	- .3	- .3	.1	1.1
20	.18	.5	.8	.5	1.05	.28	- .32	- .3	- .3	- .35	.1	1.2
21	.08	.5	.75	.58	.92	.25	- .35	- .28	- .3	- .35	.1	1.35
22	.05	.75	.68	.65	.82	.2	- .28	- .3	- .3	- .35	.4	1.4
23	.3	1.25	.6	.65	.72	.2	- .18	- .32	- .2	- .28	.9	.9
24	.4	2.2	.6	.6	.62	.15	- .15	- .38	- .2	- .2	.9	.75
25	.4	2.2	.7	.55	.58	.1	- .2	- .4	- .25	- .2	.85	.5
26	.4	2.2	.7	.5	.5	.15	- .22	- .45	- .3	- .2	.8	.4
27	.4	2.18	.7	.5	.55	.18	- .25	- .45	- .3	- .25	.72	.4
28	.4	2.05	.7	.45	.6	.08	- .3	- .45	- .3	- .25	.62	.75
29	.4	......	.65	.72	.52	.0	- .3	- .38	- .2	- .25	.55	1.05
30	.32	......	.58	2.85	.5	- .1	- .25	- .3	- .2	- .28	.52	1.15
31	.32	......	.55	......	.45	......	- .22	- .35	......	- .3	......	.95

HURON RIVER AT GEDDES, MICH.

This station is located at the power plant of the Washtenaw Light and Power Company at Geddes, Mich. It was established February 1, 1904, to obtain data for studying water-power, water-supply, and pollution problems.

Fleming Creek enters from the north about one-half mile below the station. The flow of the river at this point is determined by computing the flow through the turbines by knowing the head-gate opening, rating of the wheels, and the number of hours the turbines are run. The flow over the crest of the dam is determined by considering the dam as a weir, the proper coefficient to be applied being assumed.

The records at this station are furnished by the Washtenaw Light and Power Company, of Ann Arbor, Mich. The computations of the discharge are furnished by Gardner S. Williams. The data have not been verified by engineers of the United States Geological Survey.

Daily discharge, in second-feet, of Huron River at Geddes, Mich., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	77	358	1,420	368	2,240	574	297	[a] 102	72	162	134	685
2	212	294	1,460	376	[a] 1,990	489	282	115	78	120	143	356
3	[a] 317	460	1,450	343	1,700	408	291	87	74	[a] 135	169	383
4	249	478	1,300	[a] 286	1,960	512	[a] 232	88	103	129	173	385
5	294	528	1,040	370	1,630	571	355	148	[a] 90	111	[b] 138	[a] 399
6	243	779	1,010	359	1,640	[a] 524	301	163	182	111	161	512
7	152	[a] 909	[a] 673	360	1,580	524	155	173	117	101	[a] [b] 138	277
8	246	779	672	365	1,480	602	141	[a] 109	98	87	94	378
9	254	638	774	370	[a] 1,480	634	127	102	95	110	214	189
10	[a] 231	611	886	296	1,380	743	141	106	146	[a] 99	204	233
11	262	491	714	[a] 276	1,290	733	[a] 124	181	145	113	209	299
12	189	618	734	325	1,220	705	273	192	[a] 173	104	214	[a] 342
13	201	823	605	316	1,260	[a] 611	149	161	139	118	202	465
14	208	[a] 601	[a] 561	300	1,080	567	154	127	111	119	[a] 297	593
15	188	532	510	311	1,070	538	154	[a] 138	97	128	218	742
16	163	716	457	297	[a] 942	529	145	195	98	128	228	595
17	[a] 77	356	380	303	1,010	450	171	105	107	[a] 129	343	537
18	224	588	507	[a] 249	976	514	[a] 220	79	117	75	272	353
19	213	665	470	424	819	510	112	128	[a] 97	133	248	[a] 457
20	153	657	493	537	847	[a] 436	100	117	97	152	249	422
21	119	[a] 772	[a] 486	551	810	435	49	132	90	147	[a] 262	376
22	256	690	432	620	852	365	111	[a] 100	100	139	427	365
23	540	992	446	636	[a] 774	300	200	104	132	115	934	378
24	[a] 521	2,150	376	637	668	347	220	83	104	[a] 91	783	386
25	645	1,680	252	[a] 612	673	300	[a] 140	98	131	135	790	297
26	659	1,630	436	569	583	318	164	74	[a] 114	125	748	[a] 531
27	527	1,690	426	548	674	[a] 264	143	76	64	143	773	380
28	694	[a] 1,600	[a] 441	543	618	506	95	44	107	152	[a] 660	283
29	516	....	417	718	638	393	87	[a] 51	145	137	663	284
30	549	....	368	2,540	[a] 444	153	146	65	183	160	586	307
31	[a] 189	....	367	....	591	....	137	88	....	[a] 151	....	342

[a] Sunday.
[b] Geddes pond drawn to repair dam; value interpolated from discharge records at Superior dam, about 1½ miles below Geddes.

Monthly discharge of Huron River at Geddes, Mich., for 1909.

[Drainage area, 757 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
January	694	77	302	0.399	0.46
February	2,150	294	824	1.09	1.14
March	1,460	252	663	.876	1.01
April	2,540	249	494	.653	.73
May	2,240	444	1,130	1.49	1.72
June	743	153	485	.641	.72
July	355	49	175	.231	.27
August	195	44	114	.151	.17
September	183	64	114	.151	.17
October	162	75	124	.164	.19
November	934	94	356	.470	.52
December	742	189	403	.532	.61
The year	2,540	44	432	.571	7.71

HURON RIVER AT FLAT ROCK, MICH.

This station, which is located at the highway bridge at Flat Rock, Mich., about one-half mile below the crossing of the Detroit, Toledo and Ironton Railroad, was established August 6, 1904, to obtain data for use in studying water-power, water-supply, and pollution problems.

No important tributaries enter near the gaging station.

The ordinary flow of the stream is controlled by a dam and power plant immediately above the station, but as the river is very steady the dam produces very little artificial control. The nearness of the mill prevents the formation of ice in winter at the gaging section, but jams frequently form below the station, causing backwater. All discharge measurements are made from the bridge.

The staff gage is located at the measuring section. The datum of the gage has remained unchanged. The records are reliable and accurate.

The services of the gage reader at this station are paid by the Washtenaw Light and Power Company, Ann Arbor, Mich. This station was last inspected October 16, 1908. The accuracy of the daily and monthly discharges therefore depends on the permanency of conditions of flow and of the elevation of the gage since that date. Conditions of flow are believed to be permanent.

Daily gage height, in feet, of Huron River at Flat Rock, Mich., for 1909.

[C. L. Metler, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.6	2.0	6.85	3.1	7.85	2.85	1.4	1.1	0.55	1.1	1.05	2.85
2	1.55	2.1	6.65	3.1	8.4	2.85	1.15	1.1	.65	1.25	1.2	2.65
3	1.25	2.25	6.35	3.1	7.75	2.7	1.3	.95	.7	.95	1.15	2.55
4	1.45	2.45	6.3	3.0	7.3	2.55	1.15	.95	.7	.9	1.1	2.5
5	2.1	2.4	5.3	3.05	6.95	3.0	....	.85	.8	.8	1.25	2.4
6	1.9	2.95	5.45	3.05	6.7	2.9	1.05	.9	.9	.75	1.25	2.45
7	1.4	4.1	5.0	3.25	6.7	2.75	1.25	1.05	.8	.9	1.1	2.5
8	2.2	3.85	4.95	3.4	6.55	2.95	1.1	1.15	....	.85	1.35	2.55
9	1.5	2.85	5.2	3.25	6.25	3.25	1.25	1.2	.75	.9	1.3	2.0
10	1.9	3.05	5.4	3.05	6.1	3.55	1.1	.85	.65	1.0	1.25	2.85
11	1.75	2.7	5.6	2.9	6.05	3.75	.8	.6	.8	1.05	1.25	2.25
12	1.85	2.95	5.2	2.75	5.7	3.45	.85	.6	1.05	1.15	1.3	2.2
13	1.85	3.5	4.95	2.8	5.35	3.15	.95	.75	.8	.9	1.15	2.7
14	1.5	3.5	4.6	2.8	5.2	2.95	1.1	1.25	.85	.9	1.2	4.15
15	1.4	2.7	4.35	2.9	5.1	2.85	.85	1.15	1.05	.9	1.25	4.5
16	1.7	3.45	4.35	2.9	5.5	2.45	.95	.8	.85	.75	1.35	4.4
17	1.75	3.75	4.2	2.75	5.25	2.35	.95	1.3	.9	.8	1.7	3.9
18	1.5	3.6	3.95	2.65	4.85	2.4	.95	1.2	.8	1.05	1.6	3.35
19	1.75	3.55	3.85	2.8	4.35	2.55	.95	.75	.9	1.1	1.85	2.75
20	1.75	3.95	3.75	2.9	4.15	2.35	.95	.6	.9	1.1	1.7	2.1
21	1.7	3.95	3.8	2.8	4.0	2.2	.9	.4	.65	1.1	1.65	3.0
22	1.8	4.05	3.6	2.9	3.85	2.2	.7	.7	.8	1.05	2.0	3.1
23	1.8	4.5	3.5	3.1	3.6	2.2	.8	.8	.8	1.2	3.6	2.95
24	2.4	6.2	3.35	3.1	3.45	1.8	.8	.75	.8	1.0	3.9	3.05
25	2.75	7.3	3.75	2.95	3.25	1.9	.95	.85	.9	1.1	....	3.0
26	2.8	7.85	3.8	2.95	3.0	1.75	.9	.9	1.0	1.05	3.7	2.8
27	2.75	7.25	3.75	2.9	3.25	1.8	1.0	.9	.9	.9	3.15	2.8
28	2.65	7.2	3.65	2.75	3.3	1.85	1.05	.9	.7	.9	3.0	2.9
29	2.6	....	3.55	2.85	3.25	2.05	1.2	.75	9	1.05	2.75	2.95
30	2.45	....	3.45	5.85	2.8	1.65	1.25	.65	85	.95	3.05	2.75
31	2.5	....	3.25	....	2.85	....	1.1	.55	....	1.1	....	2.75

NOTE.—Flow affected by ice conditions during portions of January, February, and December.

Daily discharge, in second-feet, of Huron River at Flat Rock, Mich., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	356	400	2,030	757	2,420	682	312	250	148	250	240	682
2	345	400	1,960	757	2,640	682	260	250	166	280	270	625
3	280	400	1,850	757	2,380	639	291	220	174	220	260	597
4	323	400	1,840	727	2,200	597	260	220	174	211	250	583
5	477	556	1,480	742	2,060	727	250	202	192	192	280	556
6	350	712	1,540	742	1,980	697	240	211	211	183	280	570
7	350	1,070	1,380	802	1,980	654	280	240	192	211	250	583
8	350	991	1,360	849	1,920	712	250	260	188	202	302	500
9	350	682	1,450	802	1,820	802	280	270	183	211	291	400
10	350	732	1,520	742	1,760	896	250	202	166	230	280	400
11	350	639	1,590	697	1,750	959	192	157	192	240	280	400
12	350	712	1,450	654	1,620	864	202	157	240	260	291	503
13	350	700	1,360	668	1,500	772	220	183	192	211	260	639
14	350	700	1,240	668	1,450	712	250	280	202	211	270	1,090
15	350	700	1,160	697	1,420	682	202	260	240	211	280	1,210
16	350	700	1,160	697	1,560	570	220	192	202	183	302	1,170
17	350	700	1,110	654	1,470	542	220	291	211	192	379	1,010
18	350	700	1,020	625	1,330	556	220	270	192	240	356	600
19	350	896	991	668	1,160	597	166	183	211	250	415	600
20	350	1,020	959	697	1,090	542	220	157	211	250	379	600
21	379	1,020	975	668	1,040	503	211	124	166	250	368	500
22	403	1,060	911	697	991	503	174	174	192	240	452	500
23	403	1,210	880	757	911	503	192	192	192	270	911	500
24	556	1,800	834	757	864	403	192	183	192	230	1,010	500
25	654	2,200	959	712	802	427	220	202	211	250	980	500
26	668	2,420	975	712	727	391	211	211	230	240	943	400
27	654	2,180	959	697	802	403	230	211	211	211	772	400
28	625	2,160	927	654	818	415	240	211	174	211	727	400
29	400	....	896	682	802	464	270	183	211	240	654	400
30	400	....	864	1,680	668	368	280	166	202	220	742	400
31	400	....	802	....	682	....	250	148	....	250	....	400

NOTE.—The flow was affected by ice conditions January 6–20, January 29 to February 4, February 13–18, December 8–11, December 18–31, and discharge has been estimated from a study of gage heights, weather reports, and comparison with the Geddes station. The daily discharges for free-flow periods are based on a rating curve well defined between 124 and 1,040 second-feet.

Monthly discharge of Huron River at Flat Rock, Mich., for 1909.

[Drainage area, 1,000 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	668	....	406	0.406	0.47	D.
February	2,420	....	995	.995	1.04	D.
March	2,030	802	1,240	1.24	1.43	C.
April	1,680	625	747	.747	.83	B.
May	2,640	668	1,440	1.44	1.66	C.
June	959	368	609	.609	.68	B.
July	312	166	234	.234	.27	B.
August	291	124	208	.208	.24	B.
September	240	148	196	.196	.22	B.
October	280	183	227	.227	.26	B.
November	1,010	240	449	.449	.50	B.
December	1,210	....	588	.588	.68	D.
The year	2,640	124	612	.612	8.28	

LAKE ONTARIO DRAINAGE BASIN.

GENERAL FEATURES.

In the northwestern part of the State of New York, between Niagara and St. Lawrence rivers, is an area aggregating 12,400 square miles drained by streams which flow into Lake Ontario. The divide which controls this drainage is very irregular. Extending to the south and southeast from Fort Niagara, it passes around the headwaters of the Genesee a short distance into Pennsylvania; thence reentering New York it runs southward and eastward from the interior group of lakes, turns to the north, encircles the sources of Black River, turns again to the west, and descends to the lake. The country thus included is level or gently undulating in the counties bordering the lake, but farther south it becomes more rolling, and a series of ridges, gradually increasing in height, stretch down between Cayuga and Seneca and their companion lakes, finally becoming merged with the elevated, broken country forming the principal divide whose abrupt slopes reach altitudes of 2,000 to 2,500 feet about the headwaters of the Genesee.

The easterly or Black River lobe of the drainage basin receives the run-off from the southwestern slope of the Adirondack Mountains—largely a rugged and forest-covered area receiving heavy precipitation, especially in the winter.

The principal streams of the area are the Genesee, the Oswego (formed by the union of Seneca and Oneida rivers, which drain the chain of lakes in central New York), the Salmon, and Black rivers.

GENESEE RIVER DRAINAGE BASIN.

DESCRIPTION.

Genesee River rises in Potter County, Pa., 8 or 10 miles south of the New York-Pennsylvania boundary, flows northwestward for about 32 miles, then turns to the northeast and empties into Lake Ontario, 7 miles north of Rochester. Its entire length, following bends, is about 135 miles, and its drainage area comprises about 2,450 square miles.

In the northern portion of this basin the topography is rolling, with long easy slopes except along the streams, most of which flow in deep ravines hemmed in by steep banks. There is a gradual rise in a general way through the lakes, and in the upper half of the basin the country becomes rough and is broken by ridges whose summits attain elevations of 2,000 to 2,500 feet above sea level.

The mean annual precipitation in the Genesee basin is about 34 inches, ranging from 30 inches in the lower part of the basin to 42 inches in the higher altitudes in the southern part. The winters are rather less severe than in the westerly or northerly parts of New York State, although the rivers are generally frozen over for varying periods of time.

The series of remarkable lakes tributary to the Oswego basin is continued westward into the basin of the Genesee and includes Conesus, Hemlock, Canadice, Honeoye. These lakes serve as natural reservoirs, and have inlets draining considerable areas at their upper ends. The slopes adjacent to the lakes themselves are narrow and steep and are drained by gulleys and torrential brooks. Below the lakes the area is rolling and the soil is rich and extensively cultivated. The areas and elevations of these lakes are shown in the following table:

Areas and elevations of lakes in the Genesee River basin. [a]

Lake.	Elevation.	Water-surface area.	Drainage area.
	Feet.	*Sq. miles.*	*Sq. miles.*
Hemlock Lake	896	2.8	46.8
Canadice Lake	1,092	.7	12.6
Honeoye Lake	800	2.5	39.6

[a] These lake basins are shown on the Honeoye, Canandaigua, Naples, and Wayland topographic atlas sheets of the United States Geological Survey, from which the areas have been taken, with the exception of those for Hemlock and Canadice lakes, which are from surveys of Rochester waterworks.

Other excellent storage sites exist in the Genesee basin, and extensive surveys and studies have been made by the state water supply commission of New York, which has suggested a dam at Portage, furnishing a storage capacity of 18 billion cubic feet, 11 billion cubic feet of which will be available for commercial purposes. Such a reservoir would materially help to control the floods upon the Genesee, which under the present conditions periodically cause much damage.

In the 39 miles between Belmont, in central Allegany County, and Portage the river falls 253 feet (Pl. IV, *B*). At Portage there is a total fall of about 300 feet, made up in three portions, and thence nearly to Mount Morris the river flows at the bottom of a deep gorge. From Mount Morris to Rochester the valley is broad and open and the stream is bordered by meadows which are subject to overflow. At Rochester there is another abrupt descent in three heavy falls, amounting to about 360 feet within the city, most of which has been developed (Pl. IV, *A*).

The State has maintained a dam above Rochester for diverting water to the Erie Canal, and in the basin of Black Creek, one of the upper tributaries of the Genesee from the west, are two reservoirs owned by the State, also used for the benefit of the Erie Canal.

Cuba Reservoir, on the Genesee-Allegheny divide, receives a drainage from a tributary area of 26.6 square miles, having a storage volume of 454,000,000 cubic feet. The overflow from this reservoir enters Allegheny River, but the storage water may be turned into the summit of the abandoned Genesee Valley Canal and thence into Genesee River.

In the improved barge canal, now under construction, the water supply for this section is to be taken from Lake Erie, and it is probable that no diversion for this purpose will be necessary from the Genesee drainage basin.

The following gaging stations have been maintained in this river basin:

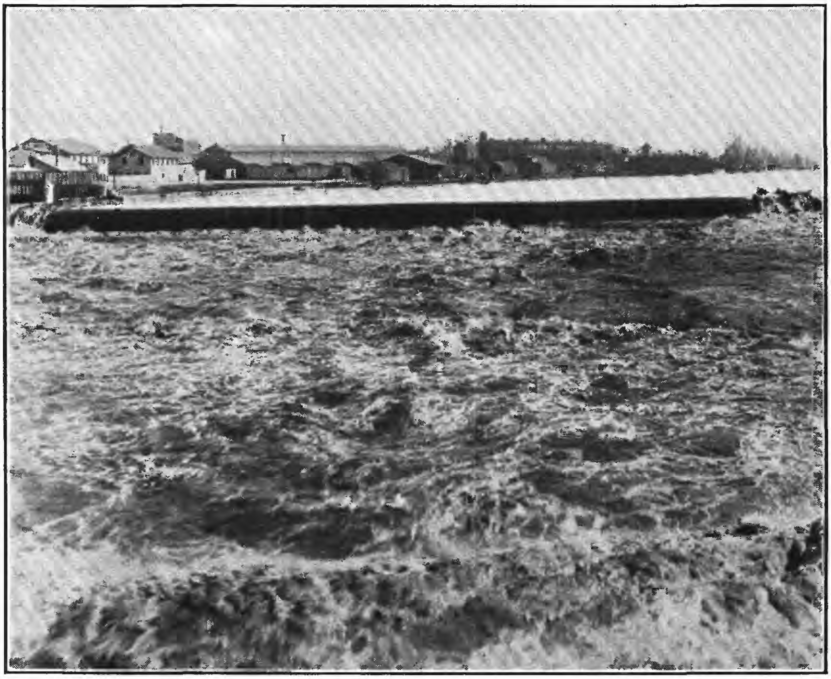
Genesee River at St. Helena, N. Y., 1908–9.
Genesee River at Mount Morris, N. Y., 1903–1909.
Genesee River at Jones Bridge, Mount Morris, N. Y., 1903–1906, 1908–9.
Genesee River at Rochester, N. Y., 1904–1909.
Hemlock Lake at Hemlock, N. Y., 1894–1902.
Canadice Lake Outlet near Hemlock, N. Y., 1903–1909.
Honeoye Creek at East Rush, N. Y., 1903–1906.

GENESEE RIVER AT ST. HELENA, N. Y.

This station, which is located at the steel highway bridge over Genesee River at St. Helena, about 6 miles by river below Genesee Lower Falls, 4 miles from Castile, and 5½ miles from Portageville, was established August 14, 1908, primarily to determine the low-water discharge of Genesee River at this point. Conditions for obtaining accurate records of discharge appear to be good, hence the station will be maintained to obtain general statistical and comparative data regarding run-off in the upper Genesee drainage basin. These data will be of value principally in connection with power development.

The discharge is somewhat affected by ice during the winter period, but it is probable that fairly good records of flow under ice cover can be obtained. The bed of the stream is of coarse gravel, with a few rocks, and is fairly permanent, and a fairly good rating curve has been developed (Pl. III). The datum of the chain gage attached to the bridge has not been changed since the establishment of the station.

Information in regard to this station is contained in the annual reports of the state water supply commission of New York.



A. GENESEE RIVER FROM COURT STREET BRIDGE, ROCHESTER, N. Y., MAY 4, 1909.

B. PORTAGE FALLS, GENESEE RIVER, NEAR PORTAGE, N. Y.

Discharge measurements of Genesee River at St. Helena, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 25[a]	C. R. Adams		1,070	5.28	3,900
February 16[b]	do	175	495	3.98	1,660
April 22	C. C. Covert	299	587	3.74	1,370
May 1	E. F. Weeks	329	2,410	9.75	22,300
May 2	do	315	2,000	8.40	14,800
Do	do	309	1,800	7.72	11,900
May 3	do	305	1,360	6.35	7,160
Do	do	302	1,260	5.96	5,800
May 4	do	306	1,120	5.60	4,780
Do	do	311	1,090	5.42	4,520
May 5	do	310	975	5.02	3,940
August 13[c]	C. C. Covert	107	93	1.60	72
August 14[c]	do	104	83	1.52	57
December 10[d]	do	103	221	2.35	182

[a] No ice at station; very little above or below.
[b] Anchor ice running in large quantities and clogging meter. Discharge not much obstructed.
[c] Measurement made at wading section.
[d] Partial ice conditions. Broken ice 0.05 foot thick.

Daily gage height, in feet, and daily discharge, in second-feet, of Genesee River at St. Helena, N. Y., for 1908.

[Herman Piper, observer.]

Day.	August.		September.		October.		November.		December.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			2.00	160	2.00	160	1.90	132	1.95	146
2			2.00	160	2.00	160	1.85	120	1.95	146
3			2.00	160	1.90	132	1.88	127	1.92	138
4			1.90	132	1.90	132	1.92	138	2.02	
5			2.00	160	1.90	132	1.82	113	1.98	
6			2.00	160	1.90	132	1.85	120	2.12	
7			2.00	160	1.90	132	1.88	127	1.90	
8			1.90	132	1.80	108	1.90	132	1.95	
9			1.80	108	1.85	120	1.82	113	2.00	
10			1.65	80	1.80	108	1.92	138	2.15	
11			1.90	132	1.90	132	1.65	80	2.12	
12			1.90	132	1.85	120	2.15	208	2.02	
13			1.80	108	1.85	120	2.12	198	2.05	
14	2.40	303	1.80	108	1.85	120	2.18	219	1.98	
15	2.55	371	1.85	120	1.92	138	2.02	166	2.05	
16	2.45	325	1.80	108	1.90	132	2.02	166	2.08	
17	2.65	422	1.90	132	1.92	138	2.25	244	2.20	
18	3.05	672	1.80	108	1.88	127	2.12	198	2.15	
19	2.75	477	1.75	98	1.88	127	2.08	185	2.25	
20	2.45	325	1.80	108	1.82	113	2.18	219	2.35	
21	2.35	282	1.75	98	1.82	113	2.22	233	2.28	
22	2.35	282	1.75	98	1.82	113	2.15	208	2.22	
23	2.25	244	1.80	108	1.82	113	2.15	208	2.45	
24	2.25	244	1.80	108	1.80	108	2.12	198	2.35	
25	2.15	208	1.80	108	1.82	113	2.15	208	2.25	
26	2.15	208	1.75	98	1.80	108	2.08	185	2.28	
27	2.15	208	1.70	88	1.82	113	2.00	160	2.30	
28	2.15	208	1.70	88	1.90	132	2.02	166	2.30	
29	2.05	176	1.90	132	1.82	113	2.02	166	2.28	
30	2.05	176	1.90	132	1.90	132	2.02	166	2.25	
31	2.00	160			1.88	127			2.38	

NOTE.—See footnote for 1908 monthly discharge table.

Daily gage height, in feet, of Genesee River at St. Helena, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	2.70	4.35	4.70	9.25	2.32	2.22	1.78	1.65	1.82	2.08	2.12
2	2.38	2.80	3.85	4.60	8.20	2.55	2.12	1.58	1.68	1.88	2.02	2.02
3	2.38	2.88	4.65	4.35	6.25	2.52	2.12	1.65	1.72	1.65	2.08	2.05
4	2.45	2.75	4.15	4.30	5.52	2.55	2.10	1.65	1.68	1.68	1.98	2.00
5	4.45	3.05	3.65	4.50	4.98	2.90	2.08	1.72	1.65	1.75	2.18	1.95
6	6.40	6.60	3.65	5.05	4.50	4.15	2.05	1.80	1.55	1.55	2.22	1.98
7	4.20	5.05	3.95	4.55	4.20	3.40	1.98	1.65	1.68	1.62	2.18	1.98
8	3.15	4.10	3.80	4.80	3.95	3.00	2.00	1.65	1.58	1.72	2.22	2.02
9	3.05	3.45	3.80	4.25	3.75	2.78	1.98	1.62	1.62	1.78	2.12	1.65
10	3.15	3.45	6.55	4.15	3.82	3.40	1.92	1.95	1.62	1.62	2.05	2.05
11	3.10	3.20	5.45	3.95	4.50	5.30	2.02	1.60	1.58	1.60	2.10	2.05
12	2.95	2.95	4.40	4.10	3.95	4.00	2.22	1.58	1.62	1.82	2.05	2.18
13	2.80	3.22	4.60	4.10	3.58	3.48	2.08	1.55	1.58	1.80	1.98	2.15
14	2.85	3.15	4.25	7.35	3.35	3.32	1.98	1.55	1.62	1.88	2.00	2.35
15	3.00	4.60	4.00	5.80	3.45	3.22	1.90	1.52	1.58	1.98	2.01	2.32
16	3.05	4.00	3.85	4.95	4.35	3.05	1.92	1.75	1.65	2.02	2.02	2.35
17	2.95	3.60	3.45	4.50	3.72	2.85	1.98	1.78	1.68	1.75	1.92	2.22
18	2.85	3.50	3.25	4.15	3.45	2.82	1.82	1.72	1.65	1.98	1.92	2.25
19	2.75	3.30	3.45	3.85	3.30	2.85	2.00	1.68	1.62	1.85	1.92	2.30
20	2.75	6.10	3.50	3.65	3.17	2.65	1.88	1.75	1.65	1.92	2.02	2.08
21	2.80	5.35	3.25	3.85	3.08	2.48	1.88	1.72	1.62	1.88	2.02	2.10
22	2.95	4.80	3.22	3.75	3.02	2.52	1.88	1.58	1.65	2.02	2.55	2.25
23	4.65	5.60	3.05	3.50	2.92	2.72	1.98	1.65	1.58	2.12	2.50	2.15
24	6.40	7.40	3.00	3.45	2.85	2.75	2.02	1.58	1.82	2.40	2.68	2.18
25	5.60	6.10	5.15	3.15	2.82	2.62	2.12	1.52	1.75	2.38	2.48	2.05
26	4.40	5.20	4.45	3.25	2.65	2.48	2.02	1.55	2.02	2.35	2.32	2.12
27	3.80	4.78	4.10	3.30	2.70	2.32	1.98	1.70	2.02	2.32	2.22	2.18
28	3.35	4.35	4.35	3.85	2.55	2.32	1.82	1.65	1.92	2.38	2.05	2.15
29	3.08	......	4.48	3.80	3.35	2.25	1.95	1.78	1.78	2.28	2.18	2.22
30	3.10	......	4.25	9.00	3.02	2.28	1.78	1.75	1.85	2.18	2.12	2.25
31	2.88	......	4.05	......	2.85	......	1.78	1.68	......	2.02	......	2.05

NOTE.—Ice conditions prevailed December 10-31. The remainder of the year was probably open.

Daily discharge, in second-feet, of Genesee River at St. Helena, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	325	448	2,300	2,930	19,400	270	233	104	80	113	185	19
2	295	506	1,510	2,740	13,900	371	198	68	85	127	166	166
3	295	556	2,840	2,300	6,680	357	198	80	92	80	185	176
4	325	477	1,960	2,210	4,750	371	191	80	85	85	154	160
5	2,470	672	1,250	2,560	3,520	568	185	92	80	98	219	146
6	7,120	7,720	1,250	3,670	2,560	1,960	176	108	64	64	233	154
7	2,040	3,670	1,660	2,650	2,040	970	154	80	85	74	219	154
8	750	1,880	1,440	3,130	1,660	635	160	80	68	92	233	166
9	672	1,020	1,440	2,120	1,380	494	154	74	74	104	198	80
10	750	1,020	7,570	1,960	1,470	970	138	146	74	74	176	180
11	710	790	4,580	1,660	2,560	4,230	166	71	68	71	191	180
12	602	602	2,380	1,880	1,660	1,730	233	68	74	113	176	180
13	506	807	2,740	1,880	1,170	1,050	185	64	68	108	154	180
14	537	750	2,120	10,200	922	894	154	64	74	127	160	180
15	635	2,740	1,730	5,450	1,020	807	132	59	68	154	163	180
16	672	1,730	1,510	3,450	2,300	672	138	98	80	166	166	180
17	602	1,190	1,020	2,560	1,340	537	154	104	85	98	138	180
18	537	1,080	832	1,960	1,020	518	113	92	80	154	138	180
19	477	875	1,020	1,510	875	537	160	85	74	120	138	180
20	477	6,260	1,080	1,250	766	422	127	98	80	138	166	180
21	506	4,340	832	1,510	695	338	127	92	74	127	166	180
22	602	3,130	807	1,380	650	357	127	68	80	166	371	180
23	2,840	4,940	672	1,080	581	460	154	80	68	198	347	180
24	7,120	10,400	635	1,020	537	477	166	68	113	303	437	180
25	4,940	6,260	3,890	750	518	406	198	59	98	295	338	180
26	2,380	4,000	2,470	832	422	338	166	64	166	282	270	180
27	1,440	3,090	1,880	875	448	270	154	88	166	270	233	180
28	922	2,300	2,300	1,510	371	270	113	80	138	295	176	180
29	695	......	2,520	1,440	922	244	146	104	104	255	219	180
30	710	......	2,120	18,000	650	255	104	98	120	219	198	180
31	556	......	1,800	......	537	......	104	85	......	166	......	180

NOTE.—Daily discharge 1908-9 based on a well-defined rating. Daily discharge December 10-31, 1909, based on an ice measurement made December 10, 1909; this period is only approximate.

Monthly discharge of Genesee River at St. Helena, N. Y., for 1908-9.

[Drainage area, 1,030 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
August 14-31	672	160	294	0.285	0.19	A.
September	160	80	121	.117	.13	A.
October	160	108	125	.121	.14	A.
November	244	80	168	.163	.18	A.
December			160	.155	.18	C.
1909.						
January	7,120	295	1,400	1.36	1.57	A.
February	10,400	448	2,620	2.54	2.64	A.
March	7,570	635	2,010	1.95	2.25	A.
April	18,000	750	2,880	2.80	3.12	A.
May	19,400	371	2,490	2.42	2.79	A.
June	4,230	244	726	.705	.79	A.
July	233	104	158	.153	.18	A.
August	146	59	83.9	.082	.09	A.
September	166	64	88.8	.086	.10	A.
October	303	64	153	.149	.17	A.
November	437	138	210	.204	.23	A.
December		80	173	.168	.19	D.
The year	19,400	59	1,080	1.05	14.12	

NOTE.—The monthly discharge for 1908 supersedes the estimates given in Water-Supply Paper 244. It is based on new data more recently available. The monthly discharge for December, 1908, is based on the discharge at Mount Morris.
See note to table of 1909 daily discharges for ice estimates for 1909.

GENESEE RIVER AT MOUNT MORRIS, N. Y.

This station, which is located at the dam of the Mount Morris Power Company, Mount Morris, N. Y., is about 2 miles above Canaseraga Creek. The station was established May 22, 1903, to obtain data regarding the flow of the river, and was discontinued September 30, 1909. The discharge is divided into two parts—that which runs over the dam and wasteways and that which is used at the mills. The station for determining the latter is at the wooden highway bridge crossing the tailrace of the Mount Morris Power Company, about one-eighth mile below the power station

The dam is of stone masonry, with horizontal crest and ogee cross section and a clear length of about 255 feet. There are two wasteways, each with a crest 18 feet long and 12 inches wide, closed by stop sills to an elevation of about 2 feet above the main dam; also one wasteway with crest 17 feet long and 6 inches wide, about 3 feet higher in elevation than the main dam. The spillways are separated by masonry piers, aggregating 20 feet in width and reaching an elevation of several feet above the main dam.

Several mills and factories use a portion of the flow, which is diverted through a headrace composed of a section of the old Genesee Valley canal. The amount of this diversion is determined by the station on the tailrace below the mills.

During medium and low water stages the water used by the wheels can be fairly well estimated from the gage readings in the tailrace, but at high water there is backwater effect from Canaseraga Creek, at times affecting gage readings. At such times, however, the quantity used by the wheels is relatively a very small portion of the total flow.

The estimates of discharge given herewith do not take account of some leakage from a wasteway at the head of the canal and seepage through the canal banks, which cause a loss varying from about 6 second-feet at low stages to about 40 second-feet at medium and high stages.

The combined results of discharge over the dam and through the wheels at this gaging station are fairly good at medium and high stages, when considerable water is flowing over the dam, and at very low stages when all the water is used by these wheels. At the ordinary low summer stage results are uncertain owing to the effect of pondage by the dam.

The observer at the dam is John McAstocker; the observer at the tailrace is F. M. Goff.

Information regarding this station is contained in the annual reports of the state water supply commission of New York and the state engineer and surveyor, State of New York.

Discharge measurements of tailrace of Mount Morris power canal at Mount Morris, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 21	C. C. Covert	29	76	2.25	199
May 6	E. F. Weeks	29	72	2.00	181
August 14 [a]	C. C. Covert	19	25	.60	38
August 15	do	28	54	1.38	106
August 16	do	28	58	1.60	114

[a] Measurement made at wading section below bridge.

Daily discharge, in second-feet, of Genesee River at Mount Morris, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	368	584	1,740	2,660	18,800	612	250	118
2	371	640	1,650	3,190	15,100	479	224	172
3	346	674	2,600	2,400	6,930	479	212	172
4	422	767	2,230	2,120	4,770	467	197	340
5	1,950	909	1,520	2,480	3,640	562	262	191
6	6,500	5,370	1,360	3,400	2,670	2,000	201	178
7	2,510	4,220	1,480	4,750	2,130	1,160	196	166
8	1,000	1,680	1,590	3,210	1,710	849	195	82
9	836	1,460	1,650	2,140	1,470	659	206	152
10	853	1,370	7,680	1,980	1,580	647	213	142
11	923	1,040	5,810	1,620	2,570	4,430	165	142
12	844	794	2,790	1,780	1,880	2,000	224	142
13	501	1,110	2,590	1,970	1,430	1,210	201	142
14	541	869	2,120	10,100	1,210	946	166	122
15	758	1,560	1,710	5,640	1,200	1,210	178	82
16	724	1,560	1,580	3,630	2,040	843	184	154
17	559	1,420	1,260	4,730	1,630	777	190	148
18	657	1,130	1,110	2,030	1,260	594	105	160
19	642	1,180	1,160	1,710	1,150	659	190	148
20	609	4,390	1,150	1,480	960	536	184	154

Daily discharge, in second-feet, of Genesee River at Mount Morris, N. Y., for 1909—Cont'd.

Day	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
21	705	4,900	918	1,360	913	443	184	136
22	659	3,300	946	1,490	823	455	197	82
23	4,700	5,430	889	1,550	777	419	190	148
24	7,740	13,400	903	1,200	752	600	190	136
25	4,880	10,800	1,820	1,050	640	428	87	142
26	2,290	4,300	6,760	946	602	377	204	154
27	1,650	3,130	1,880	966	546	337	190	154
28	1,210	2,300	2,290	1,270	519	288	190	154
29	767	....	2,310	1,590	1,130	268	184	82
30	650	....	2,060	13,700	853	212	184	154
31	672	....	1,730	....	764	....	172	154

NOTE.—Forty second-feet added for leakage through canal and waste gate January to May. Flashboards on waste gate June to September cut leakage down to about 6 second-feet.

Monthly discharge of Genesee River at Mount Morris, N. Y., for 1909.

[Drainage area, 1,070 sqnare miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	7,740	346	1,540	1.44	1.66	B.
February	13,400	584	2,870	2.68	2.79	B.
March	7,680	889	2,170	2.03	2.34	B.
April	13,700	946	2,940	2.75	3.07	B.
May	18,800	519	2,660	2.49	2.87	B.
June	4,430	212	832	.778	.87	B.
July	262	87	191	.179	.21	C.
August	340	82	148	.138	.16	D.

GENESEE RIVER AT JONES BRIDGE, NEAR MOUNT MORRIS, N. Y.

This station is located at the highway bridge across Genesee River, known as Jones Bridge, a short distance below the junction with Canaseraga Creek, and is about 5 miles below Mount Morris. It was established May 22, 1903, discontinued April 30, 1906, and reestablished August 12, 1908. It is maintained to obtain comparative data regarding the discharge of Genesee River and as a check on the discharge records obtained at High Dam, at Mount Morris.

Conditions of flow are subject to change. Both banks are high, but the left bank is flooded during extreme high water. The records are affected by ice during the winter period. The datum of the chain gage attached to the bridge has not been changed since the gage was installed. Discharge measurements are made from an auxiliary footbridge attached to the downstream side of the bridge or by wading.

Information in regard to this station is contained in the annual reports of the state water supply commission of New York and state engineer and surveyor, State of New York.

Discharge measurements of Genesee River at Jones Bridge, near Mount Morris, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 26	C. R. Adams	145	799	9.03	3,080
February 17 [a]	do	160	1,210	11.77	1,280
April 21	C. C. Covert	128	509	6.95	1,840
August 14 [b]	do	48	48	3.25	114
August 15 [b]	do	39	35	3.10	64
December 9 [c]	do	65	164	3.58	161

[a] Floating anchor ice clogged in large quantities below the bridge caused backwater. Measurement largely estimated.
[b] Measurement made at wading section.
[c] Some shore ice; measurement not materially affected thereby.

Daily gage height, in feet, of Genesee River at Jones Bridge, near Mount Morris, N. Y., for 1909.

[Elizabeth Trewer, observer]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.50	7.10	8.15	9.25	25.85	4.95	4.17	3.01	3.45	3.45	3.80	4.00
2	4.45	7.00	7.70	9.80	26.25	4.90	4.07	3.51	3.40	3.60	3.80	4.00
3	4.35	7.40	9.25	9.80	23.20	4.80	4.07	3.51	3.40	3.35	3.80	3.90
4	4.35	7.65	8.85	8.60	17.95	4.70	3.92	3.36	3.40	3.55	3.70	3.90
5	5.85	7.90	7.30	8.85	12.95	5.15	3.87	3.25	3.40	3.50	3.80	3.75
6	13.50	15.55	6.75	9.55	10.60	7.55	3.87	3.25	3.40	3.55	4.10	3.85
7	8.80	12.20	7.50	12.50	8.70	6.60	3.87	3.10	3.40	3.50	4.05	3.85
8	6.65	8.50	7.30	10.05	8.05	5.75	3.87	2.85	3.20	3.50	3.90	3.75
9	6.35	6.95	7.65	7.35	7.40	5.25	3.67	3.35	3.20	3.35	3.85	3.65
10	6.15	6.50	14.65	7.50	8.10	5.25	3.62	3.20	3.20	3.25	3.75	3.40
11	6.00	6.05	14.60	7.60	9.15	12.00	3.47	3.15	3.20	3.40	3.90	3.35
12	6.20	5.60	10.20	7.60	8.10	8.30	4.22	3.20	3.15	3.60	3.85	3.75
13	6.65	5.90	9.55	7.70	7.00	6.75	4.21	3.15	3.15	3.70	3.80	3.95
14	6.50	6.60	8.60	13.45	6.60	6.20	4.01	3.08	3.10	3.75	3.80	3.85
15	6.45	7.80	7.75	19.05	6.45	6.15	3.71	3.15	3.15	3.70	3.80	4.05
16	6.95	11.55	7.25	11.95	7.50	5.65	3.66	3.20	3.20	3.60	3.80	4.00
17	7.00	11.90	6.80	9.85	7.75	5.30	3.71	3.30	3.30	3.40	3.80	4.00
18	6.60	10.85	6.20	8.70	7.25	5.15	3.36	3.45	3.15	3.40	3.75	4.05
19	6.55	10.35	6.30	7.90	6.65	5.10	3.86	3.55	3.25	3.45	3.75	4.20
20	6.50	11.10	6.05	7.25	5.75	4.85	3.76	3.55	3.35	3.70	3.80	4.75
21	6.50	15.20	5.75	6.90	5.70	4.77	3.71	3.80	3.20	3.65	3.75	5.20
22	6.80	12.35	5.65	6.95	5.60	4.57	3.56	3.45	3.10	3.75	3.95	5.50
23	13.20	14.60	5.60	7.25	5.50	4.72	3.71	3.30	3.05	3.85	4.50	5.80
24	16.60	21.55	5.65	7.00	5.35	4.92	3.71	3.40	3.25	4.15	4.65	4.75
25	12.10	24.20	9.55	7.20	5.20	4.77	3.71	3.25	3.50	4.50	4.55	4.35
26	9.25	17.55	10.05	7.25	5.15	4.57	3.91	3.10	3.40	4.35	4.25	4.40
27	7.50	12.25	8.55	7.05	5.05	4.42	3.91	3.25	3.85	4.30	4.10	4.40
28	6.45	10.20	8.90	6.90	5.00	4.37	3.76	3.40	3.80	4.20	4.10	4.45
29	5.80	....	8.85	7.50	6.10	4.37	3.81	3.05	3.75	4.15	4.05	4.40
30	5.75	....	8.35	17.25	5.80	4.27	3.71	3.40	3.60	4.05	4.00	4.50
31	6.50	....	7.85	....	5.20	....	3.56	3.33	....	3.85	....	4.45

NOTE.—Backwater at the gage, due to ice conditions, February 1-4, 16-19, and December 18-31; also probably slight effect from ice for brief periods at other times—January to March, and December.

Daily discharge, in second-feet, of Genesee River at Jones Bridge, near Mount Morris, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	490	1,100	2,500	3,220	16,200	688	360	46	138	138	235	300
2	470	800	2,210	3,610	16,600	665	324	152	125	175	235	300
3	430	800	3,220	3,610	14,100	620	324	152	125	112	235	265
4	430	800	2,950	2,790	9,920	575	272	115	125	162	205	265
5	1,150	2,340	1,970	2,950	5,920	785	256	90	125	150	235	220
6	6,360	8,000	1,640	3,440	4,170	2,120	256	90	125	162	335	250
7	2,920	5,320	2,090	5,560	2,860	1,560	256	60	125	150	318	250
8	1,590	2,720	1,970	3,780	2,430	1,090	256	30	80	150	265	220
9	1,420	1,760	2,180	2,000	2,030	835	196	112	80	112	250	190
10	1,310	1,500	7,280	2,090	2,460	835	181	80	80	90	220	125
11	1,230	1,260	7,240	2,150	3,160	5,170	142	70	80	125	265	112
12	1,340	1,010	3,890	2,150	2,460	2,600	378	80	70	175	250	220
13	1,590	1,180	3,440	2,210	1,790	1,640	374	70	70	205	235	282
14	1,500	1,560	2,790	6,320	1,560	1,340	304	57	60	220	235	250
15	1,480	2,270	2,240	10,800	1,480	1,310	208	70	70	205	235	318
16	1,760	4,000	1,940	5,130	2,090	1,040	193	80	80	175	235	300
17	1,790	1,280	1,670	3,640	2,240	860	208	100	100	125	235	300
18	1,560	1,200	1,340	2,860	1,940	785	115	138	70	125	220	280
19	1,530	1,200	1,400	2,340	1,590	760	253	162	90	138	220	280
20	1,500	4,520	1,260	1,940	1,090	642	223	162	112	205	235	280
21	1,500	7,720	1,090	1,730	1,060	606	208	235	80	190	220	280
22	1,670	5,440	1,040	1,760	1,010	518	165	138	60	220	282	280
23	6,120	7,240	1,010	1,940	960	584	208	100	52	250	490	280
24	8,840	12,800	1,040	1,790	885	674	208	125	90	352	552	280
25	5,240	14,900	3,440	1,910	810	606	208	90	150	490	510	280
26	3,220	9,600	3,780	1,940	785	518	268	60	125	430	390	280
27	2,090	5,360	2,760	1,820	735	458	268	90	250	410	335	280
28	1,480	3,890	2,980	1,720	710	438	223	125	235	370	335	280
29	1,120	....	2,950	2,090	1,280	438	238	52	220	352	318	280
30	1,090	....	2,630	9,360	1,120	398	208	125	175	318	300	280
31	1,500	....	2,300	....	810	....	165	108	....	250	....	280

NOTE.—Daily discharge for open-channel periods based on a well-defined rating. Discharge during the periods of ice conditions based on measurements made during ice conditions and the discharge at other Genesee River stations.

Monthly discharge of Genesee River at Jones Bridge, near Mount Morris, N. Y., for 1909.

[Drainage area, 1,410 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	8,840	430	2,120	1.50	1.73	C.
February	14,900	800	3,980	2.82	2.94	C.
March	7,280	1,010	2,590	1.84	2.12	B.
April	10,800	1,730	3,290	2.33	2.60	A.
May	16,600	710	3,430	2.43	2.80	A.
June	5,170	398	1,040	.738	.82	A.
July	378	115	240	.170	.20	A.
August	235	30	102	.072	.08	A.
September	250	52	112	.079	.09	A.
October	490	90	217	.154	.18	A.
November	552	205	288	.204	.23	A.
December	318	112	261	.185	.21	C.
The year	16,600	30	1,470	1.04	14.00	

NOTE.—See footnotes to daily gage height and discharge tables.

GENESEE RIVER AT ROCHESTER, N. Y.

This station, which is located at the Elmwood avenue steel highway bridge in Rochester, N. Y., was established February 9, 1904, to determine the total flow of Genesee River. The gage heights are furnished by the city engineer and board of park commissioners of Rochester. Discharge measurements were made and rating curve developed by the United States Geological Survey.

The staff gage is located at the bridge, from which measurements are made.

The elevation of zero of gage is 506.848 feet, Barge Canal datum, and 245.591 feet, Rochester city datum. The gage datum has remained the same since the starting of the record. The rating curve is fairly well developed for all stages, and open-water estimates are considered fair except for extreme low water. During a portion of the winter estimates are affected by ice.

Information in regard to this station is contained in the reports of the state engineer and surveyor, State of New York.

Discharge measurements of Genesee River at Rochester, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 15	C. C. Covert	358	1,760	3.21	4,020
April 21	do	360	1,620	2.82	3,810
May 11	A. R. Patchke		1,960	3.88	6,010

Daily gage height, in feet, of Genesee River at Rochester, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.0	2.8	3.6	3.5	7.6	1.8	1.3	1.0	0.9	1.0	1.0	1.0
2	1.1	2.0	3.2	3.5	8.5	1.6	1.2	1.0	.8	1.0	1.0	1.0
3	1.1	1.6	3.0	3.6	9.0	1.5	1.2	.9	.8	1.0	1.0	1.0
4	1.1	1.8	2.9	3.3	9.0	1.5	1.2	.9	.8	.9	1.0	1.0
5	1.2	1.6	2.9	3.2	7.6	1.5	1.2	.9	.8	.9	1.0	1.0
6	2.0	3.5	2.8	3.4	5.4	1.5	1.2	.9	.8	.9	1.0	1.0
7	4.5	5.7	2.8	3.9	4.0	1.7	1.2	.9	.8	.9	1.0	1.0
8	3.3	4.0	2.8	4.8	3.5	2.0	1.1	.9	.8	.9	1.0	1.0
9	2.4	2.7	3.4	4.0	3.3	2.0	1.1	.9	.8	.9	1.0	1.0
10	2.1	2.5	4.9	3.0	3.3	2.0	1.0	.9	.8	.9	1.0	1.0
11	1.85	2.4	6.4	3.0	3.3	2.3	1.0	.9	.8	.9	1.0	1.0
12	2.4	2.3	4.8	2.8	3.5	3.7	1.0	.9	.8	.9	1.0	1.0
13	2.65	2.6	3.9	2.8	3.5	2.8	1.0	.9	.8	1.0	1.0	1.0
14	2.65	3.0	3.5	3.9	3.0	2.1	1.2	.9	.8	1.0	1.0	1.0
15	2.1	3.4	3.2	6.8	2.9	2.0	1.1	.9	.8	1.0	1.0	1.0
16	2.1	4.0	2.9	5.5	3.1	1.7	1.1	.9	.8	1.0	1.0	1.1
17	2.1	4.3	2.6	4.3	3.8	1.7	1.0	.9	.9	1.0	1.0	1.2
18	2.1	3.7	2.4	3.5	3.3	1.6	1.0	.9	.9	1.0	1.0	1.3
19	1.85	3.0	2.4	3.3	2.7	1.6	1.0	.9	.9	1.0	1.0	1.3
20	1.65	3.0	2.4	2.6	2.7	1.5	1.0	.9	.9	1.0	1.0	1.3
21	1.48	5.2	2.2	2.6	2.3	1.5	1.0	.9	.9	1.0	1.0	1.3
22	1.48	4.8	2.2	2.6	2.2	1.5	1.0	.9	.9	1.0	1.0	1.3
23	2.3	4.2	2.2	2.6	2.1	1.5	1.1	.9	.9	1.0	1.0	1.3
24	4.6	6.4	2.2	2.4	2.1	1.5	1.1	.9	.9	1.0	1.1	1.3
25	5.0	8.2	2.5	2.4	2.0	1.5	1.1	.9	.9	1.0	1.2	1.3
26	5.6	8.2	4.4	2.2	2.0	1.4	1.1	.9	1.0	1.0	1.3	1.3
27	4.0	7.1	3.6	2.2	2.0	1.4	1.1	.9	1.0	1.0	1.3	1.2
28	3.4	4.3	3.6	2.2	2.0	1.3	1.1	.9	1.0	1.0	1.2	1.0
29	2.0		3.7	2.5	2.0	1.3	1.1	.9	1.0	1.0	1.1	1.0
30	2.0		3.8	2.8	1.9	1.3	1.1	.9	1.0	1.0	1.1	1.0
31	2.3		3.5		1.9		1.1	.9		1.0		1.0

Daily discharge, in second-feet, of Genesee River at Rochester, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	400	3,100	4,840	4,600	16,400	1,300	670	400	320	400	400	400
2	490	1,600	3,940	4,600	19,600	1,000	580	400	240	400	400	400
3	490	1,000	3,500	4,840	21,400	850	580	320	240	400	400	400
4	490	1,300	3,300	4,160	21,400	850	580	320	240	320	400	400
5	580	1,000	3,300	3,940	16,400	850	580	320	240	320	400	400
6	1,600	4,600	3,100	4,380	9,620	850	580	320	240	320	400	400
7	7,100	10,500	3,100	5,560	5,800	1,150	580	320	240	320	400	400
8	4,160	5,800	3,100	7,940	4,600	1,600	490	320	240	320	400	400
9	2,320	2,900	4,380	5,800	4,160	1,600	490	320	240	320	400	400
10	1,780	2,500	8,220	3,500	4,160	1,600	400	320	240	320	400	400
11	1,380	2,320	12,600	3,500	4,160	2,140	400	320	240	320	400	400
12	2,320	2,140	7,940	3,100	4,600	5,080	400	320	240	320	400	400
13	2,800	2,700	5,560	3,100	4,600	3,100	400	320	240	400	400	400
14	2,800	3,500	4,600	5,560	3,500	1,780	580	320	240	400	400	400
15	1,780	4,380	3,940	13,900	3,300	1,600	490	320	240	400	400	400
16	1,780	5,800	3,300	9,900	3,720	1,150	490	320	240	400	400	490
17	1,780	6,580	2,700	6,580	5,320	1,150	400	320	320	400	400	580
18	1,780	5,080	2,320	4,600	4,160	1,000	400	320	320	400	400	670
19	1,380	3,500	2,320	4,160	2,900	1,000	400	320	320	400	400	670
20	1,080	3,500	2,320	2,700	2,900	850	400	320	320	400	400	670
21	832	9,060	1,960	2,700	2,140	850	400	320	320	400	400	670
22	832	7,940	1,960	2,700	1,960	850	400	320	320	400	400	670
23	2,140	6,320	1,960	2,700	1,780	850	490	320	320	400	400	670
24	7,380	12,600	1,960	2,320	1,780	850	490	320	320	400	490	670
25	8,500	18,500	2,500	2,320	1,600	850	490	320	320	400	580	670
26	10,200	18,500	6,840	1,960	1,600	760	490	320	400	400	670	670
27	5,800	14,800	4,840	1,960	1,600	760	490	320	400	400	670	580
28	4,380	6,580	4,840	1,960	1,600	670	490	320	400	400	580	400
29	1,600	....	5,080	2,500	1,600	670	490	320	400	400	490	400
30	1,600	....	5,320	3,100	1,450	670	490	320	400	400	490	400
31	2,140	....	4,600	....	1,450	....	490	320	....	400	....	400

NOTE.—The above daily discharges are based upon a fairly well-defined rating. No data available regarding ice conditions, and the effect from such causes is believed to be slight.

Monthly discharge of Genesee River at Rochester, N. Y., for 1909.

[Drainage area, 2,360 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	10,200	400	2,700	1.14	1.31	B.
February	18,500	1,000	6,000	2.54	2.64	B.
March	12,600	1,960	4,200	1.78	2.05	B.
April	13,900	1,960	4,350	1.84	2.05	B.
May	21,400	1,450	5,850	2.48	2.86	B.
June	5,080	670	1,280	.542	.60	B.
July	670	400	487	.206	.24	B.
August	400	320	325	.138	.16	B.
September	400	240	293	.124	.14	B.
October	400	310	377	.156	.18	B.
November	670	400	439	.186	.21	B.
December	670	400	493	.209	.24	B.
The year	21,400	240	2,230	.945	12.68	

CANADICE LAKE OUTLET NEAR HEMLOCK, N. Y.

Canadice Lake is tributary to Genesee River through Hemlock Lake outlet and Honeoye Creek. Hemlock Lake is used as a source of water supply for the city of Rochester. The gaging station was established at the outlet at the foot of the lake by the city engineers' department of Rochester in February, 1903.

A standard thin-edged weir with a 5-foot crest and two end contractions is so arranged with needle timbers at the ends that during high water the length may be increased to 14.96 feet with no end contractions. The weir crest stands 3 feet above the stream channel and is never submerged by backwater. There are two additional rectangular gates, each 1 foot square, with three complete contractions and a fourth partial contraction at the bottom. The outflow from the lake above the weir is controlled by gates.

A reading of the depth on the weir is taken each morning and also at each change of the gates, the depth being read to hundredths and corrections being made for velocity of approach for the larger discharges. The discharge is calculated by the Francis formula. The record has been furnished by E. A. Fisher, city engineer, and John F. Skinner, principal assistant city engineer, of Rochester, N. Y., and has not been verified by engineers of the United States Geological Survey.

Information in regard to this station is contained in the reports of the state engineer and surveyor, State of New York, and city engineer of Rochester.

Monthly discharge of Canadice Lake outlet near Hemlock, N. Y., for 1909.

[Drainage area, 12.6 square miles.]

Month.	Discharge in second-feet.		Run-off (depth in inches on drainage area).	Mean elevation of lake above low water, in feet.
	Mean.	Per square mile.		
January	3.286	0.261	0.30	−0.777
February	5.654	.449	.47	+ .154
March	15.976	1.27	1.46	+1.501
April	27.998	2.22	2.48	+2.096
May	19.893	1.58	1.82	+2.420
June	8.627	.685	.76	+1.770
July	5.784	.459	.53	+ .972
August	3.258	.259	.30	+ .409
September	4.791	.380	.42	− .179
October	4.469	.355	.41	− .682
November	4.489	.356	.40	−1.090
December	3.235	.257	.30	−1.434
The year	8.955	.711	9.65	+ .430

NOTE.—The figures showing discharge in second-feet per square mile and run-off depth in inches on drainage area are without significance except in the totals for the year, the monthly run-offs being controlled absolutely by discharge of water through the head-gates.

OSWEGO RIVER DRAINAGE BASIN.

DESCRIPTION.

Oswego River is formed by the union of Seneca and Oneida rivers about 12 miles northwest of Syracuse, whence its course is northwestward to Oswego, where it enters Lake Ontario. The length of the river from the junction to the mouth is about 20.5 miles, and the drainage basin in this district is a narrow strip of moderately rolling country. Above the junction of Seneca and Oneida rivers the basin spreads out, attaining a total width east and west of about 100 miles and north and south of about 80 miles. The total drainage area is about 5,000 square miles.

The rise is, on the whole, gradual from the low level lands which border Lake Ontario to the north-south ridges which separate the various lakes south of Seneca River and which farther south become merged with the still more elevated country lying along the southern boundary of the Lake Ontario drainage basin.

The most remarkable feature of the drainage basin is the chain of lakes stretching across its southern border. From west to east the principal lakes are, in order, Canandaigua, Keuka, Seneca, Cayuga, Owasco, Skaneateles, and Oneida. These seven lakes include a water surface of approximately 280 square miles, increased by four smaller lakes—Cross, Onondaga, Otisco, and Cazenovia—to about 295 square miles. The larger of the lakes—Oneida, Cayuga, and Seneca—are used for steam-towing navigation, having connection with the Erie and Oswego canals. Cayuga and Seneca lakes are noted for their depth and for the abrupt slopes of their beds. The influence of the lakes on Oswego River is of the utmost importance in contributing to the steadiness of its flow.

A fall of 100 feet in the course of the main river is largely utilized by seven dams, which also partly canalize the stream. The intervening stretches are covered by the Oswego Canal, which draws its water supply from the river.

The mean annual precipitation in this basin is about 35 inches, and the winters are rather less severe than farther east and north in the State.

The Oswego and its tributaries are important in connection with the new barge canal. The Oswego itself is to be canalized and serve as a connection from the main canal at Three Rivers to Lake Ontario. The route of the main canal passes through Oneida Lake down Oneida River to its junction with Seneca River at Three River Point, thence up Seneca River in its general westward course. The water supply for the Oswego River section will be furnished from this drainage.

The following gaging stations have been maintained in this river basin:

Fall Creek near Ithaca, N. Y., 1908-9.
Cayuga Lake at Ithaca, N. Y., 1905-1909.
Seneca River at Baldwinsville, N. Y., 1898-1909.
Oswego River above Minetto, N. Y., 1900-1903.
Oswego River at Battle Island, N. Y., 1900-1906.
Oswego River at Oswego, N. Y., 1897-1901.
Seneca Lake at Geneva, N. Y., 1905-6.
Skaneateles Lake at Skaneateles, N. Y., 1890-91.
Skaneateles Lake outlet at Willow Glen, N. Y., 1892-1908.
Skaneateles Lake outlet at Jordan, N. Y., 1890-1892.
Onondaga Lake outlet at Long Branch, N. Y., 1904.
East Branch Fish Creek at Point Rock, N. Y., 1898-99.
West Branch Fish Creek at McConnellsville, N. Y., 1898-1901.
Oneida River at Brewerton, N. Y., 1899.
Oneida River at Euclid, N. Y., 1902-1909.
Oneida Creek at Kenwood, N. Y., 1898-1900.
Chittenango Creek at Chittenango, N. Y., 1901-1906.
Chittenango Creek at Bridgeport, N. Y., 1898-1901.

FALL CREEK NEAR ITHACA, N. Y.

This station, which is located at the steel highway bridge about 1¼ miles north of the city of Ithaca and about one-half mile below the Cornell University hydraulic laboratory, was established July 7, 1908, to obtain general statistical and comparative data regarding the total flow of Fall Creek. It was discontinued July 1, 1909.

The gage heights are somewhat affected by ice during the winter and may at times be slightly affected by backwater from Cayuga Lake, which is about 800 feet downstream and 4 or 5 feet lower in elevation.

Daily gage height, in feet, of Fall Creek near Ithaca, N. Y., for 1909.

[John J. Nolan, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	6.5	23.5	7.75	23.0	29.5	4.25	16	26.9	11.65	11.15	16.5	11.75	5.15
2	7.0	28.5	11.25	19.75	28.25	3.75	17	30.0	10.5	10.65	13.75	10.25	5.0
3	8.0	28.75	11.5	23.0	22.25	3.75	18	26.75	9.5	9.0	13.0	9.15	16.2
4	4.65	28.0	11.5	19.0	16.75	3.75	19	25.5	9.15	8.75	12.75	7.75	10.0
5	7.5	28.15	7.0	20.0	14.25	6.15	20	26.0	45.0	8.25	12.0	7.0	7.5
6	15.25	27.0	9.0	20.5	12.9	6.5	21	26.75	25.5	7.25	11.25	5.0	5.4
7	10.9	16.5	11.5	24.5	11.25	5.5	22	26.9	16.5	7.25	12.0	6.5	5.0
8	32.5	11.4	9.25	18.0	11.5	4.5	23	30.5	16.0	6.5	11.5	6.0	7.15
9	31.5	9.65	9.0	14.25	11.25	4.0	24	27.5	31.5	6.75	9.75	5.5	6.15
10	32.5	10.15	25.0	14.25	10.25	4.75	25	24.0	26.0	21.0	8.5	5.25	5.0
11	19.25	10.75	23.75	13.0	15.0	10.25	26	15.0	17.25	21.0	8.0	4.5	5.0
12	30.5	9.55	14.5	12.0	13.75	6.4	27	10.75	16.25	15.5	7.5	5.25	5.3
13	24.75	9.0	14.0	11.25	11.25	5.75	28	8.75	14.75	17.75	7.5	5.25	4.25
14	25.5	9.0	12.75	35.0	11.0	7.25	29	9.25	....	17.0	7.0	6.5	3.0
15	27.65	13.0	12.0	26.5	11.25	6.25	30	10.0	....	17.0	17.25	6.75	3.0
							31	12.5	....	17.0	....	5.75	......

NOTE.—Gage heights are to top of ice on January 8-10, 16-23, and February 1-5.

CAYUGA LAKE AT ITHACA, N. Y.

This station, which is located at the breakwater, about 150 feet from the light-house at the south end of Cayuga Lake, near Ithaca, N. Y., was established August 6, 1905, and has been maintained to obtain records of fluctuations in the level of Cayuga Lake.

Previous to October 1, 1909, the elevation of the staff gage was 382.12 feet, United States Geological Survey datum. On October 1, 1909, the elevation of gage zero was changed to 381.75 feet. The gage heights in the following table are referred to the original elevation, 382.12 feet. Readings are subject to occasional slight error when the water is rough.

Information in regard to this station is contained in the reports of the state engineer and surveyor, State of New York. The 1909 data have been furnished in part for publication by the Hon. Frank M. Williams, state engineer and surveyor, State of New York.

Daily gage height, in feet, of Cayuga Lake at Ithaca, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Oct.	Nov.	Dec.
1					2.6	2.1		−0.37	−0.72
2	−0.75				2.8	2.0		− .42	− .67
3				1.75	2.7	2.1		− .47	− .72
4					2.6	2.0		− .47	− .67
5					2.4	2.0		− .37	− .72
6		−0.17	1.5		2.3	2.1		− .37	− .72
7					2.2	2.0		− .42	− .77
8					2.0	1.9	−0.07	− .47	− .72
9	− .79				2.1	1.8	− .07	− .47	− .72
10				1.7	2.3	2.0	− .07	− .47	− .72
11					2.2	1.7	− .17	− .52	− .72
12					2.2	1.6	− .17	− .57	− .77
13		− .06	1.7		2.1	1.6	− .17	− .57	− .77
14					2.2	1.6	− .17	− .62	− .77
15					2.2	1.5	− .17	− .62	− .77
16	− .71				2.0	1.4	− .17	− .62	− .77
17					2.1	1.6	− .17	− .62	− .77
18					2.0	1.6	− .22	− .57	− .77
19					2.1	1.4	− .22	− .62	− .77
20		.7	1.55		2.1	1.4	− .22	− .67	− .77
21					2.0		− .22	− .72	− .77
22					2.1		− .27	− .77	− .77
23	− .71				2.0		− .32	− .67	− .77
24					2.0		− .27	− .62	− .77
25					2.1		− .27	− .62	− .77
26	− .40				2.1		− .32	− .62	− .72
27		1.7	1.4		2.2		− .32	− .67	− .77
28					2.1		− .27	− .72	− .77
29				2.1	2.1		− .27	− .67	− .77
30	− .21			2.4	2.0		− .32	− .67	− .72
31					2.1		− .32		− .77

NOTE.—All gage heights for 1909 have been referred to the original United States Geological Survey datum, elevation 382.12.

SENECA RIVER AT BALDWINSVILLE, N. Y.

This gaging station was established November 12, 1898, at the state dam in Baldwinsville, 12 miles along the river from the junction of Seneca and Oneida rivers. Beginning with 1907, this station has been maintained by the New York state engineer's department.

The record at this station includes the discharge over the main dam, which is calculated by the formula for a broad, flat-crested weir, when flashboards are removed. The discharge over the flashboards is calculated by the Francis formula. Gage readings in the river channel below the dam are utilized to determine the average working head on the turbines. The discharge through the three main canals is determined from records of the run of water wheels kept in each mill and from the recorded lockage and opening of paddles at the Oswego Canal lock at the foot of the canal. Current-meter measurements to determine the leakage of the several mills have been made at different times, and allowance for this leakage has been made in the computations. The record has also been checked by current-meter measurements made during 1901, 1903, 1904, and 1905 at Belgium.

Owing to the complicated conditions of flow at this station and the uncertainty regarding leakage the accuracy of the results is considered only fair.

Information in regard to this station is contained in the reports of the state engineer and surveyor, State of New York. The 1909 data are not at present available for publication.

SKANEATELES LAKE OUTLET AT WILLOW GLEN, N. Y.

This station, which is located in the village of Willow Glen, 1.5 miles below the foot of Skaneateles Lake, was established March 10, 1895, and has been maintained by the city of Syracuse to obtain data regarding the flow of Skaneateles Creek.

Observation is made of the daily discharge over a thin-edged weir having a crest length of 27.8 feet, with two end contractions. The discharge is calculated from the observed depth on an iron pin set with its top at crest level, 5.2 feet upstream from the weir, by means of the Francis formula, including corrections for end contractions and velocity of approach.

Since July 1, 1894, the water supply of the city of Syracuse has been drawn from Skaneateles Lake, and the amount of this diversion should be added to the discharge of the outlet to obtain the total run-off of the drainage basin. The calculated diversion, as determined from the record of gate openings and head at the inlet gates, using the orifice formula with a constant coefficient, stated as 0.62, has been furnished by the city of Syracuse.

Several small water-power plants are in operation on Skaneateles Creek, all below the weir, but these do not affect the flow. The gage datum has remained the same during the maintenance of the station. During the winter months the discharge is only slightly affected by ice. Conditions are good for obtaining accurate discharge records, and a very good rating curve has been developed.

Information in regard to this station is contained in the reports of the New York state engineer and surveyor.

The records for 1909 are withheld for the present, because estimates of the diversion are only approximate and because of changes in the conduit lines.

ONEIDA RIVER NEAR EUCLID, N. Y.

This station, which is located at Oak Orchard state dam, 0.3 mile above Schroeppel's bridge, about 8 miles upstream from Three River Point and about 1½ miles north of Euclid, was established August 30, 1902, to obtain general information regarding the flow of Oneida River for use in connection with water-power development and canal projects. Since May 1, 1907, the station has been maintained by the state engineer's department. The 1909 records have been furnished for publication by the state engineer and surveyor, and have not been verified by engineers of the United States Geological Survey.

Prior to June 5, 1907, the gage-height observations were made by measuring down to the water surface from a reference point on the bulkhead coping of the lock at the dam; since June 5, 1907, they have been referred to the gage on the fender piles, a short distance above the entrance to this lock; elevation, 360.83 feet, Barge Canal datum. Gage readings are taken above the dam to avoid, as far as possible, backwater from ice or other causes, and the flow over the dam is computed on the basis of a rating curve constructed from current-meter measurements made at Schroeppel's bridge.

During the winter months ice occasionally affects the gage heights. Above a certain stage the dam becomes submerged and the discharge is modified. A special rating table, deduced from measurements made during the period of submergence, is used to calculate the discharge during the high period. Allowance is made for the openings of lock paddles in winter and for flashboards when used.

Information in regard to this station is contained in the reports of the New York state engineer and surveyor.

Daily discharge, in second-feet, of Oneida River near Euclid, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	814	3,362	7,542	6,864	6,864	4,335	1,874	a 830	722	280	1,471	1,162
2	918	3,081	7,408	6,864	a6,989	4,226	1,801	722	722	265	1,471	1,208
3	a1,072	2,991	7,276	6,864	7,382	4,559	1,731	722	654	a 320	1,532	1,305
4	1,305	2,991	6,901	a6,864	7,248	4,676	a1,598	722	460	621	1,598	1,208
5	1,891	3,081	6,399	6,864	7,248	4,676	1,598	654	a 370	540	1,532	a1,162
6	1,692	2,991	6,018	6,864	7,649	a4,676	1,532	654	566	540	1,471	1,030
7	1,463	a2,819	a6,018	6,111	7,649	4,676	1,598	654	654	566	a1,471	1,072
8	1,518	2,904	6,018	5,022	7,248	4,559	1,532	a 654	722	722	1,414	1,208
9	1,631	3,174	5,650	5,858	a7,248	4,559	1,471	688	722	758	1,249	1,255
10	a1,692	2,904	5,892	6,864	7,382	4,559	1,414	654	830	a 958	1,048	1,305
11	1,758	2,819	6,018	a8,188	7,516	4,445	a1,249	654	958	1,002	1,196	1,305
12	1,824	2,904	5,770	8,188	7,929	4,335	958	621	a 912	792	1,358	a1,305
13	1,824	2,819	5,770	8,390	7,929	a4,119	758	654	870	621	1,358	1,208
14	1,891	a2,819	a5,770	9,010	7,516	3,799	566	722	830	566	a1,358	1,162
15	1,891	2,904	5,770	9,298	7,382	3,799	510	a 758	758	540	1,414	1,208

a Sunday.

Daily discharge, in second-feet, of Oneida River near Euclid, N. Y., for 1909—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16	1,891	2,819	5,770	9,010	[a]7,248	3,799	540	792	830	540	1,030	1,208
17	[a]1,891	2,904	5,650	8,870	7,116	3,596	510	722	958	[a]621	814	1,208
18	1,824	2,991	5,182	[a]8,732	6,864	3,596	[a]510	722	958	958	814	1,208
19	1,758	3,081	4,719	8,598	6,495	3,596	480	654	[a]958	1,048	814	[a]1,255
20	1,631	4,171	4,836	8,460	6,111	[a]3,596	510	688	912	1,145	814	1,305
21	1,631	[a]4,171	[a]4,836	7,786	5,610	3,300	592	688	792	1,145	[a]752	1,305
22	1,961	4,386	4,836	7,516	5,254	2,921	621	[a]654	654	1,249	726	1,255
23	2,250	4,836	5,298	7,116	[a]5,022	2,831	688	621	480	1,145	752	1,305
24	[a]2,570	6,018	6,526	6,864	4,908	2,659	830	654	370	[a]1,196	814	1,208
25	2,991	6,144	6,778	[a]6,864	4,908	2,494	[a]870	592	320	1,303	781	1,356
26	3,659	6,655	6,655	6,741	4,559	2,494	870	621	[a]440	1,249	918	[a]1,409
27	3,756	7,276	6,399	6,864	4,445	[a]2,494	792	654	425	1,249	952	1,356
28	3,756	[a]7,542	[a]6,399	6,741	4,335	2,411	870	654	410	1,249	[a]1,030	1,305
29	3,460	....	6,655	6,366	4,226	2,090	958	[a]565	383	1,303	1,162	1,305
30	3,362	....	7,024	6,366	[a]4,226	2,015	958	565	383	1,358	1,208	1,208
31	[a]3,362	....	7,149	....	4,226	....	870	722	....	[a]1,358	....	1,208

[a] Sunday.

Monthly discharge of Oneida River near Euclid, N. Y., for 1909.

[Drainage area, 1,400 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
January	3,760	814	2,090	1.49	1.72
February	7,540	2,820	3,840	2.74	2.85
March	7,540	4,720	6,090	4.35	5.02
April	9,300	5,020	7,360	5.26	5.87
May	7,930	4,230	6,350	4.54	5.23
June	4,680	2,020	3,660	2.61	2.91
July	1,870	480	1,020	.729	.84
August	830	565	675	.482	.56
September	958	320	667	.476	.53
October	1,360	265	878	.627	.72
November	1,600	726	1,140	.814	.91
December	1,410	1,030	1,240	.886	1.02
The year	9,300	265	2,920	2.08	28.18

BLACK RIVER DRAINAGE BASIN.

DESCRIPTION.

Black River rises in the western part of Hamilton County, N. Y., flows southwestward across Herkimer County into Oneida County, turns near Forestport and runs somewhat west of north through Lewis County to eastern Jefferson County, and then flows westward to Black River Bay, at the eastern extremity of Lake Ontario. Its total drainage area is 1,930 square miles. The upper part of the basin is very rugged and mountainous, contains a large number of lakes, and is in a part of the Adirondack forest.

The mean annual precipitation is about 40 inches, ranging from 55 inches in the extreme headwaters to perhaps 30 inches near Lake Erie. The winters are generally quite severe, and the stream flow is affected by ice for periods of several months.

The regimen of the river is controlled by storage on its upper tributaries (including Beaver River at Beaver), a series of reservoirs at the headwaters of Moose River, and additional reservoirs at Forestport and on the headwaters of the main river.

Water is diverted from Black River through Forestport feeder to supply the Black River Canal at Boonville. A portion of this diverted water flows northward from Boonville and enters Black River again at Lyons Falls; the remainder flows southward through the Black River Canal and enters the Erie Canal at Rome.

The following gaging stations have been maintained in this river basin:

Black River near Felts Mills, Watertown, N. Y., 1902–1909.
Black River at Huntingtonville dam, near Watertown, N. Y., 1897–1901.
Moose River at Moose River, N. Y., 1900–1909.
Beaver River at Croghan, N. Y., 1901–1903.

BLACK RIVER NEAR FELTS MILLS, N. Y.

This station, which was established August 29, 1902, is located at the dam of the Harmon Paper Company, formerly owned by the Black River Traction Company, near the village of Felts Mills, 9 miles upstream from Watertown and 7 miles upstream from the old Huntingtonville gaging station on this stream. Since May 1, 1907, the station has been maintained under the direction of Hon. Frank M. Williams, state engineer and surveyor, State of New York, by whom the 1909 data have been furnished for publication.

The dam is of sawed timber, rests on limestone foundation, and is very nearly water-tight. It has a slope on the upstream face of 2.88 horizontal to 1 vertical. The crest is protected by boiler plate and the downstream face is vertical, giving a free overfall. The main crest is 380.6 feet long. There are two additional sections on the right-hand side, one 14.1 feet long and the other 17.9 feet. A similarly constructed dam, 117 feet long, at the left bank, serves as an auxiliary spillway and as a head-race wall.

The gage, which is read twice daily, at 7 a. m. and 6 p. m., is attached vertically to a crib at the left-hand side of the stream above the mill. Correction is made to the gage readings for velocity of approach during high water. The discharge over the spillways has been calculated by means of the weir formula, using coefficients derived from experiments of the United States Geological Survey for a dam of similar cross section.

A wood-pulp mill has been constructed adjacent to this dam, and was put in operation during 1907. The mill contains four 72-inch and one 45-inch Smith-McCormick turbines. A record is kept of the hours run and gage opening of each wheel, as well as of the head under which the wheels operate.

Information in regard to this station is contained also in the reports of the New York state engineer and surveyor.

Daily discharge, in second-feet, of Black River near Felts Mills, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,493	2,688	6,806	5,080	8,926	2,942	1,097	a 201	959	1,030	1,646	2,295
2	1,493	2,722	6,649	5,242	a10,204	2,214	1,081	2,113	921	959	966	2,253
3	a1,533	2,226	4,757	6,002	12,162	1,921	749	1,011	777	a 754	1,251	2,048
4	2,558	2,228	4,151	a 6,304	12,611	2,046	a 384	908	836	1,365	1,511	1,922
5	2,722	2,228	2,991	7,989	12,772	1,893	634	868	(a)	1,094	1,450	a1,597
6	3,525	3,364	3,340	8,834	10,328	a2,693	1,612	868	769	1,557	1,131	2,128
7	4,488	a5,459	a2,085	12,214	8,884	3,820	1,406	817	1,075	896	a1,082	1,608
8	4,881	6,461	2,674	15,969	8,574	3,233	1,239	a 713	1,276	996	1,622	2,009
9	4,518	6,448	2,471	16,998	a 8,786	2,839	1,191	1,097	1,049	993	1,233	938
10	a3,856	7,691	2,829	16,684	10,751	2,839	905	1,087	1,075	a 70	1,461	981
11	4,151	7,317	4,823	a13,575	11,917	2,420	a 353	981	822	1,183	....	1,269
12	3,591	7,859	5,895	11,620	12,420	2,400	1,304	1,504	a 201	848	....	a1,082
13	2,926	6,476	4,480	9,970	13,024	a2,151	1,716	855	1,268	966	....	2,098
14	2,516	a4,747	a3,448	12,414	11,963	2,330	1,337	1,438	906	933	a 914	1,608
15	2,101	5,204	3,979	16,970	9,989	2,214	1,118	a1,209	848	843	1,685	1,969
16	1,442	4,410	4,469	23,058	a 8,319	2,088	922	1,519	820	896	1,035	1,929
17	a1,473	4,113	2,705	19,107	7,933	1,837	2,561	1,571	864	a353	1,241	2,009
18	2,137	3,854	4,612	a16,626	7,175	1,637	a 384	1,693	724	1,365	1,419	1,837
19	1,102	3,591	2,890	16,075	6,963	2,176	1,138	1,580	a 754	1,368	1,810	a1,352
20	1,486	3,369	2,616	15,799	6,056	a3,139	867	1,010	897	1,307	1,589	2,244
21	1,776	a5,340	a2,019	14,957	5,621	2,695	1,249	862	897	1,330	a 914	1,770
22	1,786	7,003	2,378	14,676	4,703	2,336	1,249	a 714	820	1,580	2,621	1,849
23	2,064	7,120	2,462	13,303	a 3,287	1,837	1,128	1,146	790	2,776	2,829	1,770
24	a4,596	7,949	2,504	12,503	4,229	1,796	1,091	942	779	a1,772	3,707	1,330
25	6,689	8,561	2,990	a11,463	3,591	1,601	a1,249	879	784	2,435	2,791	1,291
26	7,896	8,722	5,839	10,735	3,139	1,521	1,851	899	a 714	1,570	2,504	a1,207
27	7,392	8,830	5,567	9,970	2,661	a1,888	1,677	1,054	1,253	1,407	2,233	1,886
28	6,879	a8,086	a4,312	8,242	2,906	1,935	1,438	a 749	820	1,289	a1,713	1,639
29	5,699	....	5,443	8,015	2,910	1,204	1,158	714	825	1,340	3,253	1,639
30	5,481	....	4,757	8,270	a 2,282	1,219	860	881	928	1,253	2,542	1,700
31	a3,476	....	4,596	....	2,997	....	1,080	811	....	a 957	....	1,700

a Sunday.

NOTE.—Discharge affected by ice obstruction during December.

Monthly discharge of Black River near Felts Mills, N. Y., for 1909.

[Drainage area, 1,850 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
January	7,900	1,100	3,480	1.88	2.17
February	8,830	2,230	5,500	2.97	3.09
March	6,810	2,020	3,920	2.12	2.44
April	23,100	5,080	12,300	6.65	7.42
May	13,000	2,280	7,680	4.15	4.78
June	3,820	1,200	2,230	1.21	1.35
July	2,560	353	1,160	.627	.72
August	1,690	201	1,050	.568	.65
September	1,280	201	862	.466	.52
October	2,780	70	1,210	.654	.75
November	3,710	914	1,750	.946	1.06
December	2,300	938	1,710	.924	1.07
The year	23,100	70	3,570	1.93	26.02

NOTE.—Daily discharge for September 5 estimated by the United States Geological Survey at 400 second-feet and 1,400 second-feet for November 11-13 in order to complete the year.

MOOSE RIVER AT MOOSE RIVER, N. Y.

This station, which is located in Moose River village, was established June 5, 1900, to obtain general statistical data regarding the flow of Moose River.

The station is about 2 miles below the McKeever dam, which is maintained for logging. A considerable fall occurs just below. Occasionally ice and log jams form at an island above the station. During the winter months discharge is usually affected by ice and the gage is read but once a week. Measurements are made by means of a car and cable.

The staff gage is in two sections. The low-water portion is near the left bank about 400 feet upstream from the cable. The upper section is about 15 feet farther downstream. The elevation of the gage zero was changed on February 28, 1903, from 15.36 feet to 15.53 feet. Conditions for obtaining discharge are fairly good, and a fairly good rating curve has been developed for open-channel conditions.

Information in regard to this station is contained in the reports of the New York state engineer and surveyor.

Discharge measurements of Moose River at Moose River, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 4 [a]	C. R. Adams	211	292	1.18	250
February 12 [b]	do	216	662	3.19	1,090
July 6	Covert and Hoyt	211	484	1.20	353
July 7	do	212	442	1.02	291
September 1 [c]	W. G. Hoyt	210	417	.86	244

[a] Ice conditions. About 0.20 foot clear ice overlaid with 0.30 foot snow ice covered with slush.
[b] Nearly complete ice cover. Average thickness of ice, 1.05 feet. Gage height to top of ice, 3.29 feet.
[c] Made by wading at the cable section.

Daily gage height, in feet, of Moose River at Moose River, N. Y., for 1909.

[Chris Hannan, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.74	2.19	3.29	1.69	5.33	1.69	0.59	0.60	0.95	1.25	0.50	1.40
2	.99	2.09	2.99	1.14	5.98	1.49	.59	.60	.90	1.40	.60	1.15
3	.19	2.09	2.64	.79	5.43	1.39	.89	.50	.90	1.40	.65	.95
4	1.19	1.99	2.59	.89	4.63	1.24	1.44	.50	.80	1.55	.80	.80
5	1.19	1.99	2.54	1.09	4.63	1.19	1.19	1.00	.80	1.65	.80	.80
6	1.59	2.49	2.49	1.44	4.08	1.99	.85	.85	.80	1.45	.80	.75
7	3.24	3.14	2.49	4.33	5.33	2.24	.95	.90	.80	1.12	.80	.70
8	2.69	3.44	2.19	5.23	6.28	2.09	.70	1.45	.80	.90	1.05	.60
9	1.79	3.74	2.19	5.23	5.39	1.94	.70	.90	.80	1.00	1.05	.70
10	1.94	3.54	2.39	3.74	6.98	1.74	.80	.90	.70	1.10	1.05	.85
11	1.79	3.29	2.69	4.09	7.18	2.14	.75	.80	.60	1.00	1.00	.95
12	1.69	3.19	2.64	3.64	5.98	2.29	.75	.80	.60	1.00	1.00	1.05
13	1.69	3.04	2.49	3.89	5.13	1.94	.70	.80	.60	.90	.90	.90
14	1.59	2.84	2.49	7.13	4.63	1.79	.80	.70	.50	.90	.90	.90
15	1.44	2.79	2.39	7.48	3.84	1.64	.80	.70	.50	.80	.90	1.00

Daily gage height, in feet, of Moose River at Moose River, N. Y., in 1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16	1.24	2.69	2.29	6.13	5.03	1.94	0.70	0.60	0.60	0.90	0.80	1.00
17	1.29	2.69	2.29	6.03	5.23	1.99	.55	.70	.60	.90	.70	1.05
18	1.39	2.89	2.19	6.68	4.28	2.39	.25	.70	.60	.90	.80	1.10
19	1.49	2.79	2.24	6.43	3.59	2.94	1.25	.60	.60	.90	.90	1.20
20	1.39	3.44	2.39	7.38	3.44	2.49	1.40	.60	.70	.95	.95	1.20
21	1.29	4.83	2.29	6.18	3.19	2.14	1.25	.60	.70	1.00	.90	1.20
22	1.44	4.88	2.29	5.68	2.79	1.89	1.10	.50	.80	.90	1.25	1.10
23	1.64	4.53	2.29	5.73	2.54	1.79	1.10	.50	.80	.90	1.65	1.10
24	1.89	4.09	2.39	5.23	2.59	1.44	1.05	.40	.90	.75	1.95	1.10
25	4.48	3.94	2.39	4.83	2.49	1.09	1.25	.40	.90	.70	2.00	1.00
26	4.68	3.79	2.49	4.68	2.34	1.04	1.45	.50	.85	.70	1.90	1.00
27	4.09	3.59	2.59	4.73	2.19	.59	1.35	.50	.85	.70	1.75	1.00
28	3.54	3.44	2.89	4.73	2.04	.99	1.10	.60	.90	.55	1.70	.90
29	2.84	......	2.44	4.58	1.89	.99	.85	.60	1.05	.50	1.70	.90
30	2.24	......	2.09	4.33	1.79	.99	.70	.55	1.10	.50	1.60	1.00
31	2.19	......	1.99	......	1.79	......	.70	.55	......	.00	......	1.10

NOTE.—Ice conditions January 1 to April 6 and December 9-31.

Daily discharge, in second-feet, of Moose River at Moose River, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	158	576	1,150	387	3,430	496	193	195	278	360	175	405
2	208	536	974	238	4,330	432	193	195	265	405	195	330
3	74	536	780	168	3,560	402	262	175	265	405	205	278
4	248	496	755	188	2,590	357	417	175	240	450	240	240
5	248	496	730	228	2,590	342	342	290	240	482	240	240
6	357	705	705	312	2,020	606	252	252	240	420	240	228
7	1,120	1,060	705	2,270	3,430	720	278	265	240	321	240	215
8	805	1,240	576	3,300	4,780	646	215	420	240	265	302	195
9	417	1,450	576	3,300	3,510	586	215	265	240	290	302	150
10	476	1,310	656	1,710	5,870	514	240	265	215	315	302	180
11	417	1,150	805	2,030	6,190	670	228	240	195	290	290	200
12	387	1,090	780	1,620	4,330	745	228	240	195	290	290	220
13	387	1,000	705	1,840	3,180	586	215	240	195	265	265	190
14	357	884	705	6,110	2,590	532	240	215	175	265	265	190
15	312	855	656	6,670	1,800	479	240	215	175	240	265	210
16	258	805	616	4,560	3,060	586	215	195	195	265	240	210
17	268	805	616	4,400	3,300	606	185	215	195	265	215	220
18	297	914	576	5,390	2,220	795	128	215	195	265	240	230
19	327	855	596	5,000	1,580	1,110	360	195	195	265	265	250
20	297	1,240	656	6,510	1,460	850	405	195	215	278	278	250
21	268	2,380	616	4,630	1,280	670	360	195	215	290	265	250
22	312	2,430	616	3,900	1,020	566	315	175	240	265	360	230
23	372	2,100	616	3,970	877	532	315	175	240	265	482	230
24	456	1,720	656	3,300	906	417	302	155	265	228	590	230
25	2,050	1,600	656	2,820	850	312	360	155	265	215	610	210
26	2,230	1,480	705	2,650	770	300	420	175	252	215	570	210
27	1,720	1,340	755	2,700	695	193	390	175	252	215	518	210
28	1,310	1,240	914	2,700	626	288	315	195	265	185	500	190
29	884	......	680	2,540	566	288	252	195	302	175	500	190
30	596	......	536	2,270	532	288	215	185	315	175	465	210
31	576	......	496	......	532	......	215	185	......	90	......	230

NOTE.—Daily discharges January 1 to April 6 and December 9-31 were obtained from an ice curve based on two 1909 measurements and are only approximate. Daily discharges for the open-water period are based on a rating curve, well defined between discharges 240 and 3,650 second-feet.

Monthly discharge of Moose River at Moose River, N. Y., for 1909.

[Drainage area, 346 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	2,230	74	587	1.70	1.96	C.
February	2,430	496	1,150	3.32	3.46	C.
March	1,150	496	696	2.01	2.32	C.
April	6,670	168	2,920	8.44	9.42	B.
May	6,190	532	2,400	6.94	8.00	B.
June	1,110	193	530	1.53	1.71	A.
July	420	128	275	.795	.92	A.
August	420	155	214	.618	.71	A.
September	315	175	233	.673	.75	A.
October	482	90	281	.812	.94	A.
November	610	175	330	.954	1.06	A.
December	405	150	226	.653	.75	D.
The year	2,430	74	820	2.37	32.00	

ST. LAWRENCE RIVER DRAINAGE BASIN.

GENERAL FEATURES.

St. Lawrence River, the outlet of the Great Lakes system, receives also the flow of a number of New York streams having their sources in the northerly slopes of the Adirondacks and fed by the innumerable lakes with which the region is dotted. Some of these rivers, as the Grass, Raquette, and St. Regis, lie entirely within the United States; others, notably Salmon, Trout, Chateaugay, and English rivers, cross the international boundary and flow northward into the St. Lawrence in Canada, as does also Richelieu River, the outlet of Lake Champlain. The following table gives a list of the principal tributaries of the St. Lawrence in the United States, with the areas drained by them:

Drainage areas of St. Lawrence River tributaries in the United States.

	Square miles.		Square miles.
Oswegatchie River	1,609	Salmon River [a]	273
Grass River	637	Trout River [b]	129
Raquette River	1,219	Chateaugay River [b]	199
St. Regis River	910	English River [b]	53
Little Salmon River [a]	103	Lake Champlain [b]	8,187

The St. Lawrence drains, through Lake Champlain, an area of about 4,560 square miles in the State of Vermont. This drainage is practically all from Missisquoi, Lamoille, and Winooski rivers and Otter Creek. Clyde, Barton, and Black rivers, in northern Vermont, are tributary to St. Lawrence River through Lake Memphremagog and St. Francis River.

[a] Above junction near international boundary. [b] Above New York state line.

OSWEGATCHIE RIVER DRAINAGE BASIN.

DESCRIPTION.

Oswegatchie River has its source in the region of lakes and timbered swamps in the southern part of St. Lawrence County, N. Y. The largest of the lakes is Cranberry Lake, which affords valuable storage to water-power users on its outlet, East Branch of Oswegatchie River. The East and West branches flow in a general northwesterly direction and unite near Talcville. From Gouverneur to Oxbow the river flows southwestward; it then turns sharply and flows northeastward to Rensselaer Falls, turns again to the northwest, receives the outlet of Black Lake at Galilee, and finally enters the St. Lawrence at Ogdensburg. Its total drainage area comprises about 1,600 square miles.

The mean annual precipitation is about 35 inches, and winter conditions are usually severe.

The basin affords many opportunities for water storage and the utilization of these sites is especially desirable, on account of the quick spilling character of this area and the tendency to floods. Considerable water power is developed, mostly in small units, and there is a large amount of undeveloped power.

The following gaging station has been maintained in this river basin: Oswegatchie River near Ogdensburg, N. Y., 1903–1909.

OSWEGATCHIE RIVER NEAR OGDENSBURG, N. Y.

This station, which is located at what is known as the Eel Weir highway bridge, about 6 miles upstream from Ogdensburg, N. Y., and one-half mile below Black Lake outlet, was established May 16, 1903, and has been maintained continuously since that date to obtain information for use in studies of power and storage development on Oswegatchie and Black rivers.

There are three dams in the vicinity of the gaging station on Oswegatchie River—one at Heuvelton, about 5 miles above; one at Rensselaer Falls, 10 miles above; and one in the city of Ogdensburg, about one-half mile above the outlet.

Open-water conditions prevail at this station throughout the year. The stream bed is rocky and permanent and the results are considered fairly good for all stages. The gage datum has remained the same since the beginning of the record.

Information in regard to this station is contained in the annual reports of the New York state engineer and surveyor.

The following discharge measurement was made by C. C. Covert:

April 20, 1909: Width, 258 feet; area, 1,240 square feet; gage height, 8.25 feet; discharge, 10,400 second-feet.

Daily gage height, in feet, of Oswegatchie River near Ogdensburg, N. Y., for 1909.

[Joseph H. La Rue, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.6	6.2	7.6	7.3	6.5	5.8	4.7	4.9	4.5	4.5	4.7	5.6
2	4.6	6.1	7.3	7.5	7.1	5.8	4.7	4.8	4.4	4.5	4.7	5.6
3	4.6	5.9	7.0	7.6	7.3	5.7	4.7	4.7	4.4	4.5	4.8	5.5
4	4.5	5.8	6.8	7.9	7.3	5.6	4.7	4.7	4.4	4.5	4.7	5.5
5	4.5	5.7	6.6	8.1	7.3	5.6	4.7	4.8	4.5	4.5	4.7	5.4
6	4.7	5.7	6.6	8.2	7.3	5.4	4.7	4.8	4.6	4.6	4.7	5.3
7	5.7	6.2	6.2	8.4	7.3	5.3	4.6	4.7	4.6	4.6	4.7	5.2
8	5.7	6.4	6.2	8.6	7.3	5.3	4.6	4.7	4.6	4.6	4.8	5.2
9	5.8	6.6	6.0	8.7	7.2	5.3	4.6	4.7	4.5	4.6	4.8	4.6
10	5.8	6.5	5.8	8.8	7.0	5.3	4.6	4.7	4.5	4.7	4.8	5.2
11	5.8	6.5	5.8	8.8	7.3	5.2	4.6	4.6	4.5	4.7	4.8	5.2
12	5.8	6.5	5.7	8.8	7.5	5.2	4.6	4.6	4.4	4.7	4.8	5.1
13	5.8	6.2	5.6	8.7	7.9	5.1	4.6	4.6	4.4	4.7	4.7	5.1
14	5.8	6.2	5.6	8.3	8.1	5.3	4.6	4.6	4.4	4.7	4.8	5.2
15	5.7	6.2	5.6	8.0	7.9	5.1	4.6	4.6	4.4	4.7	4.8	5.6
16	5.7	6.0	5.8	8.1	7.8	5.1	4.6	4.7	4.4	4.7	4.9	5.6
17	5.6	6.0	5.8	8.1	7.6	5.1	4.6	4.6	4.4	4.7	5.2	5.8
18	5.4	6.0	5.8	8.1	7.3	5.0	4.6	4.6	4.5	4.6	5.2	5.8
19	5.3	5.7	5.8	8.3	7.2	4.9	4.7	4.6	4.5	4.6	5.0	5.8
20	5.2	5.7	5.6	8.3	7.0	5.3	4.7	4.5	4.5	4.6	4.9	5.7
21	5.2	5.9	5.7	8.2	6.9	4.9	4.7	4.5	4.5	4.7	4.9	5.6
22	5.1	6.2	5.6	8.1	6.7	4.9	4.8	4.5	4.5	4.7	4.8	5.6
23	5.2	6.2	5.5	8.0	6.7	4.9	4.8	4.5	4.5	4.7	4.8	5.5
24	5.4	6.4	5.4	7.8	6.7	4.9	4.8	4.5	4.5	4.7	4.9	5.4
25	5.7	7.2	5.4	7.4	6.4	4.9	4.8	4.5	4.5	4.7	5.4	5.4
26	6.1	7.7	5.8	7.2	6.3	4.8	4.8	4.5	4.5	4.7	5.4	5.3
27	6.5	7.7	6.3	7.2	6.1	4.8	4.8	4.5	4.5	4.7	5.4	5.3
28	6.5	7.7	6.8	6.9	5.9	4.8	4.8	4.4	4.5	4.7	5.4	5.2
29	6.7	....	7.1	6.7	5.9	4.7	4.9	4.4	4.5	4.7	5.5	5.1
30	6.5	....	7.1	6.4	5.9	4.7	4.9	4.4	4.5	4.7	5.5	5.1
31	6.4	....	7.1	....	5.8	....	4.9	4.5	....	4.7	....	5.1

NOTE.—Oswegatchie River is not affected by ice conditions at the gaging station.

Daily discharge, in second-feet, of Oswegatchie River near Ogdensburg, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	780	4,020	8,150	7,250	4,890	2,890	890	1,140	680	680	890	2,400
2	780	3,730	7,250	7,850	6,660	2,890	890	1,010	590	680	890	2,400
3	780	3,160	6,360	8,150	7,250	2,640	890	890	590	680	1,010	2,180
4	680	2,890	5,780	9,050	7 250	2,400	890	890	590	680	890	2,180
5	680	2,640	5,180	9,660	7,250	2,400	890	1,010	680	680	890	1,980
6	890	2,640	5,180	9,960	7,250	1,980	890	1,010	780	780	890	1,790
7	2,640	4,020	4,020	10,600	7,250	1,790	780	890	780	780	890	1,610
8	2,640	4,600	4,020	11,200	7,250	1,790	780	890	780	780	1,010	1,610
9	2,890	5,180	3,440	11,500	6,960	1,790	780	890	680	780	1,010	780
10	2,890	4,890	2,890	11,800	6,360	1,790	780	890	680	890	1,010	1,610
11	2,890	4,890	2,890	11,800	7,250	1,610	780	780	680	890	1,010	1,610
12	2,890	4,890	2,640	11,800	7,850	1,610	780	780	590	890	1,010	1,440
13	2,890	4,020	2,400	11,500	9,050	1,440	780	780	590	890	890	1,440
14	2,890	4,020	2,400	10,300	9,660	1,790	780	780	590	890	1,010	1,610
15	2,640	4,020	2,400	9,350	9,050	1,440	780	780	590	890	1,010	2,400
16	2,640	3,440	2,890	9,660	8,750	1,440	780	890	590	890	1,140	2,400
17	2,400	3,440	2,890	9,660	8,150	1,440	780	780	590	890	1,610	2,890
18	1,980	3,440	2,890	9,660	7,250	1,280	780	780	680	780	1,610	2,890
19	1,790	2,640	2,890	10,300	6,960	1,140	890	780	680	780	1,280	2,890
20	1,610	2,640	2,400	10,300	6,360	1,790	890	680	680	780	1,140	2,640
21	1,610	3,160	2,640	9,960	6,070	1,140	890	680	680	890	1,140	2,400
22	1,440	4,020	2,400	9,660	5,480	1,140	1,010	680	680	890	1,010	2,400
23	1,610	4,020	2,180	9,350	5,480	1,140	1,010	680	680	890	1,010	2,180
24	1,980	4,600	1,980	8,750	5,480	1,140	1,010	680	680	890	1,140	1,980
25	2,640	6,960	1,980	7,550	4,600	1,140	1,010	680	680	890	1,980	1,980
26	3,730	8,450	2,890	6,960	4,310	1,010	1,010	680	680	890	1,980	1,790
27	4,890	8,450	4,310	6,960	3,730	1,010	1,010	680	680	890	1,980	1,790
28	4,890	8,450	5,780	6,070	3,160	1,010	1,010	590	680	890	1,980	1,610
29	5,480	....	6,660	5,480	3,160	890	1,140	590	680	890	2,180	1,440
30	4,890	....	6,660	4,600	3,160	890	1,140	590	680	890	2,180	1,440
31	4,600	....	6,660	....	2,890	....	1,140	680	....	890	....	1,440

NOTE.—Daily discharges based on a fairly well defined rating curve.

Monthly discharge of Oswegatchie River near Ogdensburg, N. Y., for 1909.

[Drainage area, 1,580 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	5,480	680	2,520	1.59	1.83	A.
February	8,450	2,640	4,400	2.78	2.90	A.
March	8,150	1,980	3,970	2.51	2.89	A.
April	11,800	4,600	9,220	5.84	6.52	A.
May	9,660	2,890	6,330	4.01	4.62	A.
June	2,890	890	1,600	1.01	1.13	A.
July	1,140	780	899	.569	.66	A.
August	1,140	590	791	.501	.58	A.
September	780	590	663	.420	.47	B.
October	890	680	831	.526	.61	A.
November	2,180	890	1,260	.797	.89	A.
December	2,890	780	1,970	1.25	1.44	A.
The year	11,800	590	2,870	1.82	24.54	

RAQUETTE RIVER DRAINAGE BASIN.

DESCRIPTION.

Raquette River drains a long, narrow basin extending from northern Hamilton County to St. Lawrence River. Its sources are on an elevated plateau, dotted with mountains, interspersed with lakes, in general timbered, and containing numerous marsh areas, many of which are on the divide and feed streams flowing into adjacent drainages.

The mean annual precipitation is about 38 inches, ranging from about 42 inches in the headwaters to 32 inches near the St. Lawrence. Winter conditions are the usual ones occurring in the Adirondack region, and snow and ice prevail for several months.

Raquette River possesses remarkable facilities for storage and has been very extensively studied by the state water-supply commission of New York. They propose a large reservoir at Tupper Lake to afford an effective storage of about 10,000,000,000 cubic feet. They further estimate that about double this amount will be required to adequately regulate the flow of the river. This additional storage it is planned to obtain by a system of smaller reservoirs, involving the following lakes and ponds: Little Tupper, Forked, Raquette, Blue Mountain, Utowana, Brandreth, Horseshoe, and Long lakes, South and Slim ponds, and Dead Creek.

The river also affords many opportunities for power development (see Pl. V, *A* and *B*), and, in the words of the state water-supply commission, "presents in many ways one of the most attractive fields for water-power and storage studies in the State."

A. HIGH-WATER CONDITIONS.

B. LOW-WATER CONDITIONS.

DAM ON RAQUETTE RIVER AT HANNAWA FALLS, N. Y.

The following gaging stations have been maintained in this river basin:

- Raquette River at Raquette Falls, near Coreys, N. Y., 1908-9.
- Raquette River at Piercefield, N. Y., 1908-9.
- Raquette River at South Colton, N. Y., 1904.
- Raquette River at Massena Springs, N. Y., 1903-1909.
- Bog River at Tupper Lake, N. Y., 1908-9.

RAQUETTE RIVER AT RAQUETTE FALLS, NEAR COREYS, N. Y.

This station, located near the center of Raquette Falls, about 10 miles south of Coreys and about 8 miles by river upstream from the settlement of Axton, which is 12 miles by road from the village of Tupper Lake, was established August 27, 1908, and is maintained to obtain data regarding the discharge of Raquette River at this point, to be used in the development of storage in the drainage basin under the direction of the state water-supply commission of New York.

During 1908 readings were obtained by a self-recording gage which was checked by engineers and others who periodically visited the station. In 1909 a regular observer was employed who made daily observations from July 11 to October 31. The zero of the gage has been maintained at elevation 1,606.16 feet above sea level, as based on the levels of the state water-supply commission.

Previous to October, 1909, measurements were made from a boat or by wading just below the lower falls. Later measurements have been made from a car hung on a cable which was erected during the summer of 1909 near the site of the gage. A good rating curve has been developed within the limits of the gage heights. The 1908 daily and monthly estimates of discharge have been revised on the basis of more recent data and supersede those published in Water-Supply Paper 244, page 126.

Information in regard to this station is contained in the annual reports of the state water-supply commission of New York.

Discharge measurements of Raquette River at Raquette Falls, near Coreys, N. Y., in 1909.

Date	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 10 [a]	Covert and Hoyt	93	185	1.91	258
July 14 [a]	W. G. Hoyt	90	175	1.79	267
October 3 [b]	do	83	243	1.81	260
November 7 [b]	Hoyt and Covert	69	194	1.50	153

[a] Measurement made at wading section below the falls.
[b] Measurement made at cable station.

Daily gage height, in feet, and daily discharge, in second-feet, of Raquette River at Raquette Falls, near Coreys, N. Y., for 1908–9.

[C. A. De Lancett, observer (1909 only).]

Day.	1908.							
	August.		September.		October.		November.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.25	106	1.16	91	1.30	115
2			1.24	104	1.26	108	1.18	94
3			1.23	102	1.36	127	1.19	95
4			1.22	101	1.40	135	1.25	106
5			1.21	99	1.40	135		
6			1.19	95	1.40	135		
7			1.16	91	1.40	135		
8			1.13	86	1.40	135		
9			1.10	81	1.40	135		
10			1.07	77	1.40	135		
11			1.04	73	1.40	135		
12			1.02	71	1.40	135		
13			1.00	68	1.37	129		
14			.99	67	1.35	125		
15			.97	65	1.34	123		
16			.96	64	1.32	119		
17			.94	61	1.31	117		
18			.90	57	1.29	113		
19			.85	52	1.26	108		
20			.85	52	1.22	101		
21			.85	52	1.18	94		
22			.85	52	1.13	86		
23			.85	52	1.10	81		
24			.84	52	1.11	83		
25			.83	51	1.12	84		
26			.82	50	1.14	87		
27	1.37	129	.81	49	1.18	94		
28	1.33	121	.88	55	1.23	102		
29	1.29	113	.96	64	1.28	111		
30	1.25	106	1.06	76	1.33	121		
31	1.25	106			1.36	127		

Day.	1909.							
	July.		August.		September.		October.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.7	217	1.5	159	1.65	202
2			1.65	202	1.6	187	1.65	202
3			1.6	187	1.5	159	1.8	250
4			1.55	173	1.4	135	1.8	250
5			1.5	159	1.45	147	1.8	250
6			1.5	159	1.6	187	1.7	217
7			1.45	147	1.5	159	1.6	187
8			1.4	135	1.4	135	1.5	159
9			1.4	135	1.35	125	1.45	147
10			1.35	125	1.3	115	1.45	147
11	1.95	304	1.3	115	1.3	115	1.4	135
12	1.9	285	1.3	115	1.3	115	1.35	125
13	1.9	285	1.25	106	1.3	115	1.35	125
14	1.8	250	1.25	106	1.25	106	1.35	125
15	1.7	217	1.2	97	1.3	115	1.35	125
16	1.7	217	1.35	125	1.3	115	1.3	115
17	1.7	217	1.45	147	1.3	115	1.3	115
18	1.8	250	1.65	202	1.3	115	1.3	115
19	1.9	285	1.8	250	1.3	115	1.3	115
20	1.95	304	1.85	268	1.25	106	1.2	97
21	1.9	285	1.8	250	1.15	89	1.25	106
22	1.8	250	1.7	217	1.15	89	1.35	125
23	1.8	250	1.6	187	1.15	89	1.5	159
24	1.8	250	1.5	159	1.6	187	1.6	187
25	2.0	323	1.4	135	1.4	135	1.5	159
26	2.0	323	1.4	135	1.3	115	1.45	147
27	1.9	285	1.4	135	1.3	115	1.45	147
28	1.8	250	1.4	135	1.4	135	1.45	147
29	1.8	250	1.4	135	1.5	159	1.4	135
30	1.7	217	1.4	135	1.65	202	1.4	135
31	1.75	234	1.45	147			1.4	135

NOTE.—The daily discharges for 1908–9 are based on a rating curve that is fairly well defined. This curve supersedes the one used for 1908 as published in Water-Supply Paper 244, p. 126. See description.

Monthly discharge of Raquette River at Raquette Falls, near Coreys, N. Y., for 1908-9.

[Drainage area, 418 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
August 27-31	129	106	115	0.275	0.05	B.
September	106	49	70.8	.169	.19	B.
October	135	81	114	.273	.31	B.
1909.						
July 11-31	323	217	263	.629	.49	B.
August	268	97	159	.380	.44	B.
September	202	89	132	.316	.35	B.
October	250	97	154	.368	.42	B.

NOTE.—Monthly discharges given above for 1908 supersede those published in Water-Supply Paper 244. See description.

RAQUETTE RIVER AT PIERCEFIELD, N. Y.

This station is located at the head of Black Rapids, about one-half mile downstream from the dam of the International Paper Company in the town of Piercefield. It was established August 20, 1908, to obtain data for use in studies of water power and storage problems.

Black Rapids begin about 100 feet below the measuring section. Discharge measurements at ordinary stages are made by means of a boat held in place by a wire cable. At high stages it is proposed to use the highway bridge just above the dam. The vertical staff gage is located one-third mile upstream from the measuring section and is about 1,000 feet below the International Paper Company's tailrace. Little or no fall occurs between the gage and the measuring section. The datum of the gage has remained the same since the establishment of the station. The bed of the river is rocky and quite rough, but is permanent, and a good rating curve has been developed for low and high water stages.

Information in regard to this station is contained in the annual reports of the state water supply commission of New York.

Discharge measurements of Raquette River at Piercefield, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 5 [a]	C. R. Adams	107	1,460	2.75	752
January 29 [a]	do	107	1,700	3.96	1,400
April 18 [a]	C. C. Covert	107	2,040	7.30	4,540
July 9	Covert and Hoyt	102	491	2.02	555
July 12	W. G. Hoyt	102	479	2.09	531
October 4	Hoyt and Williams	96	461	2.32	579

[a] Measurement made at the highway bridge above the dam.

Daily gage height, in feet, of Raquette River at Piercefield, N. Y., for 1909.

[W. B. Groves, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.65	3.75	3.7	3.1	7.3	6.1	2.9	1.7	1.0	1.6	1.0	2.0
2	2.75	4.0	4.1	3.25	7.1	6.1	2.9	1.7	1.2	1.6	1.0	1.75
3	2.25	3.65	4.1	3.55	7.1	5.65	2.9	1.7	1.2	1.6	1.0	1.75
4	2.1	3.65	4.1	1.0	7.1	5.5	2.85	1.7	1.1	1.6	1.2	1.5
5	2.65	4.0	4.0	3.6	7.1	5.15	2.9	1.7	1.0	1.6	1.3	1.5
6	2.7	4.0	4.0	3.5	7.1	5.65	2.5	1.7	1.05	1.8	1.3	2.0
7	2.2	3.2	4.1	3.25	7.15	5.45	2.15	1.6	1.05	1.8	1.0	2.0
8	2.45	3.75	4.2	4.4	7.1	5.15	2.1	1.5	1.1	1.8	1.3	1.9
9	2.85	3.5	4.3	5.0	7.5	5.15	2.1	1.5	1.0	1.75	1.3	2.0
10	1.1	4.1	3.9	4.7	7.5	5.2	2.0	1.5	1.15	1.8	1.3	2.0
11	2.1	4.0	4.0	4.9	7.7	4.85	2.05	1.5	1.45	1.8	1.3	2.0
12	2.85	4.05	4.15	5.2	7.7	4.8	2.0	1.5	1.75	1.8	1.3	1.0
13	2.4	4.5	3.9	5.1	8.05	4.65	2.1	1.4	2.5	1.75	1.3	2.05
14	2.5	2.5	2.4	6.4	8.1	4.4	2.1	1.4	2.55	1.65	.9	2.0
15	2.85	4.0	4.15	6.55	7.9	2.85	2.1	1.4	2.5	1.7	.55	2.0
16	3.0	3.85	4.0	6.9	7.85	2.85	2.0	1.4	2.35	1.7	1.2	2.0
17	1.4	3.9	4.0	7.3	7.9	2.85	2.0	1.25	2.2	1.2	1.2	1.85
18	2.4	4.15	3.9	7.4	7.9	2.9	1.95	1.1	1.9	1.6	1.2	1.8
19	2.4	3.3	3.95	7.7	7.9	2.85	1.85	1.1	1.5	1.7	1.2	1.2
20	2.5	4.95	3.65	7.9	7.5	2.55	1.85	1.1	1.7	1.7	1.2	1.8
21	2.5	2.5	1.85	7.9	7.45	2.9	1.8	1.1	1.85	1.7	1.0	1.7
22	2.4	2.15	3.5	7.9	7.0	3.1	1.8	1.1	1.85	1.7	1.0	1.8
23	2.85	4.0	3.7	8.05	6.9	3.15	1.8	1.15	1.8	1.2	1.05	1.8
24	1.0	4.15	3.55	8.0	7.05	3.2	1.8	1.25	1.7	1.0	1.05	1.7
25	2.4	4.0	3.6	8.0	7.35	3.15	1.8	1.25	1.55	1.2	1.8	1.7
26	2.5	4.1	3.3	7.8	7.0	3.15	1.7	1.15	1.2	1.2	2.05	1.0
27	2.5	4.0	3.05	7.9	6.85	3.1	1.7	.95	1.2	1.2	2.0	1.45
28	3.25	3.75	1.15	7.65	6.5	3.0	1.7	1.0	1.2	1.2	1.0	1.8
29	2.5	....	3.3	7.55	6.6	3.0	1.7	.95	1.4	1.2	1.75	1.8
30	4.0	....	3.5	7.45	6.7	2.95	1.7	.95	1.55	1.2	2.0	1.8
31	1.0	....	3.05	....	6.55	....	1.7	1.0	....	1.0	....	1.8

NOTE.—Ice seldom forms at this station to the extent of affecting the relation between gage heights and discharge because of the swiftness of the current.

Daily discharge, in second-feet, of Raquette River at Piercefield, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	704	1,270	1,240	918	4,540	3,250	818	371	210	344	210	318
2	748	1,430	1,500	993	4,320	3,250	818	371	249	344	210	318
3	550	1,210	1,500	1,150	4,320	2,800	818	371	249	344	210	386
4	497	1,210	1,500	210	4,320	2,650	794	371	228	344	249	386
5	704	1,430	1,430	1,180	4,320	2,340	818	371	210	344	270	462
6	725	1,430	1,430	1,120	4,320	2,800	642	371	219	400	270	462
7	532	968	1,500	993	4,370	2,600	514	344	219	400	210	462
8	623	1,270	1,570	1,710	4,320	2,340	497	318	228	400	270	430
9	794	1,120	1,640	2,200	4,780	2,340	497	318	210	386	270	462
10	228	1,500	1,360	1,940	4,780	2,380	462	318	238	400	270	462
11	497	1,430	1,430	2,110	5,020	2,060	480	318	306	400	270	462
12	794	1,460	1,540	2,380	5,020	2,020	462	318	386	400	270	210
13	604	1,780	1,360	2,290	5,440	1,900	497	293	642	386	270	480
14	642	642	604	3,560	5,500	1,710	497	293	662	358	192	462
15	794	1,430	1,540	3,710	5,260	794	497	293	642	371	142	462
16	868	1,330	1,430	4,090	5,200	794	462	293	586	371	249	462
17	293	1,360	1,430	4,540	5,260	794	462	260	532	249	249	415
18	604	1,540	1,360	4,660	5,260	818	446	228	430	344	249	400
19	604	1,020	1,400	5,020	5,260	794	415	228	318	371	249	249
20	642	2,160	1,210	5,260	4,780	662	415	228	371	371	249	400
21	642	642	415	5,260	4,720	818	400	228	415	371	210	371
22	604	514	1,120	5,260	4,200	918	400	228	415	371	210	400
23	794	1,430	1,240	5,440	4,090	943	400	238	400	249	219	400
24	210	1,540	1,150	5,380	4,260	968	400	260	371	210	219	371
25	604	1,430	1,180	5,380	4,600	943	400	260	331	249	400	371
26	642	1,500	1,020	5,140	4,200	943	371	238	249	249	480	210
27	642	1,430	893	5,260	4,040	918	371	201	249	249	462	306
28	993	1,270	238	4,960	3,660	868	371	210	249	249	210	400
29	642	....	1,020	4,840	3,760	868	371	201	293	249	386	400
30	1,430	....	1,120	4,720	3,870	843	371	201	331	249	462	400
31	210	....	893	....	3,710	....	371	210	....	210	....	400

NOTE.—Daily discharges are based on a rating well defined between 90 and 4,780 second-feet.

Monthly discharge of Raquette River at Piercefield, N. Y., for 1909.

[Drainage area, 723 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	1,430	210	641	0.887	1.02	A.
February	2,160	514	1,310	1.81	1.88	A.
March	1,640	238	1,230	1.70	1.96	A.
April	5,440	210	3,390	4.69	5.23	A.
May	5,500	3,660	4,560	6.31	7.28	A.
June	3,250	662	1,600	2.21	2.47	A.
July	818	371	501	.693	.80	A.
August	371	201	282	.390	.45	A.
September	662	210	348	.481	.54	A.
October	400	210	330	.456	.53	A.
November	480	142	270	.373	.42	A.
December	480	210	393	.544	.63	A.
The year	5,500	142	1,230	1.71	23.21	......

RAQUETTE RIVER AT MASSENA SPRINGS, N. Y.

This station is located at the highway bridge at Massena Springs, N. Y. It was established September 21, 1903, was temporarily discontinued October 17, 1903, and resumed April 9, 1904. It is maintained to obtain data regarding the total flow of the river.

The nearest power development is at Raymondville, about 8 miles above the station. The Sunday flow of this stream is often held back during the low-water season while ponds at mills above are being refilled, and under these conditions the effect may be shown in the stream for several days.

The vertical staff gage attached to the right abutment of the upstream side of the bridge from which measurements are made was replaced on August 15, 1906, by a standard chain gage on the bridge at a datum 1.00 foot lower in order to avoid minus readings. All gage heights during 1906 and thereafter are referred to this new datum. Conditions for obtaining accurate discharge measurements are good, and a good rating table has been developed. During the winter months the discharge is affected by ice.

Information in regard to this station is contained in the annual reports of the New York state water-supply commission and the state engineer and surveyor.

Discharge measurements of Raquette River at Massena Springs, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 14 [a]	C. R. Adams	168	709	5.55	1,660
April 19	C. C. Covert	176	1,640	9.19	8,300
July 3	do	169	426	2.50	961

[a] Measurement made under partial ice cover. Average thickness of ice, 1.70 feet. Gage height to top of ice, 5.75 feet. Ice varied in section from 0.0 feet to 3.0 feet thick.

Daily gage height, in feet, of Raquette River at Massena Springs, N. Y., for 1909.

[Mrs. C. A. Waitt, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.9	5.6	7.2	7.4	9.5	6.35	2.8	1.5	1.45	1.75	1.85	3.15
2	2.9	5.3	7.0	7.4	10.3	6.3	2.4	1.8	2.15	2.1	1.8	2.95
3	3.2	5.6	7.0	7.7	9.8	5.75	2.65	1.8	1.85	1.75	1.75	2.85
4	2.6	5.5	6.8	7.8	8.2	5.65	1.95	1.7	1.95	2.2	1.65	2.65
5	3.1	5.3	6.8	9.2	7.7	5.2	2.95	1.65	2.05	2.15	1.75	2.3
6	4.8	9.15	6.7	9.4	7.2	5.5	2.95	1.8	1.75	2.4	1.75	2.2
7	4.8	9.1	6.5	9.0	7.5	5.45	2.8	1.85	1.8	2.2	1.65	2.45
8	4.6	7.0	6.4	7.9	7.7	5.35	2.15	1.75	1.85	2.15	1.75	2.55
9	4.6	6.2	6.4	7.5	7.5	5.1	2.3	1.7	1.75	2.1	1.75	2.75
10	4.0	6.1	6.4	6.6	7.6	4.95	2.2	1.7	1.85	2.15	2.05	2.95
11	4.4	6.1	6.3	7.0	10.9	4.85	1.7	2.15	1.85	2.0	2.15	2.95
12	4.4	6.1	6.3	7.8	10.6	4.65	1.6	1.95	1.6	1.9	2.05	3.4
13	4.4	6.1	6.3	8.0	8.9	4.55	2.25	1.9	1.6	1.95	1.75	3.4
14	4.6	5.9	6.3	8.0	8.7	4.55	2.35	1.85	1.75	1.85	1.6	3.5
15	4.5	6.0	6.1	8.9	8.2	4.5	2.3	1.65	1.9	1.95	1.65	3.25
16	4.5	6.0	6.1	8.9	8.6	4.2	2.4	1.65	1.8	2.05	1.85	3.15
17	3.7	6.0	5.4	9.0	8.7	3.85	2.25	1.65	1.95	1.9	2.1	3.1
18	3.9	5.8	5.4	9.0	8.5	3.6	2.05	1.75	2.05	1.85	1.95	2.65
19	3.9	5.7	5.5	9.2	8.2	2.75	2.1	1.65	2.0	1.9	1.8	2.5
20	3.5	5.6	5.5	9.1	8.4	2.75	2.05	1.9	1.9	1.85	1.8	2.4
21	3.5	7.7	5.3	9.1	8.0	3.05	2.5	1.85	1.95	1.95	2.2	2.35
22	4.3	7.5	5.2	9.0	7.9	3.05	2.45	1.65	1.9	2.15	1.7	2.35
23	4.5	7.3	5.2	9.0	7.9	3.0	2.35	1.8	1.8	1.9	1.8	2.25
24	5.0	7.3	5.4	8.9	7.7	3.1	2.35	1.85	1.9	1.45	2.65	2.25
25	5.2	10.5	5.4	8.7	7.35	2.95	2.0	1.7	1.8	2.15	2.85	2.35
26	5.5	8.2	6.2	8.7	7.0	2.8	1.6	1.75	1.75	2.05	3.15	2.05
27	5.6	7.5	6.3	8.5	6.95	2.95	2.05	1.6	1.85	2.05	3.25	2.4
28	5.4	7.3	7.0	8.4	6.95	3.0	2.25	1.6	1.75	2.15	2.75	2.05
29	5.5	......	7.0	8.5	6.95	2.8	2.1	1.4	1.8	1.9	2.25	2.35
30	5.5	......	7.2	8.8	6.8	3.0	2.15	1.6	1.75	1.75	2.4	2.55
31	5.6	......	7.2	......	6.55	......	2.2	1.45	......	1.65	......	2.8

Note.—Gage heights affected by backwater from ice conditions January 1 to about April 15 and from about November 24 to December 31.

Daily discharge, in second-feet, of Raquette River at Massena Springs, N. Y., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	......	8,800	4,430	1,120	365	345	475	525
2	......	10,100	4,360	845	500	690	660	500
3	......	9,280	3,760	1,020	500	525	475	475
4	......	6,880	3,660	578	450	578	720	428
5	......	6,180	3,200	1,230	428	632	690	475
6	......	5,490	3,500	1,230	500	475	845	475
7	......	5,900	3,450	1,120	525	500	720	428
8	......	6,180	3,350	690	475	525	690	475
9	......	5,900	3,100	780	450	475	660	475
10	......	6,040	2,950	720	450	525	690	632
11	......	11,000	2,850	450	690	525	605	690
12	......	10,600	2,660	405	578	405	550	632
13	......	7,900	2,580	750	550	405	578	475
14	......	7,600	2,580	812	525	475	525	405
15	......	6,880	2,530	780	428	550	578	428
16	7,900	7,450	2,260	845	428	500	632	525
17	8,050	7,600	1,950	750	428	578	550	660
18	8,050	7,300	1,740	632	475	632	525	578
19	8,350	6,880	1,080	660	428	605	550	500
20	8,200	7,160	1,080	632	550	550	525	500
21	8,200	6,600	1,310	910	525	578	578	720
22	8,050	6,460	1,310	878	428	550	690	450
23	8,050	6,460	1,270	812	500	500	550	500
24	7,900	6,180	1,340	812	525	550	345	550
25	7,600	5,690	1,230	605	450	500	690	550
26	7,600	5,230	1,120	405	475	475	632	550
27	7,300	5,160	1,230	632	405	525	632	550
28	7,160	5,160	1,270	750	405	475	690	550
29	7,300	5,160	1,120	660	325	500	550	550
30	7,750	4,970	1,270	690	405	475	475	550
31	......	4,670	......	720	345	......	428	......

NOTE.—Daily discharges are based on a rating well defined between 185 and 9,600 second-feet.

Monthly discharge of Raquette River at Massena Springs, N. Y., for 1909.

[Drainage area, 1,170 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			850	0.726	0.84	C.
February			1,800	1.54	1.60	C.
March			1,700	1.45	1.67	C.
April	8,350		5,170	4.42	4.93	B.
May	11,000	4,670	6.870	5.87	6.77	A.
June	4,430	1,080	2,320	1.98	2.21	A.
July	1,230	405	772	.660	.76	A.
August	690	325	468	.400	.46	B.
September	690	345	521	.445	.50	A.
October	845	345	597	.510	.59	A.
November	720	405	527	.450	.50	A.
December			550	.470	.54	C.
The year			1,850	1.58	21.37	

NOTE.—Discharge during the periods of ice conditions based on the discharge of Raquette River at Piercefield where the channel was open.

BOG RIVER NEAR TUPPER LAKE, N. Y.

This station, which is located just above Bog River Falls, was established August 24, 1908, to obtain data for use in water-power and storage investigations. During the summer of 1909 discharge measurements were made from a car hung on a cable erected about 300 feet below the forks of Tupper Lake stream and Bog River, about 2½ miles above Big Tupper Lake in the town of Piercefield, and about 11 miles southwest of the town of Tupper Lake. Prior to 1909 the measurements were made by wading or from a boat.

The staff gage is located at the head of Bog River Falls, about 2½ miles downstream from the cable section, and is within a few rods of Big Tupper Lake. The elevation of the zero of the gage, based on the United States Geological Survey benchmark at Tupper Lake Junction, according to the levels of the state water supply commission of New York, is 1,563.76 feet above sea level. The bed of the stream is sandy and contains scattered bowlders, but it is probably permanent and a good low-water rating curve has been developed.

There is no regular observer here, gage readings during 1909 being obtained either by a recording gage or by hydrographers and other engineers who periodically visit the station.

Information in regard to this station is contained in the annual reports of the state water supply commission of New York.

Discharge measurements of Bog River near Tupper Lake, N. Y., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 8 [a]	Covert and Hoyt	50	103	1.38	64
July 13 [a]	W. G. Hoyt	49	105	1.40	70
September 6 [a]	do	47	89	1.16	41
October 1 [b]	do	44	87	1.17	42
October 14 [b]	C. C. Covert	49	100	1.24	54

[a] Measurement made by wading at the gage. [b] Measurement made from the cable.

Daily gage height, in feet, and daily discharge, in second-feet, of Bog River near Tupper Lake, N. Y., for 1909.

Day.	July.		August.		September.		October.		November.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.22	48.1	1.13	38.2	1.17	42.4		
2			1.23	49.3	1.13	38.2	1.20	45.6		
3					1.13	38.2				
4					1.12	37.2				
5					1.16	41.3				
6					1.16	41.3			1.30	58.2
7					1.12	37.2				
8	1.34	63.6	1.12	37.2	1.13	38.2				
9					1.13	38.2	1.30	58.2	1.30	58.2
10			1.18	43.4	1.13	38.2				
11			1.09	34.3	1.14	39.2				
12			1.22	48.1	1.14	39.2				
13	1.39	70.9	1.23	49.3	1.13	38.2				
14			1.11	36.2			1.24	50.6	1.40	72.4
15			1.09	34.3						
16			1.13	38.2			1.25	51.8	1.40	72.4
17	1.34	63.6	1.12	37.2						
18			1.13	38.2	1.20	45.6				
19			1.13	38.2						
20			1.13	38.2					1.40	72.4
21	1.16	41.3	1.20	45.6						
22										
23							1.40	72.4	1.60	109
24			1.13	38.2						
25					1.20	45.6				
26			1.13	38.2						
27	1.32	60.9	1.14	39.2					1.30	
28			1.13	38.2						
29										
30			1.13	38.2	1.20	45.6	1.50	89.5	1.40	
31			1.13	38.2						

NOTE.—Gage heights are from observations made by E. W. Owen, B. O. Lott, and engineers of the state water-supply commission and the United States Geological Survey. The stream is controlled by power development above the gage. Records from a recording gage were used as a basis for correcting to mean gage height. The river was frozen over November 27. Daily discharges are based on a well-defined rating.

Monthly discharge of Bog River near Tupper Lake, N. Y., for 1909.

[Drainage area, 132 square miles.]

Month.	Discharge in second-feet.		Run-off (depth in inches on drainage area).	Accuracy.
	Mean.	Per square mile.		
July 8–31	(60)	0.455	0.41	C.
August	(42)	.318	.37	C.
September	(44)	.333	.37	C.
October	(62)	.470	.54	C.
November	(68)	.515	.57	C.

NOTE.—Monthly estimates based on frequent observations of daily gage heights and Raquette Falls record.

LAKE CHAMPLAIN DRAINAGE BASIN.

DESCRIPTION.

Lake Champlain occupies a long and narrow valley, extending in a north-south direction and forming a part of the boundary between New York and Vermont. The elevation of the lake is about 95 feet above tide, and the water-surface area is 436 square miles.

The drainage basin is irregular in form, being about 75 miles wide from a point opposite Middlebury, Vt., northward to the outlet of the lake at Rouse Point, on the international boundary. South of Middlebury the average width of the basin is about 35 miles, and the lake itself is very narrow, forming virtually a drowned river.

The tributary region is rugged and mountainous, covered with little depth of soil except in the stream valleys. The drainage is received almost entirely through large tributaries, there being little direct coast drainage into the lake. The outlet of the lake is Richelieu River, which flows northward from Rouse Point to St. Lawrence River. The total drainage area at the mouth of the lake is about 7,900 square miles (including lake surface).

The following gaging stations have been maintained in this river basin:

Lake Champlain at Burlington, Vt., 1907-1909.
Richelieu River at Fort Montgomery, N. Y., 1875-1909.
Missisquoi River at Richford, Vt., 1909.
Missisquoi River at Swanton, Vt , 1903.
Lamoille River near Morrisville, Vt., 1909.
Lamoille River at West Milton, Vt., 1903.
Winooski River above Stevens Branch near Montpelier, Vt., 1909.
Winooski River at Montpelier, Vt., 1909.
Winooski River at Richmond, Vt., 1903-1907.
Worcester Branch of Winooski River at Montpelier, Vt., 1909.
Dog River at Northfield, Vt., 1909.
Otter Creek at Middlebury, Vt., 1903-1907.
Poultney River at Fairhaven, Vt., 1908.
Mettawee River at Whitehall, N. Y., 1908.
Lake George Outlet at Ticonderoga, N. Y., 1904-5.
Bouquet River at Willsboro, N. Y., 1904 and 1908.
Au Sable River at Keeseville, N. Y., 1904 and 1908.
Saranac River at Saranac Lake, N. Y., 1902-3.
Saranac River at Plattsburg, N. Y., 1903-1909.
Big Chazy River at Mooers, N. Y., 1908.

LAKE CHAMPLAIN AT BURLINGTON, VT.

This station is located on the south side of the roadway leading to the docks of the Champlain Transportation Company, of Burlington, Vt., at a point about 80 feet from the roadway at the foot of King street, and readings have been obtained since May 1, 1907.

A comparison of gage readings on calm days during 1907 and 1908, made under the direction of Prof. A. D. Butterfield, formerly of the University of Vermont, indicates that the zeros of the gages at Fort Montgomery and at Burlington are at substantially the same elevation, namely, 92.50 feet above mean sea level. The gage readings at Burlington during 1909, as published in the following table, were taken and furnished through the courtesy of Mr. D. A. Loomis, general manager of the Champlain Transportation Company.

Daily gage height, in feet, of Lake Champlain at Burlington, Vt., for 1909.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			3.48		6.95	6.00			1.00	0.75	0.40	
2				[a]4.10		5.92	3.40	1.85	1.00	.75	.40	
3		1.33			6.90	5.78	3.35	1.80	1.00		.42	0.50
4					6.90	5.65		1.78	1.00		.42	
5	−0.05			[a]4.45	6.80		3.25	1.70		.80	.42	
6							3.15	1.65	.90	.80	.42	
7					6.70	5.45	3.10	1.60	.88	.80		
8	.25	[b]1.67	3.60	5.37	6.70	5.40			.85	.80	.35	
9				5.80		5.35	3.00	1.52	.83	.80	.35	
10					6.70	5.20	2.90	1.50	.80		.30	
11	.33	1.90			7.00	5.10		1.49	.80	.75	.30	
12				[c]5.95	7.17	5.00	2.75	1.45		.75	.38	
13					7.18		2.65	1.40	.75	.70	.40	
14					7.10	4.80	2.65	1.35	.72	.70		.75
15		2.06	3.55	6.55	7.08	4.72	2.60			.65		
16				6.95			2.60	1.33	.80	.60	.40	
17				7.05	7.00		2.60	1.30	.75			
18					7.08		2.50	1.30	.70	.60	.45	
19		2.30		7.35	7.08		2.45	1.30				
20	.50			7.56	7.04		2.40	1.30	.60	.55	.25	
21				7.61	6.95	4.30	2.37	1.30	.58	.50		
22		2.66	3.30	7.50	6.90	4.25	2.30		.51	.50		
23	.53			7.54		4.20	2.25	1.20	.50	.52		
24		2.90		7.52	6.68			1.15	.60			
25	.70	3.06			6.65			1.12	.59	.50		
26	.93	3.02		7.41	6.45	3.95	2.10	1.10		.45		
27	1.03	3.36		7.31	6.30		2.05	1.10		.45		.73
28	1.17			7.13	6.20		2.00	1.10	.70	.45		
29	1.20		3.67	7.13	6.15		1.98		.70			
30	1.25						1.95	1.10	.80	.42		
31							1.90	1.05				

[a] Gage height to top of ice. [b] Lake closed; no open water in sight.
[c] Lake apparently open; no ice in sight.

NOTE.—The lake was frozen at the gage from about January 29 to April 8. The thickest ice recorded was 13½ inches on March 8. No ice notes recorded for the latter part of the year.

RICHELIEU RIVER AT FORT MONTGOMERY, N. Y.

This station is located in the fort, about one-half mile from the head of Richelieu River, at the outlet of Lake Champlain at Rouse Point, N. Y., where a record of gage heights has been kept by the United States Corps of Engineers since 1875. Through the courtesy of Maj. Edward Burr the daily gage readings are reported weekly to the United States Geological Survey.

The entire surface of Lake Champlain freezes over nearly every winter, and the freezing may affect the discharge.

The elevation of gage zero at Fort Montgomery is 92.50 feet above mean sea level, according to the adjustment in 1906 of mean sea datum in this vicinity by the topographic branch of the United States Geological Survey. High-water level is at elevation 101.6 feet, and on November 13, 1908, an elevation of 91.9 feet was recorded at Fort Montgomery, probably the lowest on record.

The daily discharge of the lake has been determined from observations of the depth and discharge over the Chambly dam, 35 miles below the head of Richelieu River, made in 1898 by the United States Board on Deep Waterways. A rating table has been derived from the observations at the Chambly dam and the gage readings taken at Rouse Point. The area tributary to the river between Rouse Point and Chambly is 310 square miles, making the total drainage basin above Chambly 8,210 square miles.

Estimates of monthly discharge are withheld pending the verification of the rating curve previously used to determine the discharge at this point.

Information in regard to this station is contained in the reports of the New York state engineer and surveyor.

Daily gage height, in feet, of Richelieu River at Fort Montgomery, N. Y., for 1909.

[William McComb, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.15	3.3	3.9	7.3	5.9	3.55	1.85	1.0	0.75	0.4	0.5
2	....	1.2	3.3	4.0	7.0	5.85	3.4	1.8	1.0	.7	.5	.5
3	....	1.25	3.35	4.1	6.9	5.7	3.4	1.75	1.0	.7	.4	.5
4	....	1.25	3.3	4.15	6.8	5.65	3.3	1.8	1.1	.75	.35	.55
5	....	1.25	3.3	4.3	6.75	5.6	3.2	1.75	.9	.8	.3	.55
6	....	1.3	3.4	4.5	6.65	5.45	3.2	1.7	.95	.8	.3	.5
7	....	1.45	3.35	4.85	6.85	5.4	3.1	1.6	.8	.8	.35	.55
8	0.2	1.6	3.4	5.15	6.65	5.35	3.0	1.65	.9	.8	.5	.6
9	.25	1.6	3.45	5.5	6.8	5.3	2.95	1.55	.7	.75	.3	.7
10	.3	1.75	3.5	5.75	6.9	5.2	3.0	1.45	.9	.8	.5	.45
11	.35	1.85	3.45	5.9	7.0	5.1	2.95	1.45	.8	.85	.45	.5
12	.3	1.9	3.4	6.0	7.1	5.0	2.95	1.5	.8	.8	.4	.5
13	.25	1.85	3.4	6.1	7.15	4.9	2.8	1.55	.85	.8	.35	.6
14	.3	1.85	3.4	....	7.15	4.85	2.7	1.45	.75	.85	.35	.5
15	.2	1.9	3.4	....	6.9	4.7	2.7	1.5	.85	.65	.6	.6
16	.3	1.9	3.45	....	6.95	4.65	2.65	1.5	.7	.7	.3	.55
17	.2	2.05	3.4	....	7.0	4.7	2.55	1.3	.8	.6	.5	.5
18	.3	2.1	3.3	....	7.0	4.55	2.55	1.25	.6	.6	.2	.55
19	.35	....	3.35	....	7.05	4.5	2.35	1.3	.7	.5	.3	.5
20	.4	2.15	3.25	....	7.05	4.45	2.3	1.25	.8	.55	.45	.5
21	.45	2.2	3.2	....	7.0	4.35	2.35	1.2	.7	.6	.35	.45
22	.4	2.55	3.15	....	6.9	4.3	2.45	1.25	.7	.5	.25	.5
23	.5	2.6	3.1	7.5	6.75	4.2	2.4	1.25	.65	.5	.3	.5
24	.7	2.75	3.2	7.4	6.6	4.1	2.3	1.25	.6	.4	.25	.45
25	.9	2.95	3.2	7.45	6.45	4.05	2.15	1.2	.55	.45	.3	.55
26	1.05	3.1	3.3	7.2	6.4	3.95	2.15	1.2	.5	.6	.4	.4
27	1.1	3.15	3.35	7.4	6.35	3.8	2.1	1.05	.55	.5	.4	.45
28	1.1	3.2	3.45	6.95	6.3	3.8	2.05	1.15	.6	.5	.6	.5
29	1.05	....	3.6	7.0	6.2	3.6	2.15	1.05	.75	.35	.35	.5
30	1.05	....	3.7	7.1	6.1	3.6	1.85	1.05	.7	.3	.45	.5
31	1.1	....	3.8	....	6.05	....	1.9	1.15	....	.4	....	.5

NOTE.—Gage inaccessible because of high water April 14–22.

MISSISQUOI RIVER DRAINAGE BASIN.

DESCRIPTION.

Missisquoi River drains the northern part of Vermont and the southern parts of the Missisquoi and Brome districts, in the province of Quebec, Canada. The river is formed by the junction of two branches, one rising in the mountainous region near Lowell, in the southwestern part of Orleans County, and flowing in a general northerly direction, the other rising near Bolton, Brome, and taking a southerly course. The two unite at Mansonville, in Brome, and the river takes a general westerly course to Lake Champlain, which it enters at Missisquoi Bay. From North Troy to Richford it lies in Canada. The important tributaries of the Missisquoi are the North Branch, Trout River, Tylers Branch, and Black Creek.

The mean annual rainfall in this region is probably about 40 inches. The driest year since 1892, according to observations made at Enosburg Falls, was 1908, when the precipitation amounted to 31.90 inches; the wettest was 1901, with 52.30 inches. The winters are severe. The snowfall has an average depth of about 26 inches, and the average temperature for January and February is 16° F.

Throughout its course the Missisquoi flows alternately through long stretches having gentle slope and shorter sections having much greater fall. The power sites along the river are fairly numerous, but storage is not well developed.

MISSISQUOI RIVER AT RICHFORD, VT.

This station, which is located just below the steel highway bridge in Richford, Vt., was established May 24, 1909, in cooperation with the State of Vermont, to determine the flow of the upper portion of this river and to obtain general information regarding the regimen of the streams in northern Vermont. North Branch enters the main river a little below the station, but above the tributaries are small.

Three gages are used—a chain gage, which is located just below the mill of the Sweat-Comings Company, and two staff gages, which are attached to rocks in the river. All readings from the staff gages are referred to the chain gage. Discharge measurements are made by wading a short distance below the gage or from the highway bridge several miles below. If the latter place is used, it is necessary to measure and subtract the flow of the North Branch. The water is used by the mill of the Sweat-Comings Company, the wheels operating under a head of about 15 feet. The gate openings are controlled hydraulically and cause considerable fluctuation in the gage heights in low-water periods. For this reason special computations of flow are necessary during a portion of the year.

The winter flow of the river is affected by anchor and shore ice, the channel being considerably narrowed. Conditions for obtaining accurate discharge data are fair. The discharge curve is not yet accurately defined.

Gage readings are furnished through the courtesy of the Sweat-Comings Manufacturing Company.

Discharge measurements of Missisquoi River at Richford, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
May 22 [a]	D. M. Wood			7.09	1,100
July 1 [b]	do	146	160	5.36	198
Do	do			4.63	[c] 35
July 25 [d]	do	36	163	4.91	76.8
July 26 [b]	do	82	133	5.22	147
Do [a]	do			5.21	100
Oct. 28 [a]	do			[e] 5.93	254

[a] At highway bridge, about 3 miles below gage. Intermediate flow subtracted.
[b] Wading measurement.
[c] Discharge estimated at gage.
[d] At highway bridge above gage. No wheels running; hence measures flow of river.
[e] Gage height fluctuated from 6.05 to 5.82 feet.

Daily gage height, in feet, of Missisquoi River at Richford, Vt., for 1909.

[R. H. Whitman, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.15	5.25		4.95	6.45	5.6	6.85
2		6.1	5.0			7.05	5.9	6.55
3		5.95	5.2		5.2	7.75	6.1	6.5
4		5.85	5.8		5.25	7.25	6.05	6.3
5		5.8	5.8		5.2	6.85	6.05	6.25
6		6.05	5.65		5.55	6.5	5.95	6.1
7		5.9	5.5		5.55	5.95		6.05
8		5.7	5.45		5.45	5.8	5.85	6.15
9		5.7	5.35		5.15	5.7	6.4	5.85
10		5.55	5.2		5.15		6.3	5.95
11		5.6			4.6	5.5	6.2	6.0
12		5.5	5.4		5.3	4.9	5.95	6.05
13			5.4		5.3	5.5	6.05	5.85
14		5.45	4.9		5.3	5.5		5.95
15		5.4	5.15		5.25	5.6	5.9	5.95
16		5.55	5.0		5.2	5.55	5.8	5.9
17		5.4	4.95		4.9	5.6	5.85	
18		5.85			5.15	5.7	5.9	5.9
19		6.45	5.3		5.3	5.8	5.85	
20		6.3	5.3	4.9	5.1	5.6	5.85	5.8
21		6.15	5.35	5.45	4.65	5.7	6.2	5.9
22	7.1	5.9	5.3	5.35	4.75	5.65	6.55	5.85
23		5.75	5.15	5.1	4.7	6.35	7.3	5.85
24	6.6	5.55	5.1	5.05	4.75	6.2	7.65	5.8
25	6.45	5.5	5.2	4.95	5.25	6.0	6.85	5.75
26	6.35	5.45	5.2	4.9	5.25	5.9	6.85	5.9
27	6.25		5.05	5.25	5.15	5.85	6.7	5.8
28	6.2		5.15	5.2	6.8		6.55	5.65
29	6.8	5.3	4.55	5.4	7.7	5.85	7.35	5.65
30	6.6	4.85	5.15	5.1	6.8	5.75	7.25	5.85
31	6.4		5.25			5.6		

NOTE.—Ice conditions existed December 10–31.

Daily discharge, in second-feet, of Missisquoi River at Richford, Vt., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		540	160	120	85	702	285	942
2		515	95	120	120	1,070	415	760
3		440	145	120	145	1,560	515	730
4		392	370	75	160	1,200	490	620
5		370	370	66	145	942	490	592
6		490	305	66	265	730	440	515
7		415	245	66	265	440	415	490
8		325	228	40	228	370	392	540
9		325	192	40	132	325	675	392
10		265	145	40	132	285	620	395
11		285	178	30	31	245	565	420
12		245	210	30	175	75	440	440
13		236	210	40	175	245	490	392
14		228	75	30	175	245	450	400
15		210	132	20	160	285	415	400
16		265	95	40	145	265	370	410
17		210	85	50	75	285	392	400
18		392	130	50	132	325	415	375
19		702	175	40	175	370	392	350
20		620	175	75	120	285	392	345
21		540	192	228	37	325	565	345
22	1,100	415	175	192	50	305	760	330
23	945	348	132	120	43	648	1,240	330
24	790	265	120	108	50	565	1,480	295
25	702	245	145	85	160	465	942	280
26	648	228	145	75	160	415	942	310
27	592	210	108	160	132	392	850	280
28	565	192	132	145	910	392	760	230
29	910	175	55	210	1,520	392	1,280	230
30	790	66	132	120	910	348	1,200	275
31	675		160	80		285		270

NOTE.—These daily discharges have been obtained from an approximate rating curve, except for July 29, August 1-19, August 31, September 2, November 7 and 14, when special computations, based on knowledge of controlled conditions of flow, were necessary. Discharges for December 10-31 for period of ice conditions are estimates based upon ice notes and knowledge of the conditions. Discharges for other days when gage was not read were interpolated.

Monthly discharge of Missisquoi River at Richford, Vt., for 1909.

[Drainage area, 328 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
May 22-31	1,100	565	772	2.35	0.87	B.
June	702	66	338	1.03	1.15	B.
July	370	55	168	.512	.59	C.
August	228	20	86.5	.264	.30	D.
September	1,520	31	234	.713	.80	C.
October	1,560	75	477	1.45	1.67	B.
November	1,480	285	636	1.94	2.16	B.
December	942	230	422	1.29	1.49	C.

LAMOILLE RIVER DRAINAGE BASIN.

DESCRIPTION.

Lamoille River has its source in several ponds, the largest of which is Caspian Lake, in the Green Mountain district of north-central Vermont, flows in a general westerly direction, and enters Lake

Champlain near Champlain. Its most important tributaries are Alder and Wild brooks, Ginon River, North Branch, and Brown River.

Considerable areas in the upper part of the basin are in forest. Lakes are numerous and some storage has already been developed, but opportunities for improvement are many. Several power sites are yet undeveloped.

The mean annual rainfall in this region is probably about 34 inches. The general temperature changes and the winter conditions are similar to those in the Winooski basin. (See pp. 112–119.)

LAMOILLE RIVER NEAR MORRISVILLE, VT.

This station, which was established July 28, 1909, in cooperation with the State of Vermont, to obtain general statistical data on the flow of the upper Lamoille, is located at the Morrisville municipal plant, about 1½ miles below Morrisville, Vt. Above the station the stream receives many tributaries, on some of which power developments are already installed; below the station no large tributary enters for about 8 miles, when Ginon River comes in at Johnson.

The chain gage, which is placed on the highway bridge just below the municipal plant, serves as an index of the total flow of the river and the height of the water in the tailrace. During the winter months the flow is only slightly affected by ice. The datum of the gage has been unchanged during the maintenance of this station. The gage heights are furnished through the courtesy of the Morrisville municipal plant.

Discharge measurements are made by wading at a ford about one-half mile below the station and from the highway bridge.

The flow at the station is well controlled, there being about 550 acres of pond area, and the plant can be run throughout the year without auxiliary power. Extensive improvements are being made at the electric plant. On their completion the flow of the river will be computed by measuring the flow over the dam and through the wheels. The dam is of concrete, of ogee section, and is 188 feet long. The water for the wheels is taken from the pond through about 1,200 feet of steel pipe to the power house, where a large standpipe with overflow is installed. The present equipment consists of one pair of 33-inch Victor turbines, hydraulically governed and operating under about a 40-foot head. Power is supplied chiefly for municipal lighting, but some is sold for industrial uses.

Estimates of discharge are withheld for the present, as the flow will have to be specially computed, owing to the irregular hours of running, in connection with the improvements being made at the plant.

Discharge measurements of Lamoille River near Morrisville, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 29 [a]	D. M. Wood	70	206	2.48	150
July 29 [b]	do	28	29	1.61	24.1
Do. [c]	do	122	121	2.26	98.2

[a] Highway bridge.
[b] Wading about 100 feet below bridge. Plant not running.
[c] Wading about one-half mile below bridge.

Daily gage height, in feet, of Lamoille River (tail-race gage) near Morrisville, Vt., for 1909.

[E. C. Hill, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		(a)	2.28	2.98	2.37	2.78	16		2.21	2.21	2.31	2.57	2.87
2		2.26	2.28	2.83	2.39	2.04	17		2.20	2.19	(a)	2.48	2.76
3		2.10	1.89	(a)	2.73	3.01	18		2.19	2.18	2.83	2.67	2.72
4		2.14	1.94	2.91	2.80	2.90	19		2.59	(a)	2.81	2.67	(a)
5		2.19	(a)	2.74	2.79	(a)	20		2.41	2.23	2.71	2.63	2.62
6		2.37	1.78	2.64	2.80	2.80	21		2.54	2.15	2.65	(a)	2.64
7		2.37	1.82	2.56	(a)	2.75	22		(a)	2.17	2.92	2.90	2.72
8		(a)	1.82	2.58	2.56	2.76	23		2.22	2.17	3.16	3.30	2.65
9		2.17	1.82	2.46	2.88	2.58	24		2.32	2.17	(a)	3.37	2.57
10		2.24	2.36	(a)	2.83	2.54	25		2.31	2.11	2.82	3.83	2.54
11		2.18	2.20	2.41	2.70	2.40	26		2.25	(a)	2.73	3.56	(a)
12		2.30	(a)	2.34	2.68	(a)	27		2.43	2.17	2.81	3.21	2.56
13		2.27	2.22	2.36	2.60	2.46	28	2.17	2.48	4.39	2.81	(a)	2.47
14		2.14	2.18	2.38	(a)	2.52	29	2.18	(a)	4.64	3.62	3.91	2.57
15		(a)	1.87	2.42	2.54	2.84	30	2.24	2.24	3.38	2.73	3.75	2.45
							31	1.89	2.22		(a)		2.47

[a] Sunday. Plant running part of day.

NOTE.—Ice did not affect the gage heights for 1909.

WINOOSKI RIVER DRAINAGE BASIN.

DESCRIPTION.

Winooski River, which is one of the most important of the Vermont rivers draining into Lake Champlain, has its source in the Green Mountains in the east-central part of the State. The river is formed at Marshfield by several branches which start from many small ponds; it then flows in a general southwesterly direction as far as Montpelier, at which place it has received the drainage from Kingsbury Brook, Stevens Branch, Worcester Branch, Dog River, and several less important tributaries; from Montpelier its general course is northwestward to Lake Champlain, which it enters near Burlington, having been joined near Middlesex by Mad River and at Waterbury by Waterbury River. From mouth to source the river is about 60 miles long and its drainage area comprises about 995 square miles. The ratio of lake surface to the entire area is small.

Along the river are several important power sites, some of which are already developed. The storage on the river, artificial or natural, is small, but it is believed that opportunities for development are fairly good.

In the upper part of the basin the country is mountainous and fairly well forested. Below Montpelier the slope of the river in general is rather flat.

The mean annual rainfall for this region is about 33 inches; at Burlington for a period of eighty-one years the mean is 32.68 inches. During the winter months the precipitation is generally the least of the year. The average depth of snow is about 24 inches, while the average temperature ranges through the year from about 66° to 15° F.

WINOOSKI RIVER ABOVE STEVENS BRANCH, NEAR MONTPELIER, VT.

This station, which is located about 3 miles above Montpelier at the plant of the Corry-Deavitt & Frost Company, was established on May 18, 1909, in cooperation with the State of Vermont, to obtain data for use in future storage and power studies in this basin, as well as general information on the regimen of stream flow in this region.

The station is located above the several large tributaries of Winooski River which enter in the vicinity of Montpelier. The staff gage is bolted to a bowlder on the right bank about 100 feet below the power plant. Discharge measurements are made from the lower railroad bridge about one-half mile below the gage.

Daily fluctuations in the stage of the river are not usually great, as the power plant operates on a twenty-four hour basis. The flow during the winter is considerably affected by anchor ice. Conditions for obtaining accurate discharge data are good. The definite relation of gage heights to discharge is well determined for the low stages of the river. No change has been made in the gage datum.

The gage heights at this station were furnished by the Corry-Deavitt & Frost Electric Company.

Discharge measurements of Winooski River above Stevens Branch, near Montpelier, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 18	D. M. Wood	70	308	4.15	888
May 27	do	66	228	3.25	394
June 26	do	64	206	2.86	196
July 2	do	63	174	2.60	107
July 22	do	62.5	174	2.59	104
Do	do	62.5	163	2.29	59.5
Do	do	62	154	2.28	54.4

Daily gage height, in feet, of Winooski River above Stevens Branch, near Montpelier, Vt., for 1909.

[P. S. Tirrill, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		3.18	2.44	2.12	2.19	3.45	16		2.96	2.30	1.99	2.19	2.36
2		3.16	2.42	2.12	2.14	3.24	17		2.89	2.39	2.45	2.19	2.38
3		3.12	2.55	2.17	3.00	3.35	18	4.14	3.25	2.32	2.42	2.22	2.41
4		3.02	2.82	2.34	3.34	3.72	19	3.85	3.15	2.44	2.38	2.28	2.38
5		3.18	2.66	2.29	2.82	3.26	20	4.14	2.96	2.56	2.32	2.26	2.37
6		3.78	2.58	2.45	2.09	3.20	21	3.80	2.88	2.42	2.29	2.22	2.40
7		3.40	2.50	2.50	2.15	3.08	22	3.54	2.85	2.42	2.28	2.20	2.36
8		3.22	2.28	2.35	2.16	2.99	23	3.54	2.76	2.48	2.23	2.22	2.35
9		3.10	2.42	2.29	2.18	2.88	24	3.42	2.77	2.42	2.12	2.25	2.38
10		3.04	2.45	2.40	2.15	2.61	25	3.29	2.70	2.38	2.10	2.29	2.35
11		3.00	2.42	2.35	2.15	2.52	26	3.28	2.79	2.37	2.01	2.35	2.35
12		2.96	2.34	2.34	2.15	2.55	27	3.25	2.56	2.32	1.95	2.38	2.32
13		2.89	2.35	2.26	2.08	2.46	28	3.23	2.53	2.22	2.00	3.65	2.35
14		3.45	2.34	2.14	2.08	2.53	29	3.65	2.44	2.20	2.04	3.85	2.37
15		3.12	2.35	2.05	2.10	2.45	30	3.42	2.36	2.20	2.02	3.60	2.36
							31	3.22		2.15	2.18		

NOTE.—No records after October 30.

Daily discharge, in second-feet, of Winooski River above Stevens Branch, near Montpelier, Vt., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		337	76	41	47	482	16		235	58	30	47	65
2		327	73	41	43	368	17		206	69	78	47	68
3		308	96	45	252	428	18	886	374	60	73	50	72
4		261	179	63	422	632	19	710	322	76	68	56	68
5		337	124	57	179	379	20	886	235	99	60	54	66
6		668	103	78	38	347	21	680	202	73	57	50	70
7		455	86	86	44	289	22	532	190	73	56	48	65
8		358	56	64	44	248	23	532	157	83	51	50	64
9		298	73	57	46	202	24	466	160	73	41	53	68
10		270	78	70	44	110	25	395	136	68	39	57	64
11		252	73	64	44	90	26	389	168	66	32	64	64
12		235	63	63	44	96	27	374	98	60	28	68	60
13		206	64	54	37	80	28	363	92	50	31	592	64
14		482	63	43	37	92	29	592	76	48	34	710	66
15		308	64	35	39	78	30	466	65	48	33	565	65
							31	358		44	46		65

NOTE.—These daily discharges are based on a rating curve well defined above discharge 48 second feet.

Monthly discharge of Winooski River above Stevens Branch, near Montpelier, Vt., for 1909.

[Drainage area, 196 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
May 18-31	886	358	545	2.78	1.45	A.
June	668	65	261	1.33	1.48	A.
July	179	44	74.8	.382	.44	A.
August	86	28	52.2	.266	.31	B.
September	710	37	129	.658	.73	A.
October	632	60	160	.816	.94	A.

WINOOSKI RIVER AT MONTPELIER, VT.

This station, which was established in cooperation with the State of Vermont, May 19, 1909, to obtain data for use in a special investigation and report on the Winooski basin, is located at the covered wooden highway bridge near the Central Vermont Railroad station in Montpelier, and is near the plant of the Colton Manufacturing Company, through whose courtesy the gage readings are obtained.

Worcester and Stevens branches enter above the gaging station, and Dog River enters just below.

Discharge measurements are made from a footbridge about one-half mile below the chain gage which is located on the highway bridge.

As the flow through the wheels is controlled by automatic governors and varies considerably throughout the day, many computations are necessary. Anchor ice during the winter sometimes affects the relation between discharge and gage height. The data are not considered very good, but special investigations to be made later should make them more reliable.

The gage datum has remained unchanged throughout the period of maintenance of this station. The discharge curve is not yet definitely determined.

Discharge measurements of Winooski River at Montpelier, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 20	D. M. Wood	184	804	6.40	1,750
May 27	do	181	476	4.69	457
June 25	do	180	387	4.17	259
July 22	do	181	380	4.17	242

Daily discharge, in second-feet, of Winooski River at Montpelier, Vt., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1,130	197	a 168	130	335	274	311
2		976	132	178	130	355	299	292
3		371	50	152	130	a 329	292	260
4		335	a 350	138	118	303	307	260
5		455	300	150	a 120	281	307	a 278
6		a 415	253	142	122	256	264	295
7		387	208	228	135	242	a 257	235
8		292	232	a 203	140	228	250	211
9		331	148	178	140	239	242	239
10		367	138	118	130	a 275	250	260
11		315	a 145	125	130	311	264	256
12		540	152	142	a 128	295	256	a 258
13		a 486	148	138	125	292	239	260
14		431	214	142	122	307	a 264	260
15		447	152	a 123	148	239	288	260
16		363	132	104	120	228	260	274
17		343	239	100	132	a 239	295	260
18		518	a 239	108	132	253	274	307
19	1,300	447	239	122	a 135	250	295	a 294
20	1,730	a 419	222	122	138	240	281	280

a Sunday.

Daily discharge, in second-feet, of Winooski River at Montpelier, Vt., for 1909—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
21	1,210	391	187	128	138	275	a 288	267
22	912	253	166	a 132	130	300	295	253
23	a 882	315	148	135	125	264	285	181
24	789	295	228	142	110	a 294	303	253
25	716	335	a 193	200	135	323	296	250
26	478	339	158	181	a 140	307	288	a 240
27	455	a 284	118	158	145	311	335	327
28	560	228	132	166	845	292	a 314	307
29	905	222	148	a 160	968	288	292	327
30	a 838	232	140	155	455	264	281	246
31	984	....	158	140	....	a 269	....	407

a Sunday.

NOTE.—These daily discharges are based mainly upon a fairly well defined rating curve above discharge of 240 second-feet. The variable flow through the wheels necessitated special computations in many instances. Sunday discharges were usually obtained by interpolation, as the storage was rather small. The ice effect at the end of the year was very little.

Monthly discharge of Winooski River at Montpelier, Vt., for 1909.

[Drainage area, 417 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
May 19–31	1,730	455	904	2.17	1.05	B.
June	1,130	222	409	.981	1.09	B.
July	350	50	183	.439	.51	C.
August	228	100	148	.355	.41	C.
September	968	110	193	.463	.52	C.
October	355	228	280	.671	.77	B.
November	335	239	281	.674	.75	B.
December	407	181	271	.650	.75	C.

WORCESTER BRANCH OF WINOOSKI RIVER AT MONTPELIER, VT.

This station, which is located a short distance below the Lane Manufacturing Company's plant at Montpelier and near the junction of Worcester Branch with the main river, was established May 15, 1909, in cooperation with the State of Vermont, and is being maintained to obtain general information concerning the flow of rivers in this region, with special regard to future work in the Winooski basin. This stream is one of the important tributaries of the Winooski.

The vertical staff gage is fastened to a stone wall and tree about 100 feet below the plant. The gage datum has remained unchanged.

Discharge measurements are made from a steel highway bridge about 300 feet below the staff gage. The conditions under which gagings are made are good except in low water, when the control of the flow causes variable gage heights. The winter conditions are materially affected by ice.

The rating curve is not finally developed, but is fairly well defined. The gage heights are read under the direction of the Lane Manufacturing Company, through whose courtesy they are furnished.

Discharge measurements of Worcester Branch of Winooski River at Montpelier, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 17	D. M. Wood	68.5	221	3.10	557
May 19	do	66.5	172	2.60	327
May 28	do	60	89.6	1.50	81.5
June 25	do	53	66.7	1.10	30.1
Do	do			.80	[a]4.0
July 2	do	49	61.9	[b]1.02	21.1
Do	do			.78	[a]2.0
July 23	do	56.5	92.0	1.43	67.1

[a] Discharge estimated. [b] Gage height doubtful.

Daily discharge, in second-feet, of Worcester Branch of Winooski River at Montpelier, Vt., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		79	19	4	25	32	35	46
2		82	19	20	22	27	30	51
3		79	20	20	22	64	40	35
4		79	27	20	15	51	42	30
5		106	41	22	4	40	40	51
9		158	21	22	35	30	30	40
7		95	22	14	29	25	40	21
8		55	11	4	22	20	30	26
9		49	10	22	20	8	38	12
10		55	2	22	20	30	42	30
11		49	18	20	14	25	46	26
12		48	20	20	12	20	35	35
13		33	20	20	22	30	40	30
14		62	20	14	20	30	46	32
15	190	44	20	4	20	30	35	30
16	482	37	20	20	18	12	28	30
17	526	34	45	30	18	21	26	30
18	482	79	79	44	14	20	35	30
19	494	115	72	50	4	20	26	46
20	507	51	72	48	20	18	35	30
21	290	25	40	59	20	40	51	32
22	220	26	20	51	20	170	54	30
23	182	20	26	45	18	95	126	30
24	136	20	17	40	18	28	82	30
25	88	19	21	39	15	30	64	42
26	79	21	12	29	12	35	147	40
27	72	20	19	20	29	46	64	38
28	145	20	16	14	261	40	96	38
29	204	20	16	12	207	35	233	38
30	182	20	16	29	51	16	88	38
31	132		10	29		40		38

NOTE.—The gage was read twice a day, once when the plant was running and again when shut down. In determining the daily flow, a weighted value was given to each gage height, this weight depending upon the number of hours it represented. The ice effect was very little in December.

Monthly discharge of Worcester Branch of Winooski River at Montpelier, Vt., for 1909.

[Drainage area, 78 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
May 15–31	526	72	259	3.32	2.10	A.
June	158	19	53.3	.683	.76	B.
July	79	2	25.5	.327	.38	C.
August	59	4	26.0	.333	.38	C.
September	261	4	34.2	.438	.49	C.
October	170	8	36.4	.467	.54	C.
November	233	26	57.5	.737	.82	B.
December	51	12	34.0	.436	.50	C.

DOG RIVER AT NORTHFIELD, VT.

The station, which was established May 14, 1909, in cooperation with the State of Vermont, is located at a wooden highway bridge about 600 feet below the dam of the Rabidou Lumber Company and about three-fourths of a mile from the railroad station at Northfield. Discharge measurements are made from this bridge, where the staff gage is located, and also from a highway bridge near Norwich University. The datum of the gage has remained unchanged.

With the exception of the computations of results and a few discharge measurements, all of the data at this station have been obtained by students of Norwich University under the direction of Prof. C. S. Carleton. The data show the run-off from a small drainage area and illustrate the effect of mill control on stream flow. This effect is here so great as to seriously impair the accuracy of the results. Special computations are necessary throughout the year, particular attention being given to the flow with the mills running and with no water passing through the wheels.

The winter data will have little value because of ice conditions, but with a great number of observations the results at other seasons should prove very useful.

Discharge measurements of Dog River at Northfield, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 14	D. M. Wood	28.5	115	3.28	133
May 19	Norwich University students, under direction of Prof. C. S. Carleton.	20.0	112	3.58	180
May 28	D. M. Wood	29.0	114	3.29	127
June 24	do	21.5	95.6	2.76	41.5
July 21	do	21.5	94.7	2.71	40.1
Do	do			2.02	[a] 1±

[a] Discharge estimated. Zero flow at gage height 2.0 feet.

Daily discharge, in second-feet, of Dog River at Northfield, Vt., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		103	16	2	8	16	11	29
2		159	14	14	10	10	18	6
3		123	31	14	7	4	23	4
4		96	26	9	7	5	26	4
5		284	.7	10	6	6	32	23
6		278	15	14	14	6	25	25
7		127	12	22	5	6	32	32
8		156	7	3	9	7	20	18
9		135	15	8	8	6	18	17
10		93	12	12	6	6	16	29
11		100	12	9	6	16	12	32
12		76	16	10	5	40	8	15
13		63	16	2	7	16	4	25
14	127	97	15	2	5	17	10	20
15	148	72	14	0	7	13	10	20

Daily discharge, in second-feet, of Dog River at Northfield, Vt., for 1909—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16	260	84	14	24	5	8	9	20
17	218	56	24	23	6	4	11	20
18	220	61	13	39	5	16	18	20
19	190	40	19	16	4	5	13	15
20	226	18	18	6	5	8	18	25
21	204	24	15	3	5	8	12	15
22	156	23	10	4	5	11	19	20
23	160	60	15	3	7	15	13	20
24	148	18	14	9	22	23	23	20
25	129	18	3	22	10	16	23	25
26	98	22	16	12	2	14	32	25
27	74	31	11	13	4	11	28	25
28	156	18	13	12	71	11	48	20
29	156	16	15	4	52	11	43	25
30	148	14	14	16	32	14	16	10
31	141	....	10	8	....	18	....	15

NOTE.—Daily discharges were obtained by special computations, using an approximate rating when applicable, but largely based upon knowledge of conditions of the controlled flow. Precipitation records were considered. The estimates December 12–25 were based on temperature, precipitation, and ice conditions.

Monthly discharge of Dog River at Northfield, Vt., for 1909.

[Drainage area, 57 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
May 14–31	260	74	164	2.88	1.93	B.
June	284	14	82.2	1.44	1.61	B.
July	31	3	14.6	.256	.30	C.
August	39	0	11.1	.195	.22	D.
September	71	2	11.5	.202	.23	D.
October	40	4	11.8	.207	.24	C.
November	48	4	19.7	.346	.39	B.
December	32	4	20.0	.351	.40	C.

SARANAC RIVER DRAINAGE BASIN.

DESCRIPTION.

Saranac River rises in the lakes in southeastern Franklin County, N. Y., and flows northeastward to a point near Cadyville and thence eastward into Lake Champlain at Plattsburg. The basin varies from 10 to less than 25 miles in width and is about 60 miles long, the total drainage area comprising about 630 square miles. The southern boundary of the basin is the Ampersand Mountain range and the stream drains the north slope of the most elevated region of the State of New York.

About 16.2 per cent of the upper drainage is water surface. Owing to its somewhat equalized flow and rapid fall the stream presents many opportunities for power development. The mean annual precipitation is about 35 inches, and the winters are usually severe.

SARANAC RIVER NEAR PLATTSBURG, N. Y.

This station, which is located at the Lozier dam of the Plattsburgh Gas and Electric Company, about 6 miles above Plattsburg, was established March 27, 1903, to obtain general statistical data regarding the total flow of Saranac River.

The record includes the flow over a spillway crest 171.75 feet in length, the discharge through two 5-foot waste gates when open, and the discharge through four 33-inch Victor turbines controlled by automatic governors. The records are furnished by Herbert A. Stutchbury, superintendent. Experiments have been made at Cornell University hydraulic laboratory on a model of the ogee section of the dam, from which coefficients have been derived for the calculation of the discharge.

The elevation of the zeros of both the spillway gage and the tailrace gage have remained the same during the maintenance of the station.

Information in regard to this station is contained in the reports of the New York state engineer and surveyor.

Daily discharge, in second-feet, of Saranac River near Plattsburg, N. Y., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Jnne.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	202	414	820	760	1,820	1,120	523	184	399	425	458	386
2	216	266	851	848	2,960	1,080	459	335	399	385	365	379
3	126	343	727	861	2,230	897	359	338	389	232	386	419
4	254	267	860	863	2,000	809	253	207	373	480	427	368
5	200	393	893	1,020	1,710	1,020	249	282	155	320	423	373
6	273	571	842	1,680	1,750	1,580	433	247	204	343	387	488
7	351	910	803	3,690	1,890	1,150	323	357	242	375	368	372
8	248	725	871	4,200	1,990	921	375	349	310	202	452	410
9	274	672	788	2,000	1,960	903	228	352	266	263	409	344
10	185	619	837	1,390	2,420	1,020	254	238	408	338	395	283
11	310	850	1,020	1,450	3,800	860	167	182	230	287	349	230
12	257	747	929	1,740	2,660	924	262	186	68	289	268	158
13	203	700	847	2,580	2,280	805	305	114	225	186	283	274
14	267	628	783	3,700	2,320	992	316	210	204	253	225	368
15	189	672	753	3,060	2,160	875	212	133	211	198	407	440
16	336	674	495	2,890	2,260	866	216	286	262	228	463	385
17	176	661	499	3,510	2,570	821	275	228	216	109	383	405
18	359	618	423	3,890	2,300	917	139	588	192	346	412	362
19	214	705	268	3,540	2,020	916	462	301	104	226	408	223
20	228	853	445	3,120	1,920	830	574	284	240	293	275	355
21	261	1,210	311	2,430	1,880	856	432	271	204	242	204	313
22	280	1,120	483	2,790	1,580	751	335	167	217	190	427	398
23	493	961	434	2,580	1,550	761	388	402	227	388	508	368
24	721	910	483	2,330	1,460	762	377	230	207	305	478	329
25	935	1,250	455	2,120	1,300	684	337	186	214	438	395	320
26	704	1,100	548	2,200	1,300	832	317	201	135	386	358	268
27	476	952	722	2,050	1,180	161	420	413	337	354	236	327
28	453	824	460	1,940	1,240	237	285	395	240	367	302	270
29	462	....	598	1,740	1,930	1,160	224	308	503	266	512	270
30	357	....	477	1,700	1,640	262	206	402	260	328	493	258
31	247	....	827	....	1,400	....	237	a 400	....	223	....	273

a Estimated.

NOTE.—The daily discharge for low-water stages is probably somewhat too low.

Monthly discharge of Saranac River near Plattsburg, N. Y., for 1909.

[Drainage area, 624 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
January	935	126	331	0.530	0.61
February	1,250	266	736	1.18	1.23
March	1,020	268	663	1.06	1.22
April	4,200	760	2,290	3.67	4.10
May	3,800	1,180	1,980	3.17	3.66
June	1,580	161	859	1.38	1.54
July	574	139	321	.514	.59
August	588	114	283	.454	.52
September	503	68	255	.409	.46
October	480	109	299	.479	.55
November	512	204	382	.612	.68
December	488	158	336	.538	.62
The year	4,200	68	728	1.17	15.78

ST. FRANCIS RIVER DRAINAGE BASIN.

DESCRIPTION.

St. Francis River rises in Lake St. Francis, in the district of Beauce, in the southeastern part of the province of Quebec. After flowing southwest for about 100 miles, it turns to the northwest at almost right angles in the district of Sherbrooke and joins St. Lawrence River in Lake St. Peter. Lake Memphremagog, which crosses the international boundary into Vermont, is tributary to St. Francis River near the bend through Magog River. The principal tributaries of Lake Memphremagog in Vermont are Clyde, Barton, and Black rivers.

CLYDE RIVER DRAINAGE BASIN.

DESCRIPTION.

Clyde River rises in a lake region near Island Pond, in the northeastern part of Vermont, and flows in a general northwesterly direction to Newport, where it enters Lake Memphremagog. Its basin is considerably broken with hills and low mountains.

Although its drainage area is smaller than that of some other Vermont rivers, it has great opportunities for development. The area contains many natural ponds, and it is possible to create several artificial ponds, which should make the flow of this river very uniform. The stream is very quick spilling. Many power plants are already in place.

No reliable information concerning the mean annual precipitation in this basin is available, but from the data at hand it seems that the average is about 38 inches. Winter conditions are similar to those in the Missisquoi basin (pp. 108–110).

The following gaging station has been maintained in this basin: Clyde River at West Derby, Vt., 1909.

CLYDE RIVER AT WEST DERBY, VT.

This station, which is located just below the Newport Electric Light Company's plant at West Derby, Vt., was established May 25, 1909, in cooperation with the State of Vermont, to obtain data for a study of storage conditions on this river and general information as to the flow of rivers in northern Vermont.

At this place are two dams, both operated by the same management. At the upper dam part of the water is used by a paper mill, and the remainder of it is delivered to the water wheels at the electric plant through a steel penstock. The total operating head from this source is about 108 feet. All of the flow from the second dam is diverted to the wheels in the power house, giving a head of about 30 feet. There is practically no water storage at the upper dam, but a pond of considerable size may be made by building a dam above this point.

Near and below the station the river has rapid fall and the bed is very rough.

The low water section of the staff gage is located about 75 feet below the plant; the high water section is nailed to a tree on the right bank, 10 feet farther downstream. The gage datum has remained unchanged throughout the year. Gage-heights are furnished by the Newport Electric Light Company.

Discharge measurements are made from a highway bridge about one-half mile below the gage.

In general the conditions for obtaining accurate discharge data are favorable. A good rating curve has not yet been developed.

Discharge measurements of Clyde River at West Derby, Vt., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 25	D. M. Wood	54	236	2.80	370
June 30	do	50	188	2.06	102
July 24	do	49	179	1.92	74.5
October 29	do	50	188	2.12	102

Daily gage height, in feet, of Clyde River at West Derby, Vt., for 1909.

[E. C. Rogers, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.60	2.05	1.72	1.80	2.50	2.10	2.35
2		2.58	2.10	1.75	1.78	2.62	2.12	2.32
3		2.55	2.12	1.75	1.82	2.68	2.10	2.32
4		2.50	2.10	1.80	1.80	2.65	2.10	2.28
5		2.48	2.05	1.72	1.78	2.60	2.10	2.30
6		2.45	2.08	1.70	1.78	2.55	2.12	2.22
7		2.40	2.15	1.60	1.78	2.52	2.15	2.20
8		2.35	2.15	1.68	1.75	2.45	2.18	2.22
9		2.35	2.12	1.70	1.78	2.38	2.15	2.18
10		2.38	2.08	1.65	1.82	2.30	2.20	2.18

Wm. A. Lamb.

Daily gage height, in feet, of Clyde River at West Derby, Vt., for 1909—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
11		2.32	2.05	1.60	1.82	2.25	2.20	2.15
12		2.25	1.98	1.75	1.85	2.18	2.18	2.15
13		2.25	2.00	1.70	1.85	2.15	2.12	2.10
14		2.28	1.95	1.65	1.85	2.10	2.12	2.15
15		2.25	1.90	1.68	1.88	2.08	2.15	2.10
16		2.22	1.98	1.62	1.88	2.02	2.08	2.12
17		2.30	1.98	1.58	1.88	2.05	2.15	2.10
18		2.30	1.95	1.60	1.82	2.02	2.08	2.12
19		2.32	1.90	1.78	1.82	2.02	2.10	2.12
20		2.32	1.95	1.75	1.85	2.00	2.08	2.02
21		2.32	1.90	1.78	1.80	2.05	2.08	2.08
22		2.35	1.95	1.78	1.82	2.05	2.10	2.10
23		2.32	1.92	1.75	1.85	2.05	2.15	2.10
24		2.28	1.95	1.70	1.88	2.10	2.20	2.08
25	2.80	2.25	1.90	1.70	1.88	2.12	2.28	2.10
26	2.78	2.15	1.85	1.78	1.88	2.12	2.28	2.08
27	2.70	2.15	1.78	1.80	1.95	2.18	2.32	2.00
28	2.70	2.10	1.72	1.80	2.10	2.20	2.35	a 2.30
29	2.68	2.05	1.75	1.80	2.25	2.18	1.38	(a)
30	2.62	2.02	1.75	1.80	2.40	2.12	2.38	(a)
31	2.60		1.78	1.80		2.12		(a)

a Heavy shore ice in river. Ice at and near gage causes backwater.

MISCELLANEOUS DISCHARGE MEASUREMENTS IN ST. LAWRENCE RIVER DRAINAGE BASIN.

The following miscellaneous discharge measurements were made in St. Lawrence River drainage basin during 1906, 1908, and 1909:

Miscellaneous measurements in St. Lawrence River basin in 1906, 1908, and 1909.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
1906.				*Feet.*	*Sec.-ft.*
Aug. 31	Au Sable River	Lake Huron	Rogers Bank, Mich		1,210
1908.					
Sept. 13	Au Sable River	Lake Huron	Rogers Bank, Mich	1.30	1,090
Oct. 27	do	do	do	1.53	1,240
1909.					
Jan. 11a	Au Sable River	Lake Huron	Rogers Bank, Mich	3.06	1,230
Jan. 15a	do	do	do	2.16	927
Jan. 16a	do	do	do	2.84	1,180
Feb. 15a	do	do	do	3.48	1,330
Do	do	do	do	3.38	1,270
Do	do	do	do	3.35	1,240
Feb. 18a	do	do	do	3.36	1,150
Mar. 12a	do	do	do	3.52	1,440
Do	do	do	do	3.52	1,480
June 28	Lamoille River	Lake Champlain	Covered highway bridge at Johnson, Vt.	(b)	128
May 19	Dog River	Winooski River	Highway bridge 1 mile above Northfield, Vt.	c 10.25	164
May 27	do	do	do	c 10.90	88.6
June 24	do	do	do	c 11.60	22.0
May 20	do	do	Railroad bridge at mouth near Montpelier, Vt.	(d)	417

a Measurements made through ice.
b Reference point is a U-shaped tack in top outer side of guard rail at station 50. Distance to water surface, 28.82 feet. Initial point is face of left abutment.
c Water surface to reference point. Reference point is under edge of zinc cover over the upstream truss at about station 5 from face of east abutment.
d Reference point, southwest corner of top of plate on middle floor beam, upstream side of bridge. Distance to water surface, 18.08 feet.

NOTE.—See also ice measurements made on Au Sable River at Bamfield, Mich., p. 59.

SUMMARIES OF DISCHARGE PER SQUARE MILE.

The following tables of summaries of discharge per square mile are given to allow of ready comparison of relative rates of run-off from different areas in the St. Lawrence River drainage. They show in a general way the seasonal distribution of run-off and the effect of snow, ground, surface, and artificial storage. But the most important fact worth noting is the almost entire lack of uniformity of agreement between any two stations. It indicates that the discharge of each stream is a law unto itself, and that all projects dependent upon stream flow, if they are to be developed along the safest and most economical lines, must be based on records of stream flow collected with great care over a long series of years as near the location of the project under consideration as possible:

Summary of discharge, in second-feet per square mile, for river stations in the St. Lawrence River drainage basin in 1909.

Station.	Drainage area.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	Sq.m.													
Escanaba River near Escanaba, Mich	800	....	....	....	....	....	1.05	0.62	0.44	0.34	0.39	1.12	0.97	....
Menominee River near Iron Mountain, Mich	2,420	0.37	0.33	0.46	....	....	....	1.13	.79	.65	.58	1.35	1.02	....
Menominee River, at Koss, Mich	3,780	.41	.35	.51	....	....	....	....	....	....	....	....	....	....
Oconto River near Gillett, Wis	814	.36	.36	.41	....	....	....	....	....	....	....	....	....	....
Wolf River at Keshena, Wis	797	.53	.56	.54	....	....	....	....	....	....	....	....	....	....
Manistee River near Sherman, Mich	900	1.11	1.12	1.11	2.02	1.80	1.22	1.09	.99	1.06	1.00	1.08	1.10	1.22
Cass River at Frankenmuth, Mich	863	.22	.95	1.96	....	....	....	....	....	....	....	....	....	....
Huron River at Geddes, Mich	757	.40	1.09	.88	.65	1.49	.64	.23	.15	.15	.16	.47	.53	.57
Huron River at Flat Rock, Mich	1,000	.41	1.00	1.24	.75	1.44	.61	.23	.21	.20	.23	.45	.59	.61
Genesee River at St. Helena, N. Y	1,030	1.36	2.54	1.95	2.80	2.42	.70	.15	.08	.09	.15	.20	.17	1.05
Genesee River at Mount Morris, N. Y	1,070	1.44	2.68	2.03	2.75	2.49	.78	.18	.14	....	....	....	....	....
Genesee River at Jones Bridge near Mount Morris, N. Y.	1,410	1.50	2 82	1.84	2.33	2.43	.74	.17	.07	.08	.15	.20	.18	1.04
Genesee River at Rochester, N. Y	2,360	1.14	2,54	1.78	1.84	2.48	.54	.21	.14	.12	.16	.19	.21	.94
Canadice Lake outlet near Hemlock, N. Y	12.6	.26	.45	1.27	2.22	1.58	.68	.46	.26	.38	.36	.36	.26	.71
Oneida River near Euclid, N. Y	1,400	1.49	2.74	4.35	5.26	4.54	2.61	.73	.48	.48	.63	.81	.89	2.08
Black River near Felts Mills, N. Y	1,850	1.88	2.97	2.12	6.65	4.15	1.21	.63	.57	.47	.65	.95	.92	1.93
Moose River at Moose River, N. Y	346	1.70	3.32	2.01	8.44	6.94	1.53	.80	.62	.67	.81	.95	.65	2 37
Oswegatchie near Ogdensburg, N. Y	1.580	1.59	2.78	2.51	5.84	4.01	1.01	.57	.50	.42	.53	.80	1.25	1.82
Raquette River at Raquette Falls near Coreys, N. Y	418	....	....	....	....	....	....	....	38	.32	.37	....	....	....
Raquette River at Piercefield, N. Y	723	.89	1.81	1.70	4.69	6.31	2.21	.69	.39	.48	.46	.37	.54	1.71
Raquette River at Massena Springs, N. Y	1,170	.73	1.54	1.45	4.42	5.87	1.98	.66	.40	.44	.51	.45	.47	1.58
Bog River near Tupper Lake, N. Y	132	....	....	....	....	....	....	....	.32	.33	.47	.52	....	....
Missisquoi River at Richford, Vt	328	....	....	....	....	....	1.03	.51	.26	.71	1.45	1.94	1.29	....
Winooski River above Stevens Branch near Montpelier, Vt	196	....	....	....	....	....	1.33	.38	.27	.66	.82	....	....	....
Winooski at Montpelier, Vt	417	....	....	....	....	....	.98	.44	.36	.46	.67	.67	.65	....
Worcester Branch of Winooski River at Montpelier, Vt	78	....	....	....	....	....	.68	.33	.33	.44	.47	.74	.44	....
Dog River at Northfield, Vt	57	....	....	....	....	....	1.44	.26	.20	.20	.21	.35	.35	....
Saranac River near Plattsburg, N. Y	624	.53	1.18	1.06	3.67	3.17	1.38	.51	.45	.41	.48	.61	.54	1.17

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