DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 265

SURFACE WATER SUPPLY OF THE UNITED STATES

1909

PART V. HUDSON BAY AND UPPER MISSISSIPPI RIVER BASINS

PREPARED UNDER THE DIRECTION OF M. O. LEIGHTON

BY

ROBERT FOLLANSBEE, A. H. HORTON
AND R. H. BOLSTER

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SURFACE WATER SUPPLY OF THE HUDSON BAY AND UPPER MISSISSIPPI RIVER BASINS, 1909.

By Robert Follansbee, 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 coöperation 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 with 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 unforseen 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 upon 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 has 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 some 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	50	66, 75	85	100	133, (134)	175, (177)	211, (213)	249, (251)	269 (271)
Great Basin	38, (39)	51	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-feet.
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.
1⅓ 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 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 backwater conditions.

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

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 textbooks 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 dams 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; (2) those with beds which change only during extreme high water; (3) those

[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 water-supply paper is nearly exhausted. The paper can, however, be consulted at most of the larger libraries of the country or it can be obtained from the Superintendent of Documents, Washington, D. C., at a cost of 20 cents.

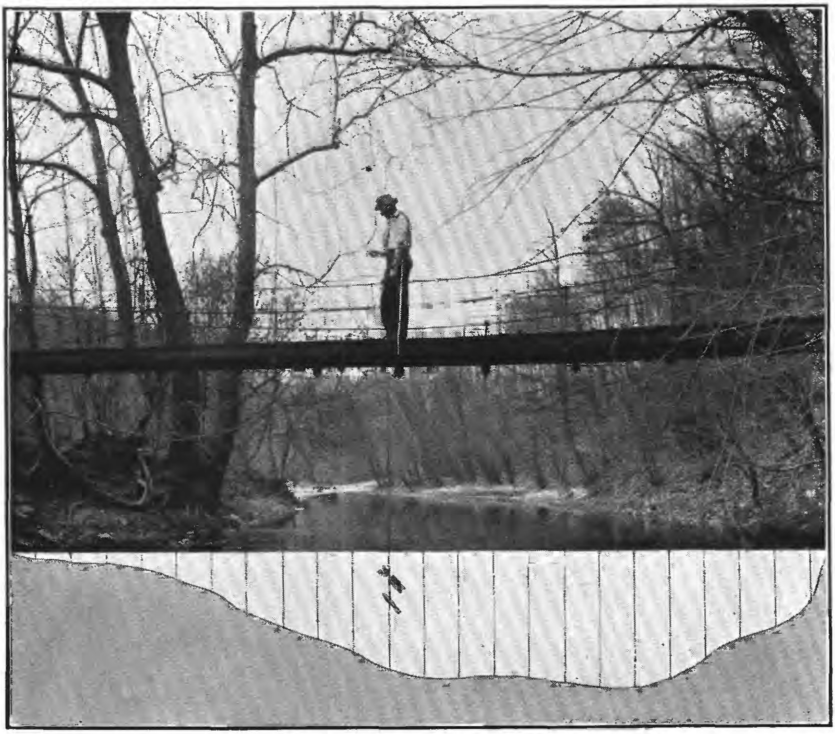
with beds which change frequently but which do not cause a variation of more than about 5 per cent of the discharge curves from year to year; and (4) those with constantly shifting beds. In determining the daily flow different office methods are necessary for each class. The field data on which the determinations 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 expense 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.

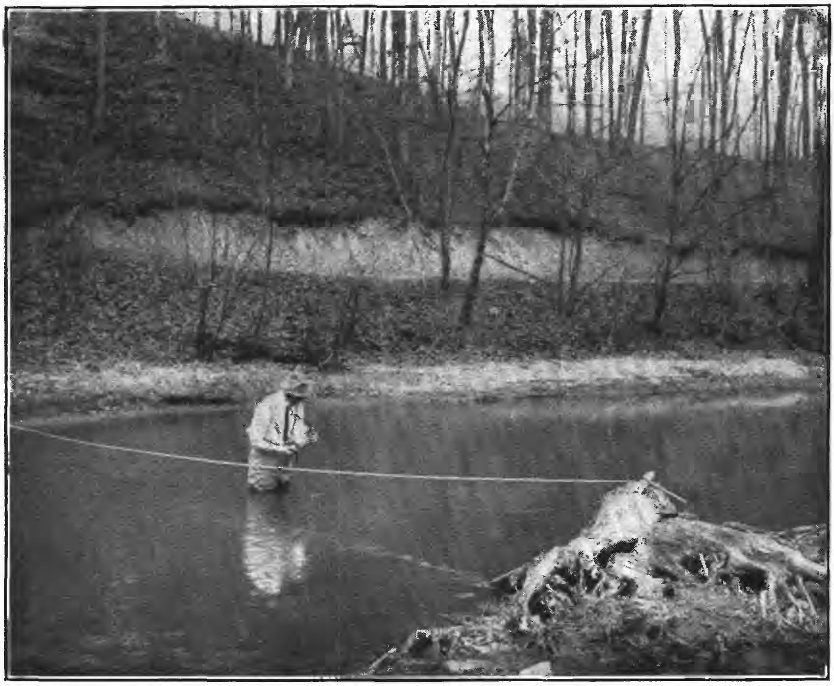
A gaging station consists essentially of a gage for determining the daily fluctuations of stage of the river and some structure or apparatus from which discharge measurements are made, usually a bridge or cable.

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



A. FOR BRIDGE MEASUREMENT.



B. FOR WADING MEASUREMENT.

TYPICAL GAGING STATIONS.

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 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 measure-

[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 text-books 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 United States Geological Survey: Trans. Am. Soc. C. E., vol. 66, 1910, p. 70.

ments, to record by the acoustic method; the meter is shown on the right equipped to record electrically. (See Pl. I, *B*.) Briefly, the meter consists of six cups attached to a vertical shaft which revolves on a conical hardened-steel point when immersed in moving water. The revolutions are 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.

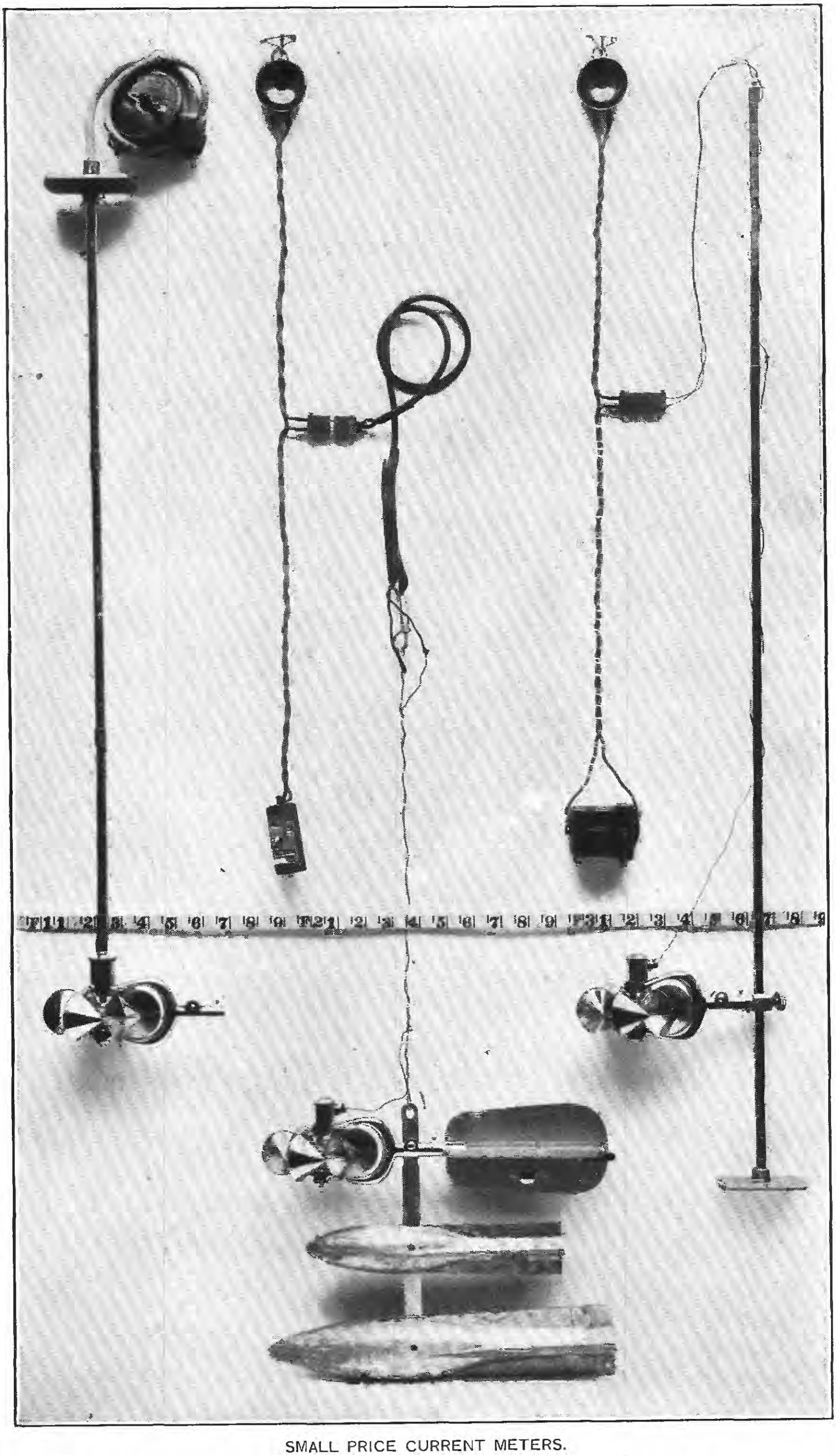
Three classes of methods of measuring velocity with current meters are in general use—multiple-point, single-point, and integration.

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 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



SMALL PRICE CURRENT METERS.

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]

[a] For information in regard to flow under ice cover see Water-Supply Paper U. S. Geol. Survey No. 187.

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. 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.

For every rating table the following assumptions are made for the period of application of the table: (*a*) That the discharge is a function of and increases gradually with the stage; (*b*) that the discharge is the same whenever the stream is at a given stage, and hence such changes in conditions of flow as may have occurred during the period of application are either compensating or negligible, except that the rating 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. 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 slope. 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 as the disposal of the Survey this is manifestly impossible, nor is it necessary for the uses to which discharge data are applied. The critical points are as a rule at relatively high or low stages. The precentage 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 given 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 of 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 daily 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 tables 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.

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 parties who supply the records gratuitously to the United States Geological Survey for publication. When such records are supplied by responsible parties 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 completely verify all such records furnished—because of lack of funds or for other causes—they are published for what they are worth, as 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.

Assistance has been rendered or records furnished by the following, to whom special acknowledgment is due: United States Engineer Corps, United States Reclamation Service, United States Weather Bureau, Minnesota and Ontario Power Company, St. Anthony Falls Water Power Company, Kettle River Quarries Company, Great Northern Development Company, Great Northern Power Company, Wisconsin Valley Improvement Company, Chippewa Valley Railway, Light and Power Company, Chippewa Lumber and Boom Company, New Athens Journal, Mr. Frank Dearborn.

The State of Illinois cooperates in the stream-gaging work in that State, the appropriation being under the control of the Internal Improvement Commission, Isham Randolph, chairman.

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.

The Minnesota State Board of Health (Dr. H. M. Bracken, secretary) cooperated in the survey of Mille Lac Lake, which was made to determine its availability for storage.

DIVISION OF WORK.

The field data for the Hudson Bay drainage area were collected under the direction of J. E. Stewart and Robert Follansbee, district engineers, assisted by W. A. Lamb, E. F. Chandler, G. A. Gray, and J. O. Nomland.

The field data for the upper Mississippi drainage basin were collected under the direction of Robert Follansbee and A. H. Horton, district engineers, assisted by G. A. Gray, C. R. Adams, C. B. Gibson, C. J. Emerson, R. J. Taylor, W. M. O'Neill, and H. J. Jackson.

The ratings, special estimates, and studies of the completed data were made by Robert Follansbee, A. H. Horton, W. A. Lamb, R. H. Bolster, and E. F. Chandler.

The computations and preparation of the completed data for publication were made under the direction of R. H. Bolster, assistant engineer, by W. A. Lamb, G. C. Stevens, H. D. Padgett, R. C. Rice, J. G. Mathers, and M. I. Walters. The report was edited by Mrs. B. D. Wood.

GAGING STATIONS MAINTAINED IN HUDSON BAY AND UPPER MISSISSIPPI RIVER DRAINAGE BASINS.

The following list comprises the gaging stations maintained in Hudson Bay and upper Mississippi River basins by the United States Geological Survey and cooperative parties. Data for these stations have been published in the reports listed on pages 11 and 12. The stations are arranged by river basins, in downstream order, tributaries of main streams being indicated by indention, as described on page 13.

HUDSON BAY DRAINAGE BASIN.

St. Mary River at Main, Mont., 1901-2.
St. Mary River near Babb (formerly Dam Site), Mont., 1902-1909.
St. Mary River near Cardston, Alberta, 1902-1909.
  Swiftcurrent Creek near Babb (formerly Wetzel), Mont., 1902-1909.
  Kennedy Creek near Babb (formerly Wetzel), Mont., 1903-1906.
Ottertail River (head of Red River), near Fergus Falls, Minn., 1904-1909.
Red River at Fargo, N. Dak., 1901-1909.
Red River at Grand Forks, N. Dak., 1901-1909 (gage height record 1895-1901).
Red River at Emerson, Manitoba, 1902.
  Pelican River near Fergus Falls, Minn., 1909.
  Sheyenne River at Haggart, N. Dak., 1902-1907.
    Devils Lake near Devils Lake, N. Dak., 1901-1909.
  Wild Rice River at Twin Valley, Minn., 1909.
  Red Lake River at Thief River Falls, Minn., 1909.
  Red Lake River at Crookston, Minn., 1901-1909.
    Thief River near Thief River Falls, Minn., 1909.
    Clearwater at Red Lake Falls, Minn., 1909.
  Pembina River at Neche, N. Dak., 1903-1909.

Mouse River near Foxholm, N. Dak., 1904–1906.
Mouse River at Minot, N. Dak., 1903–1909.
Des Lacs River at Foxholm, N. Dak., 1904–1906.
Rainy River at International Falls, Minn., 1909.
Little Fork Rainy River at Little Fork, Minn., 1909.
Big Fork River at Big Falls, Minn., 1909.
Big Fork River near Laurel, Minn., 1909.
Black River near Loman, Minn., 1909.

UPPER MISSISSIPPI RIVER DRAINAGE BASIN.

Mississippi River near Fort Ripley, Minn., 1909.
Mississippi River near Sauk Rapids, Minn., 1903–1906.
Mississippi River at Anoka, Minn., 1905–1909.
Mississippi River at St. Paul, Minn., 1895–1901.
Prairie River near Grand Rapids, Minn., 1909.
Crow Wing River at Motley, Minn., 1909.
Crow Wing River at Pillager, Minn., 1903 and 1909.
Long Prairie River near Motley, Minn., 1909.
Sauk River near St. Cloud, Minn., 1909.
Crow River, North Fork, near Rockford, Minn., 1909.
Crow River at Rockford, Minn., 1909.
Crow River near Dayton, Minn., 1906.
South Fork of Crow River near Rockford, Minn., 1909.
Rum River at Onamia, Minn., 1909.
Rum River at Cambridge, Minn., 1909.
Rum River at St. Francis, Minn., 1903.
Rum River near Anoka, Minn., 1905–1909.
Minnesota River near Odessa, Minn., 1909.
Minnesota River near Montevideo, Minn., 1909.
Minnesota River near Mankato, Minn., 1903–1906.
Chippewa River near Watson, Minn., 1909.
Redwood River near Redwood Falls, Minn., 1909.
Cottonwood River near New Ulm, Minn., 1909.
Blue Earth River at Rapidan Mills, Minn., 1909.
St. Croix River:
Kettle River near Sandstone, Minn., 1909.
Snake River at Mora, Minn., 1909.
Cannon River at Welch, Minn., 1909.
Chippewa River at Chippewa Falls, Wis., 1899–1909.
Chippewa River near Eau Claire, Wis., 1902–1909.
Flambeau River near Ladysmith, Wis., 1903–1906.
Red Cedar River at Cedar Falls, Wis., 1907–1909.
Red Cedar River at Menominee, Wis., 1907–8.
Zumbro River at Zumbro Falls, Minn., 1909.
Black River at Neillsville, Wis., 1905–1909.
Black River at Melrose, Wis., 1902–3.
Root River near Houston, Minn., 1909.
Wisconsin River near Rhinelander, Wis., 1905-1909.
Wisconsin River at Merrill, Wis., 1902–1909.
Wisconsin River near Necedah, Wis., 1902–1909.
Wisconsin River at Muscoda, Wis., 1902–3.
Maquoketa River at Manchester, Iowa, 1903.
Wapsipinicon River at Stone City, Iowa, 1903–1909.
Rock River above mouth of Pecatonica River at Rockton, Ill., 1903.
Rock River below mouth of Pecatonica River at Rockton, Ill., 1903–1909.
Rock River near Nelson, Ill., 1906.

Rock River at Sterling, Ill., 1905–6.
Catfish River at Madison, Wis., 1902–3.
Lake Mendota at Madison, Wis., 1902–3.
Iowa River at Marshalltown, Iowa, 1903.
Iowa River at Iowa City, Iowa, 1903–1906.
Cedar River near Austin, Minn., 1909.
Red Cedar River at Janesville, Iowa, 1905–6.
Cedar River at Cedar Rapids, Iowa, 1903–1909.
Des Moines River at Fort Dodge, Iowa, 1905–6.
Des Moines River at Des Moines, Iowa, 1902–3, 1905–6.
Des Moines at Keosauqua, Iowa, 1903–1906.
Raccoon River near Des Moines, Iowa, 1902–3.
Illinois River near Minooka, Ill., 1903–4.
Illinois River near Seneca, Ill., 1903.
Illinois River at Ottawa, Ill., 1903–4.
Illinois River near La Salle, Ill., 1903.
Illinois River near Peoria, Ill., 1903–1906.
Kankakee River at Davis, Ind., 1905–6.
Kankakee River at Momence, Ill., 1905–6.
Yellow River at Knox, Ind., 1905–6.
Desplaines River above mouth of Jackson Creek near Channahon, Ill., 1903–1906.
Desplaines River above Kankakee River, near Channahon, Ill., 1902–3.
Fox River at Sheridan, Ill., 1905–6.
Fox River at Ottawa, Ill., 1903.
Sangamon River at Monticello, Ill., 1908.
Sangamon River at Decatur, Ill., 1905.
Sangamon River at Riverton, Ill., 1908–9.
Sangamon River near Springfield, Ill., 1903.
Sangamon River near Oakford, Ill., 1909.
Sangamon River near Chandlerville, Ill., 1908.
Sangamon River, South Fork, near Taylorville, Ill., 1908–9.
Salt Creek near Kenney, Ill., 1908–9.
Cahokia Creek at Poag, Ill., 1909.
Kaskaskia River near Arcola, Ill., 1908–9.
Kaskaskia River at Shelbyville, Ill., 1908–9.
Kaskaskia River at Vandalia, Ill., 1908–9.
Kaskaskia River at Carlysle, Ill., 1908–9.
Kaskaskia River at New Athens, Ill., 1909.
Shoal Creek near Breese, Ill., 1909.
Silver Creek near Lebanon, Ill., 1908–9.
Big Muddy River near Cambon, Ill., 1908–9.
Beaucoup Creek near Pinckneyville, Ill., 1908–9.

HUDSON BAY DRAINAGE BASIN.

GENERAL FEATURES.

All the waters that reach Hudson Bay from the United States pass through Lake Winnipeg and thence into the bay through Nelson River. The principal tributaries of Lake Winnipeg, and thus, indirectly, of Nelson River, are Saskatchewan, Red, and Winnipeg rivers. The Saskatchewan drains the major portions of the Provinces of Alberta and Saskatchewan, in the Dominion of Canada, and, through

St. Mary River, a small area in northwestern Montana, in the United States. Red River drains a large basin in the United States, covering portions of Minnesota and North and South Dakota. Winnipeg River is the outlet of Lake of the Woods, which receives Rainy River, an international stream rising in Rainy Lake.

ST. MARY RIVER DRAINAGE BASIN.

DESCRIPTION.

St. Mary River heads in northern Montana, near the Canadian boundary line, on the eastern slope of the main range of the Rocky Mountains, in a region of perpetual snow and in the midst of innumerable glaciers. It starts from the great Blackfoot Glacier, probably the largest in the Rocky Mountains within the United States, and receives affluents from at least a dozen lesser glaciers. These small streams unite within a short distance from their source and flow into a lake which is hemmed in by high mountains and is known as Upper St. Mary Lake. Below this lake and separated from it by a narrow strip of land is Lower St. Mary Lake. The aggregate length of these two lakes is about 22 miles. The river flows out of the lower lake, the elevation of which is 4,460 feet above sea level, and within 2 miles is joined by Swiftcurrent Creek, which is fed by waters of Grinnell Glacier and four small glaciers. From the confluence of these streams to the international boundary, a distance of 12 miles, the St. Mary flows in a northerly direction, receiving Kennedy Creek a few miles before crossing the boundary. Entering the Province of Alberta it empties into Belly River, its waters eventually finding their way through the Saskatchewan into Hudson Bay.[a]

That portion of the drainage area below the region of glaciers is heavily forested, the timber consisting of spruce and fir on the higher slopes and a dense growth of willows and aspen on the lower portions.

The mean annual precipitation is about 60 inches, and occurs in greater part in the form of snow. The altitude of the drainage basin within the United States ranges from 4,000 feet to 10,000 feet.

The only diversion from the St. Mary in the United States is that which is being made by the United States Reclamation Service in connection with the Milk River project. It is proposed to reservoir Lower St. Mary Lake and divert 850 second-feet of water into the Milk River drainage basin. Both Upper and Lower St. Mary lakes can be made into storage reservoirs. Water power is not important in this basin, as the many small streams which form the river are frozen over during the winter months.

[a] Information and data on stations maintained by the Dominion of Canada in this basin are contained in a Report of Progress of Stream Measurements for 1909, published by the Department of Interior, Dominion of Canada.

ST. MARY RIVER NEAR BABB, MONT.

This station, which was established April 9, 1902, for the purpose of procuring run-off data for use in connection with irrigation projects on the Blackfoot Indian Reservation and in the Milk River Valley, is located below Lower St. Mary Lake, above the mouth of Swiftcurrent Creek, the nearest tributary, and about 2 miles south of Babb. The run-off at this point is that from Upper and Lower St. Mary lakes. The drainage area is 177 square miles. No water is diverted above the station, but the United States Reclamation Service has appropriated 850 second-feet of water which will be diverted near the station. A reservoir will also be formed at Lower St. Mary Lake.

Discharge measurements are made from a cable or by wading. The cable was originally located about 4,500 feet below Lower St. Mary Lake and about 2,500 feet above the mouth of Swiftcurrent Creek. It was moved about 300 feet upstream to a better location on September 13, 1909. The chain gage, which is located about 1,000 feet above the original cable, has been maintained at a constant datum since the station was established.

Discharge measurements of St. Mary River near Babb, Mont., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 27	W A. Lamb	96	219	2.98	938
June 13	do	110	407	4.42	2,440
July 6	do	98	352	4.40	2,210
July 7	do	98	359	4.39	2,250
September 14[a]	do	97	333	1.80	361
Do.[a]	J E. Stewart	97	330	1.80	356
September 18[a]	W A. Lamb	97	313	1.76	322
October 13[b]	do	106	88	1.50	235

[a] Made from new cable station.

[b] Made by wading above gage.

Daily gage height, in feet, of St. Mary River near Babb, Mont., for 1909.

[Herman S. Bruce, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					1.25	4.15	3.95	3.25	2.25		1.25	2.25
2					1.25	4.6	4.05		2.35	1.55	1.25	
3		1.3	1.3		1.25	5.15	4.25		2.4		1.5	1.85
4					1.25	5.5	4.35		2.35	1.55	1.75	
5	1.15				1.25	5.65	4.25		2.3	1.55	1.85	
6					1.25	5.05	4.35		2.25		2.2	
7					1.3	5.05	4.35		2.25	1.55	2.15	
8					1.35	4.85			2.35		2.1	1.7
9					1.55	4.85	4.1		2.35	1.55	1.85	
10		1.25	1.35		1.55	4.6	4.1		2.15		1.95	
11					1.5	4.4	3.95		1.85	1.55	2.05	
12	1.15				1.55	4.35	3.7	2.80	1.8		2.0	
13					1.6		3.6	2.75	1.8	1.5	1.8	
14					1.75	4.5	3.45	2.65	1.8		1.85	
15					1.75	4.65	3.35	2.7	1.8	1.5	1.9	1.6
16						4.65	3.35	2.65	1.75	1.45	1.8	
17		1.3	1.35		1.85	4.25	3.3	2.6	1.75	1.45	2.05	
18					2.05	4.05	3.25	2.6		1.4		
19	1.2				2.05	5.6	2.85	2.55	1.65	1.4		1.55
20					2.1	5.65	2.7	2.6		1.4		
21					2.15	5.8	2.55	2.45	1.65	1.35		1.45
22					2.55	5.45	2.25	2.5		1.4		
23					2.3	5.15	2.05	2.45	1.6	1.35	1.95	
24		1.3	1.35		2.4	5.0	1.95	2.45		1.35		
25					2.4	4.45	2.05	2.4	1.55	1.35	2.05	
26	1.35		1.3		2.75	4.3	2.55	2.4				1.35
27					2.95	4.25	2.75	2.35	1.55	1.3	2.05	
28				1.15	3.0	4.45	2.9	2.35	1.55	1.35		1.3
29				1.15	3.05	4.15	3.35	2.25		1.3	2.05	
30				1.15	3.05	4.05	3.4	2.25	1.55	1.25	2.1	1.3
31					4.15		3.3	2.35		1.25		

NOTE.—Ice conditions prevailed from January 1 to some time in April, and from November 23 to December 31. Gage heights during ice periods are to water surface.

Daily discharge, in second-feet, of St. Mary River near Babb, Mont., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		161	1,960	1,760	1,130	538	252	161
2		161	2,460	1,860	1,100	582	252	161
3		161	3,100	2,080	1,070	605	252	235
4		161	3,520	2,180	1,040	582	252	326
5		161	3,700	2,080	1,010	560	252	366
6		161	2,980	2,180	979	538	252	515
7		174	2,980	2,180	948	538	252	493
8		188	2,740	2,040	917	582	244	471
9		252	2,740	1,910	886	582	235	366
10		252	2,460	1,910	855	493	244	407
11		235	2,240	1,760	825	366	252	450
12		252	2,180	1,510	825	366	244	428
13		270	2,260	1,420	795	366	235	346
14		326	2,350	1,280	738	366	235	366
15		326	2,520	1,200	765	366	235	386
16		346	2,520	1,200	738	326	219	346
17		366	2,080	1,160	710	326	219	450
18		450	1,860	1,130	710	307	203	443
19		450	3,640	855	682	288	203	436
20		471	3,700	765	710	288	203	429
21		493	3,900	682	630	288	188	421
22		682	3,460	538	655	279	203	414
23		560	3,100	450	630	270	188	407
24		605	2,920	407	630	261	188	428
25		605	2,300	450	605	252	188	450
26		795	2,130	682	605	252	181	450
27		918	2,080	795	582	252	174	450
28	136	950	2,300	885	582	252	188	450
29	136	985	1,960	1,200	538	252	174	450
30	136	985	1,860	1,240	538	252	161	471
31		1,960		1,160	582		161	

NOTE.—These discharges are based on a rating curve that is well defined between 174 and 2,350 second-feet. The open-channel rating was used for November 23–30, as it is believed that the ice conditions did not seriously affect the flow.

Discharges interpolated for days between April 28 and November 30, when the gage was not read.

Monthly discharge of St. Mary River near Babb, Mont., for 1909.

[Drainage area, 177 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
May	1,960	161	479	2.71	3.12	29,500	A.
June	3,900	1,860	2,670	15.1	16.85	159,000	B.
July	2,180	407	1,320	7.46	8.60	81,200	A.
August	1,130	538	775	4.38	5.05	47,700	B.
September	605	252	386	2.18	2.43	23,000	A.
October	252	161	217	1.23	1.42	13,300	A.
November	515	161	399	2.25	2.51	23,700	A.
The period						377,000	

ST. MARY RIVER NEAR CARDSTON, ALBERTA.

This station was established September 4, 1902, near Shaw's ranch, one-fourth mile north of the boundary line between the United States and Canada and 17 miles south of Cardston, Alberta, for the purpose of obtaining data for use in connection with irrigation projects in the Milk River valley.

The station is 6 miles below the mouth of Kennedy Creek, the last tributary entering from the United States. With the exception of the area drained by Boundary Creek, a small stream entering a short distance above the station, the drainage basin lies within the United States. The total area drained is 452 square miles.

The only diversion above the station is that which is being made at Babb by the United States Reclamation Service in connection with the Milk River project. About 850 second-feet of water will be diverted into the Milk River drainage basin.

The chain gage was originally located about 1,200 feet above the cable. This gage was destroyed during the highwater of June, 1908, and a new chain gage was installed July 17, 1908, about one-fourth mile below the cable. There is no determined relation between the gages. An auxiliary staff gage with the same datum as the chain gage, was established October 14, 1909, and was used during low water. Results at this station are affected by shifting channel and heavy ice during the winter months.

Discharge measurements are made from the cable or by wading.

Monthly estimates for June to December, 1908, computed by means of data procured since the high water of June, 1908, are included in this report.

Discharge measurements of St. Mary River near Cardston, Alberta, in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 14 [a]	W. A. Lamb	186	681	6.15	4,350
July 8 [a]	do	151	505	5.20	3,020
September 16 [b]	J. E. Stewart	101	241	1.47	527
October 14 [b]	W. A. Lamb	97	207	1.16	387

[a] Made from highway bridge at Kimball, 7 miles by river below the gaging station.
[b] Made from cable.

NOTE.—A canal that heads just above the bridge at Kimball was diverting 486 and 420 second-feet on June 14 and July 8 respectively. These amounts have been included in the discharge for measurements made on these dates.

Daily gage height, in feet, of St. Mary River near Cardston, Alberta, for 1909.

[Vernon Shaw, observer.]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			6.2	5.2				0.75	2.15
2		3.05	6.55	5.2				.85	2.0
3		4.2	6.8	5.3				1.05	
4		3.6	6.85	5.3				1.5	1.9
5		3.1	6.7	5.35				2.05	
6		2.8		5.35				2.0	
7		2.6	6.7	5.3				1.9	1.75
8		2.75	6.7	5.2				1.9	
9		2.75	6.35	4.9				1.85	1.4
10		3.1	6.1	4.75				1.85	
11		3.2	6.0	4.5				1.8	1.3
12		3.0	5.85	4.5				1.7	1.55
13		3.0	6.0	4.4					
14		3.3	6.0	4.4			1.2	1.6	
15		3.35	6.3	4.2			1.15	1.4	1.55
16		3.25	6.4	4.1			1.15	1.45	
17		3.1	6.5	4.0			1.1	1.45	
18		3.05	6.55	4.0		1.5	1.1	1.6	
19		3.4	6.65	3.9		1.4	1.1	1.55	
20		4.0	6.75	3.7		1.4	1.1	1.6	
21		4.15	6.85	3.6		1.4	1.1		
22		4.35	6.5	3.5		1.3	1.1		
23	2.6	4.65	6.3	3.35		1.3	1.0	1.8	
24	3.2	4.85	6.1	3.35		1.3	1.0		
25	3.75	5.1	5.9	3.3		1.3	.95	2.15	
26	3.8	5.4		3.5			.9		
27	3.85	5.65	5.6	4.5			.85	2.0	
28		5.85	5.25	6.6			.85	2.15	
29		5.9	5.15	6.6			.85	2.2	
30		5.9	5.1	5.0			.85	2.15	
31		5.95					.8		

NOTE.—Ice conditions prevailed from January 1 to about April 22, and from November 21 to December 31.

Daily discharge, in second-feet, of St. Mary River near Cardston, Alberta, for 1908–9.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.									
1	255	1,340	5,360	2,580	1,180	475	440	458	510
2	255	1,390	4,960	2,580	1,100	458	425	458	545
3	255	1,390	4,450	2,750	1,100	458	425	475	545
4	345	1,450	6,440	2,800	1,040	458	425	475	564
5	255	1,510	18,000	3,000	1,006	458	418	475	564
6	255	1,720	17,000	3,050	975	449	410	458	573
7	255	1,930	15,000	3,000	948	440	410	458	582
8	240	2,440	13,000	2,800	920	440	410	458	564
9	225	2,630	11,000	2,800	895	440	495	458	....
10	240	2,730	9,000	2,850	882	440	380	458	....
11	272	2,730	7,400	2,850	870	440	380	475	....
12	325	3,040	7,000	2,850	848	440	365	475	....
13	388	3,150	6,400	2,800	825	458	380	475	....
14	455	3,150	5,900	3,000	780	475	528	492	....
15	505	3,260	5,500	2,850	760	475	601	484	....
16	532	3,260	5,400	3,000	700	492	640	475	....
17	620	3,040	5,100	2,800	640	510	640	440	....
18	830	2,740	4,800	2,800	640	510	660	440	....
19	1,060	2,440	4,400	2,750	640	492	620	475	....
20	1,280	2,440	4,200	2,550	620	475	545	510	....
21	1,510	2,260	3,900	2,450	740	475	528	528	....
22	1,580	2,180	3,600	2,350	660	475	510	528	....
23	1,710	2,090	3,100	2,350	740	475	510	510	....
24	1,780	2,090	3,100	2,350	700	475	528	510	....
25	1,860	2,090	2,900	2,300	720	475	492	492	....
26	1,780	2,830	3,100	2,100	700	440	492	475	....
27	1,710	3,720	3,100	1,560	545	458	475	458	....
28	1,640	3,260	3,000	1,430	545	425	475	410	....
29	1,510	2,630	2,900	1,340	545	425	475	425	....
30	1,390	2,630	2,700	1,260	536	440	475	458	....
31	....	3,490	....	1,180	528	....	466	....	....
1909.									
1	....	895	4,410	3,010	....	....	....	265	....
2	....	895	4,940	3,010	....	....	....	288	....
3	....	1,810	5,310	3,140	....	....	....	348	....
4	....	1,260	5,380	3,140	....	....	....	545	....
5	....	920	5,160	3,210	....	....	....	828	....
6	....	780	5,160	3,210	....	....	....	800	....
7	....	700	5,160	3,140	....	....	....	745	....
8	....	760	5,160	3,010	....	....	....	745	....
9	....	760	4,640	2,620	....	....	....	720	....
10	....	920	4,260	2,440	....	....	....	720	....
11	....	975	4,120	2,140	....	....	....	695	....
12	....	870	3,910	2,140	....	....	....	645	....
13	....	870	4,120	2,030	....	....	....	620	....
14	....	1,040	4,120	2,030	....	....	405	595	....
15	....	1,070	4,560	1,810	....	....	385	495	....
16	....	1,000	4,710	1,710	....	....	385	520	....
17	....	920	4,860	1,610	....	....	365	520	....
18	700	895	4,940	1,610	....	545	365	595	....
19	975	1,100	5,080	1,520	....	495	365	570	....
20	1,380	1,610	5,240	1,340	....	495	365	595	....
21	1,430	1,760	5,380	1,260	....	495	365	....	....
22	1,480	1,980	4,860	1,180	....	450	365	....	....
23	....	2,320	4,560	1,070	....	450	330	....	....
24	....	2,560	4,260	1,070	....	450	330	....	....
25	....	2,880	3,980	1,040	....	450	315	....	....
26	....	3,280	3,770	1,180	....	....	300	....	....
27	....	3,630	3,560	2,140	....	....	288	....	....
28	....	3,910	3,080	5,010	....	....	288	....	....
29	....	3,980	2,940	5,010	....	....	288	....	....
30	....	3,980	2,880	2,750	....	....	288	....	....
31	....	4,050	....	2,750	....	....	275	....	....

NOTE.—These discharges, except those for June 5 to July 26, 1908, are based on rating curves applicable as follows: April 1 to June 4, 1908, well defined; July 27, 1908, to July 31, 1909, fairly well defined between 325 and 870 second-feet and between 2,140 and 4,860 second-feet; poorly defined between 870 and 2,140 second-feet; September 18 to November 20, 1909, not well defined.

Discharges June 5 to July 26, 1908, were obtained by hydrograph comparison with St. Mary River near Babb, Mont.

Monthly discharge of St. Mary River near Cardston, Alberta, for 1908–9.

[Drainage area, 452 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
1908.							
January *a*			50	0.111	0.13	3,070	D.
February *a*			100	.221	.24	5,750	D.
March *a*			225	.498	.57	13,800	D.
April	1,860	225	844	1.87	2.09	50,200	A.
May	3,720	1,340	2,490	5.51	6.35	153,000	A.
June	18,000	2,700	6,390	14.1	15.73	380,000	B.
July	3,050	1,180	2,490	5.51	6.35	153,000	B.
August	1,180	528	785	1.74	2.01	48,300	A.
September	510	425	462	1.02	1.14	27,500	A.
October	660	365	485	1.07	1.23	29.800	A.
November	528	410	472	1.04	1.16	28,100	A.
December *a*			125	.277	.32	7,690	D.
The year			1,240	2.75	37.32	900,000	
1909.							
April 23–27	1,480	700	1,190	2.63	0.49	11,800	A.
May	4,050	700	1,750	3.87	4.46	108,000	A.
June	5,380	2,880	4,480	9.91	11.06	267,000	A.
July	5,010	1,040	2,330	5.15	5.94	143,000	A.
September 18–25	545	450	479	1.06	.32	7,600	B.
October 14–31	405	275	337	.746	.50	12,000	B.
November 1–20	828	265	593	1.31	.97	23,500	B.

a Ice conditions and discharge estimated.

SWIFTCURRENT CREEK NEAR BABB, MONT.

This station, which is located about 1 mile from the mouth of the stream, at a point where it leaves the foothills, and about 2 miles south of Babb, was established April 8, 1902, to obtain data for use in connection with irrigation projects on the Blackfoot Indian Reservation and in the Milk River valley.

No water is diverted or stored above this station. The construction of storage reservoirs is, however, feasible, and because of the great fall of the stream considerable power could be developed. Although the current is swift the flow during the winter months is to some extent affected by ice.

Discharge measurements are made from a cable or by wading. The cable has been located at different positions since the station was first established. Low-water measurements are made by wading near the gage.

The first gage was destroyed by high water in June, 1902, and the station was reestablished July 30, 1902, at a point 1,800 feet above the first gage. It was again moved September 27, 1902, to a point about 900 feet farther upstream and set at a different datum. At this location it remained until it was destroyed by the flood of June 5, 1908. July 26, 1908, the gage was reestablished, with a new datum, about 100 feet above its former location and 400 feet above the present cable.

Discharge measurements of Swiftcurrent Creek near Babb, Mont., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 27	W. A. Lamb	120	240	4.83	1,890
June 13	....do	115	207	4.23	1,220
July 7	....do	85	188	3.95	958
September 14[a]	J. E. Stewart	48	81	2.72	143
September 17[a]	....do	51	75	2.67	129
October 13[a]	W. A. Lamb	58	71	2.76	147

[a] Made by wading.

Daily gage height, in feet, of Swiftcurrent Creek near Babb, Mont., for 1909.

[Herman S. Bruce, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1						4.95		4.75		2.55	2.45	3.3
2		2.2			3.45	5.15		4.55			2.4	
3			2.3	2.55	3.45	5.45		4.05			2.8	2.95
4				2.6	3.45	5.3		4.0		2.5	3.1	
5	2.2				3.55	4.85				2.5	3.3	
6					3.55	4.7					3.2	
7				2.55	3.45	4.75	3.95			2.45		
8					3.35	4.95					2.9	2.9
9					3.35	5.15	3.7			2.55	2.9	
10		2.15	2.3	2.55	3.25	4.85	3.65				2.7	
11					3.15	4.75	3.65			2.7	2.65	
12	2.15			2.55	2.95	4.65	3.6				2.6	
13					2.85	4.65	3.45			2.75	2.6	
14				2.55	3.0	4.6	3.45		2.7			
15					2.95	4.65	3.3			2.65	2.4	1.65
16				2.55		4.65	3.3			2.65	2.4	
17		2.2	2.35		3.35	4.65	3.3		2.65	2.6		
18					3.35	4.75	3.2			2.55		
19	2.25				3.6	4.9	3.05		2.75	2.55		
20					3.55	5.55	3.05			2.55		
21					3.75	6.0	2.8		2.7	2.5		
22					3.9	5.85	2.55			2.55		
23				2.6	3.9	5.8	2.55		2.7	2.5	2.4	
24			2.4		3.95	5.75	2.95			2.5		
25		2.2			4.1	5.55	2.95		2.65	2.5	2.6	
26	2.3		2.35	2.65	4.25	5.25	3.65			2.5		
27					4.85	4.95	3.75		2.6	2.5	2.55	
28				2.85			3.85		2.55	2.45		
29				3.05	4.85		4.7			2.45	2.4	
30				3.3	4.75		4.85		2.6	2 5	3.1	
31			2.4		4.75		5.0					

NOTE.—Ice conditions prevailed during January, February, March, and after November 23. Readings are to water surface during periods of ice conditions.

Daily discharge, in second-feet, of Swiftcurrent Creek near Babb, Mont., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	a 85	464	2,010	1,330	1,780	250	95	78
2	a 90	518	2,250	1,400	1,560	260	92	70
3	95	518	2,640	1,500	1,040	270	88	160
4	105	518	2,440	1,360	995	250	85	290
5	101	595	1,890	1,220	700	240	85	410
6	98	595	1,720	1,080	500	240	82	345
7	95	518	1,780	945	460	250	78	270
8	95	445	2,010	832	430	260	86	195
9	95	445	2,250	720	415	250	95	195
10	95	378	1,890	678	400	230	112	130
11	95	318	1,780	678	375	200	130	118
12	95	218	1,660	635	350	180	138	105
13	95	178	1,660	518	350	155	145	105
14	95	240	1,610	518	350	130	132	88
15	95	218	1,660	410	350	126	118	70
16	95	332	1,660	410	340	122	118	70
17	96	445	1,660	410	340	118	105	71
18	97	445	1,780	345	330	132	95	73
19	99	635	1,950	265	330	145	95	74
20	100	595	2,760	265	320	138	95	75
21	110	765	3,360	160	320	130	85	76
22	103	900	3,160	95	310	130	95	77
23	105	900	3,100	95	300	130	85	78
24	109	948	3,030	218	290	124	85	....
25	113	1,090	2,760	218	280	118	85	....
26	118	1,240	2,380	678	270	112	85	....
27	148	1,890	2,010	765	260	105	85	....
28	178	1,890	1,780	855	250	95	78	....
29	265	1,890	1,620	1,720	250	100	78	....
30	410	1,780	1,340	1,890	250	105	85	....
31	....	1,780	....	2,070	250	....	82	....

a Estimated.

NOTE.—These discharges are based on a rating curve that is well defined between 105 and 2,070 second-feet. Discharges June 27 to July 7 and August 5 to September 13 estimated by hydrograph comparison with St. Marys River near Babb, Mont. Discharges interpolated for other days having no gage record.

Monthly discharge of Swiftcurrent Creek near Babb, Mont., for 1909.

[Drainage area, 101 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
April	410	85	119	1.18	1.32	7,080	A.
May	1,890	178	764	7.56	8.72	47,000	A.
June	3,360	1,340	2,120	21.0	23.43	126,000	A.
July	2,070	95	783	7.75	8.94	48,100	B.
August	1,780	250	476	4.71	5.43	29,300	C.
September	270	95	170	1.68	1.87	10,100	C.
October	145	78	96.7	.957	1.10	5,950	C.
November 1-23	410	70	140	1.39	1.19	6,390	C.
The period	....	....	....	....	....	280,000	

RED RIVER DRAINAGE BASIN.

DESCRIPTION.

Red River rises in Minnesota, its most remote source being a small lake near the southwest corner of Clearwater County, about 13 miles west of Lake Itasca, at an elevation of about 1,550 feet above sea level. From this lake it flows southward 60 miles (measured in a direct line) through a succession of small lakes to Ottertail Lake (elevation about 1,320 feet), thence westward 42 miles to Breckenridge, Minn., and Wahpeton, N. Dak. (elevation 943 feet); from this point it runs northward 285 miles (measured in a direct line) to the southern end of Lake Winnipeg, passing the Canadian boundary at Pembina at a distance of 190 miles and the city of Winnipeg at about 250 miles. On account of the meandering of the river the length of its channel is nearly double the length of the direct line.

Lake Winnipeg is about 250 miles long, and from its north end Nelson River flows northeastward 400 miles to Hudson Bay.

The upper part of Red River is called Ottertail River, that name being variously applied down as far as Ottertail Lake, Fergus Falls, or exceptionally to Breckinridge and Wahpeton as a lower limit; the portion flowing northward from Wahpeton to Lake Winnipeg is universally called Red River.

The upper course of Red River lies in that region of many lakes known as the park region of Minnesota. In Ottertail County there are more than 1,000 lakes, the largest being Ottertail Lake itself, which is 8 miles long and 2½ miles in average width. Many of these lakes have no visible outlet except during high water. In this portion of the drainage basin the country is a rolling prairie.

A survey of Ottertail River from the dam at Phelps to a point several miles below the Dayton Hollow dam was made to determine the amount of power available on the river. From the data collected on this survey, sheets have been prepared showing a profile of the water surface, a plan of the river, and the topography adjacent to the river. The results of this survey have been published on separate sheets and may be had upon application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn. From this survey the following table of elevations and distances has been compiled:

Elevations and distances along Ottertail River.

	Distance below Phelps dam.	Elevation.
	Miles.	*Feet.*
Highway bridge, sec. 26, T. 132 N., R. 44 W	51	1,035
Ottertail Power Co., tail water	45	1,073
Ottertail Power Co., head water	45	1,108
Pelican River	39	1,118
Township line, 132-133 N	38	1,125
Red River Milling Co., tail water	35	1,157
Red River Milling Co., head water	35	1,167
Fergus Flour Mill, tail water	35	1,168
Fergus Flour Mill, head water	35	1,182
City Water Co., tail water	34	1,185
City Water Co., head water	34	1,198
Electric Power Plant, tail water	32	1,203
Electric Power Plant, head water	32	1,215
Northern Pacific Railway	28	1,232
United States Geological Survey gaging station	21	1,251
Range line, 42-43 W	15	1,268
Outlet chain of ponds	13	1,287
Oliver dam, tail water	9	1,298
Oliver dam, head water	9	1,302
West Lost Lake outlet	6	1,303
Phelps dam, tail water		1,309
Phelps dam, head water		1,318

Although the main branch of Red River is Ottertail River, the term Red River Valley is applied to the valley of the Bois des Sioux rather than to that of the Ottertail. This valley, which extends from Lake Traverse northward to Lake Winnipeg, is a plain from 30 to 50 miles wide and 315 miles long. As the elevation of Lake Traverse is 970 feet and that of Lake Winnipeg is 710 feet, the fall of the valley in the entire distance is 260 feet, or considerably less than 1 foot per mile.

Lake Traverse is 15 miles long, from 1 mile to 1½ miles wide and is shallow, being for the most part less than 10 feet deep. It is bordered on both sides by bluffs that rise 100 to 150 feet above the lake level and that continue on each side of Brown's valley to Bigstone Lake. During the glacial epoch Red River Valley was occupied by an immense lake, called Lake Agassiz, which had outlet through Brown's valley into Bigstone Lake and through the present Minnesota Valley. At the present time there is water connection between the two lakes during periods of very high water, as the divide is a marsh that is only 3 feet above Lake Traverse and 11 feet above Bigstone Lake.

In addition to its gentle northward slope the valley slopes gently from each side toward the center. In this axial depression Red River has cut a channel 20 to 60 feet deep. Between the drainage lines of the tributaries, which cross the valley at right angles to the river, there are areas 5 to 15 miles wide that have no watercourses. The whole basin of Red River is deeply covered with glacial drift, or, in the bottom of Lake Agassiz, with an even layer of silt. No rock in place is found.

The water of the wells, springs, and streams in the Red River Valley is hard, owing to the presence of calcium and magnesium carbonates. In the lower part of the valley, especially in Kittson County, salt water is found, not only in the gravel beds of the glacial drift, but also in the underlying rock; much of the surface water is also permeated by salt.

At the margins of the Red River drainage basin elevations range between 1,200 and 1,600 feet, but the boundaries are not precisely defined. Along much of the eastern side the country is so level that the many swamps and marshes drain with equal facility to either side; along the western side there are wide belts whose drainage systems were destroyed by the accumulation of drift and moraines left by the ice of the glacial epoch, and in these belts the surface water collects in innumerable hollows, kettle holes, and sloughs, and stands till it evaporates. If the rainfall were greater these many sink holes and lakelets would overflow, and natural erosion would perfect the drainage system and make it again apparent to the eye.

So far as can be determined from the best existing maps the drainage area tributary to Red River above the point where it crosses the Canadian boundary at Pembina comprises 34,330 square miles, of which 16,100 are in Minnesota, 930 in South Dakota, and 17,300 in North Dakota.

East of a north-south line drawn about 50 miles east of the main Red River the whole country is heavily timbered; west of such a line it is open prairie, treeless except along the streams.

The mean annual rainfall of the Red River drainage area increases uniformly from west to east, being 15 to 18 inches at the western boundary, 19 to 24 inches at stations in the middle of the valley, and 24 to 26 inches at the eastern boundary. Owing to the larger rainfall on the eastern side of the area the run-off per square mile from the tributaries on this side is from two to ten times as great as that from the tributaries on the west side. About 75 per cent of the total rainfall occurs in the six months from April 1 to September 30.

Drainage work is being carried on rapidly in this basin, especially in that portion lying in Minnesota. As a result, the following areas have been benefited by ditching:

Areas improved by drainage.

	Acres.		Acres.
Kittson County	220,000	Traverse County	89,000
Roseau County	160,000	Grant County	54,000
Norman County	164,000	Polk County	972,000
Clay County	262,000	Clearwater County	23,000
Wilkin County	196,000		
Ottertail County	27,000	Total	2,170,000
Becker County	3,000		

As a consequence of this extensive improvement of natural drainage, which is being actively continued, the regimen of the various streams in the basin is being changed materially.

The principal tributaries of Red River are as follows: On the east side, Pelican, Buffalo, Wild Rice, Red Lake, and Snake rivers, and Two Rivers; on the west side, Bois des Sioux, which forms the Minnesota-North Dakota boundary from Wahpeton to the southeast corner of North Dakota, but is otherwise unimportant, being merely a prairie stream having very small flow except during a few weeks in the spring. Other western tributaries are Wild Rice, Sheyenne, Goose, Park, and Pembina rivers. These tributaries drain a district bounded on the south by the Minnesota River basin, on the east by the basins of the upper Mississippi River and of Rainy River (which flows into Lake Winnipeg), on the west by the basin of James River (which flows into the Missouri), by the Devils Lake Basin (an inland basin), and by the basin of Mouse River, which enters Red River at Winnipeg.

Red Lake River, the principal tributary of Red River, drains a large area in Beltrami and Polk Counties. It is the outlet of Red Lake, which is the largest lake wholly within Minnesota, its area being 441 square miles. From Red Lake the river flows in a general westerly, though very tortuous, course until it reaches Red Lake Falls, where it receives the water from Thief River, and turning sharply to the south, pursues a southerly and then a westerly course to Red River, joining that stream at Grand Forks. Above the junction it carries a larger volume than Red River. For 10 to 15 miles below Red Lake the river is bordered by extensive swamps. The many swamps and lakes within its basin act as natural reservoirs, and the range in stage of Red Lake River is therefore small.

In order to determine the availability of Red Lake River for power development a survey was made during 1909 from the outlet of Red Lake to Crookston. From the data collected on this survey, sheets have been prepared showing a profile of the water surface, a plan of the river, and the contours along the river bank. The results of this survey have been published on separate sheets and may be had on application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn.

From this survey the following table of elevations and distances has been compiled:

Elevations and distances on Red Lake River above Crookston, Minn.

	Distance above Crookston.	Elevation.
	Miles.	*Feet.*
Crookston, tail-water	0	842
Crookston, headwater	0	852
Section line, 32-33	6	853
Highway bridge	11	861
Highway bridge	14	865
Section line, 7-8	18	873
Polk-Red Lake County line	23	883
Huot bridge	26	887
Section line, 26-27	28	893
Section line, 25-26	30	904
Range line, 44-45 W	32	917
Northern Pacific Ry	37	937
Lower dam, tail-water	38	943
Lower dam, headwater	38	955
Red Lake Falls, highway bridge	39	955
Upper dam, tail-water	42	963
Upper dam, headwater	42	973
Range line, 43-44 W	45	981
	47	1,007
	49	1,027
Section line, 17-20	56	1,062
St. Hilaire, tail-water	61	1,075
St. Hilaire, headwater	61	1,080
Section line, 17-20	67	1,085
Thief River Falls, tail-water	72	1,102
Thief River Falls, headwater	72	1,116
Range line, 42-43 W	77	1,118
Section line, 10-15	85	1,130
Range line, 41-42 W	90	1,136
Section line, 22-23	99	1,145
Township line, 152-153 N	110	1,154
Western boundary Red Lake Indian Reservation	124	1,165
Red Lake	143	1,175

Red Lake River is used extensively for logging as far down as Crookston, although there are no dams to control the flow for that purpose. During the spring and summer months, when the logs are being driven down the river, they may jam at different points and cause temporary backwater above or hold back the natural flow below the jam.

The basin of Red River lies so far north that the streams are ice-bound from the middle of November until late in March or early in April, and the winter flow is small but uniform, for thaws sufficient to cause winter floods never occur. Destructive floods sometimes occur in the spring, however, if the snow accumulation is large and if the ground is frozen so deeply that little of the water percolates downward.

The headwaters of the tributaries on the eastern side nearly all of which pass through numerous lakes, afford many opportunities for inexpensive storage; on the west side a few localities for limited storage are also found on Pembina and Sheyenne rivers; on Red River itself, below Breckenridge, there are no feasible storage sites.

The lake-regulated tributaries on the eastern side also present opportunities for power development, and power plants are in operation at a number of places, especially on Ottertail River within a few miles of Fergus Falls, where there are five plants; on Red River at Crookston, Red Lake Falls, and Thief River Falls; on Wild Rice River at Heiberg and Perley; on Pelican River at Lakeview, Kingsbury Lock, Pelican Rapids, and Elizabeth; and on Sand Hill River at Fertile. There are numbers of undeveloped power sites on these rivers that could be profitably utilized.

Red River is navigable from Grand Forks down to Winnipeg. Theoretically it is navigable from Grand Forks up to Breckenridge except during low water, but in recent years there has been no traffic except in the lower 25 miles of this portion, and many fixed bridges have been cheaply built, practically closing it to navigation. Red Lake River is navigable in its lower course and also in the upper 40 miles, there being regular traffic from Thief River Falls to Red Lake.

The records of the gaging stations in this area provide data of value for general statistical and comparative use in settling questions concerning the seasonal or total flow of the whole river or any of its tributaries. On the main river such questions will relate chiefly to navigation and the prevention of flood damage; on the tributaries they will relate also to water power and opportunities for drainage development.

OTTERTAIL RIVER NEAR FERGUS FALLS, MINN.

This station which was established May 9, 1904, is located at Threemile Bridge, about 3¼ miles northeast of Fergus Falls, Minn.; because of the loop in the river, however, it is 8 miles higher up the valley than Fergus Falls.

The records furnish information of especial value in connection with the future development of water power, for which this stream is particularly available.

The nearest tributary is the outlet of Wall Lake, which enters Ottertail River several miles below the station. Twenty miles above the station is Ottertail Lake, about 22 square miles in area, through which the river flows and by which its flow is so well regulated that the recorded range of stage has not exceeded 1.45 feet. On the upper part of the river there are a number of logging dams used to drive logs to the sawmill at Frazee, but there are none between the lowest logging dam at Frazee and the dam at Maine, several miles below Ottertail Lake, in about sec. 35, T. 134, R. 41. During the low-water season the closing of the turbine gates at Maine may affect the flow immediately below the dam, but the small lakes through which the river flows before reaching the gaging station serve to equalize the flow at the latter point. Below the station there are a number of power plants, but owing to the fall of the river the operation of the plants produces no effect at the gage. The chain gage is attached to the bridge from which discharge measurements are made. Two vertical rod gages, located at the left bank near the bridge, have occasionally been used, the readings being reduced to the datum of the chain gage.

There have been no changes in either gage datum or discharge curve since the station was established and the results are excllent for the entire open season. From December to March the river is frozen over and occasional discharge measurements are made through the ice to determine the winter flow.

The United States Engineer Office maintained a gaging station on Ottertail River at the outlet of Ottertail Lake from May 1, 1899, to May 14, 1904. As there is no important tributary between, these records are almost directly comparable with those of the Geological Survey given herewith, the difference in drainage area being about 12 per cent.

Discharge measurements of Ottertail River near Fergus Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 12	E. F. Chandler	91	146	3.10	353
August 4	do	90.5	136	2.99	306
September 3	do	92	178	3.45	543
December 13[a]	do	92	195	4.26	440

[a] Ice conditions.

Daily gage height, in feet, of Ottertail River near Fergus Falls, Minn., for 1909.

[H. G. Evensen, jr., observer.]

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.45	3.20	3.45	3.20	3.00	3.40	3.50	3.35	3.15
2		3.45	3.20	3.45	3.20	3.00	3.40	3.50	3.30	3.15
3		3.42	3.20	3.50	3.20	3.00	3.40	3.50	3.30	3.15
4		3.40	3.25	3.50	3.15	2.95	3.40	3.50	3.30	3.15
5		3.40	3.25	3.50	3.15	2.95	3.40	3.50	3.30	
6		3.40	3.25	3.45	3.15	2.95	3.45	3.50	3.30	
7		3.35	3.30	3.45	3.10	3.05	3.45	3.50	3.30	
8		3.35	3.30	3.45	3.10	3.05	3.45	3.50	3.30	
9		3.30	3.30	3.40	3.10	3.05	3.50	3.50	3.30	
10		3.25	3.30	3.40	3.10	3.05	3.50	3.50	3.30	
11		3.25	3.30	3.40	3.10	3.05	3.50	3.50	3.25	
12		3.20	3.30	3.40	3.10	3.00	3.50	3.45	3.25	
13		3.20	3.30	3.40	3.10	3.00	3.50	3.45	3.25	
14		3.15	3.30	3.40	3.05	3.00	3.50	3.40	3.25	
15		3.10	3.30	3.40	3.05	3.05	3.55	3.40	3.25	
16		3.05	3.30	3.40	3.00	3.05	3.55	3.40	3.25	
17		3.00	3.30	3.40	3.00	3.10	3.55	3.40	3.25	
18		3.00	3.35	3.40	3.00	3.10	3.55	3.40	3.25	
19		3.00	3.35	3.40	3.05	3.15	3.55	3.40	3.25	
20		3.00	3.35	3.40	3.05	3.20	3.55	3.40	3.25	
21		3.00	3.35	3.35	3.05	3.20	3.55	3.35	3.25	
22		3.00	3.35	3.35	3.00	3.25	3.55	3.35	3.20	
23		3.05	3.35	3.35	3.00	3.30	3.55	3.35	3.20	
24		3.05	3.35	3.30	3.00	3.30	3.50	3.35	3.20	
25		3.05	3.40	3.30	3.00	3.30	3.50	3.35	3.20	
26		3.10	3.40	3.30	3.00	3.35	3.50	3.35	3.20	
27		3.10	3.40	3.25	3.00	3.35	3.50	3.35	3.20	
28	3.50	3.15	3.40	3.25	3.00	3.35	3.50	3.35	3.20	
29	3.50	3.15	3.40	3.25	3.00	3.35	3.50	3.35	3.15	
30	3.45	3.20	3.40	3.25	3.00	3.35	3.50	3.35	3.15	
31	3.45		3.45			3.35		3.35		

NOTE.—The river was frozen over January 1 to March 27 and December 5 to 31.

Daily discharge, in second-feet, of Ottertail River near Fergus Falls, Minn., for 1909.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	526	402	526	402	315	499	552	474	380
2	....	526	402	526	402	315	499	552	449	380
3	....	510	402	552	402	315	499	552	449	380
4	....	499	426	552	380	294	499	552	449	380
5	....	499	426	552	380	294	499	552	449	....
6	....	499	426	526	380	294	526	552	449	....
7	....	474	449	526	357	336	526	552	449	....
8	....	474	449	526	357	336	526	552	449	....
9	....	449	449	499	357	336	552	552	449	....
10	....	426	449	499	357	336	552	552	449	....
11	....	426	449	499	357	336	552	426	426	....
12	....	402	449	499	357	315	552	526	426	....
13	....	402	449	499	357	315	552	526	426	....
14	....	380	449	499	336	315	552	499	426	....
15	....	357	449	499	336	336	580	499	426	....
16	....	336	449	499	315	336	580	499	426	....
17	....	315	449	499	315	357	580	499	426	....
18	....	315	474	499	315	357	580	499	426	....
19	....	315	474	499	336	380	580	499	426	....
20	....	315	474	499	336	402	580	499	426	....
21	....	315	474	474	336	402	580	474	426	....
22	....	315	474	474	315	426	580	474	402	....
23	....	336	474	474	315	449	580	474	402	....
24	....	336	474	449	315	449	552	474	402	....
25	....	336	499	449	315	449	552	474	402	....
26	....	357	499	449	315	474	552	474	402	....
27	....	357	499	426	315	474	552	474	402	....
28	552	380	499	426	315	474	552	474	402	....
29	552	380	499	426	315	474	552	474	380	....
30	526	402	499	426	315	474	552	474	380	....
31	526	....	526	....	315	474	....	474	....	....

NOTE.—These discharges are based on a rating curve that is well defined.

Monthly discharge of Ottertail River near Fergus Falls, Minn., for 1909.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
April	526	315	399	0.305	0.34	23,700	A.
May	526	402	460	.351	.40	28,300	A.
June	552	426	492	.376	.42	29,300	A.
July	402	315	343	.262	.30	21,100	A.
August	474	294	375	.286	.33	23,100	A.
September	580	499	549	.419	.47	32,700	A.
October	552	474	511	.390	.45	31,400	A.
November	474	380	426	.325	.36	25,300	A.
December	....	....	a 390	.298	.34	24,000	D.
The period	....	....	....	....	....	....	

a Estimated.

RED RIVER NEAR FERGUS FALLS, MINN.

This station, which is located at Dewey Bridge, 3½ miles west of Fergus Falls and about 1 mile below the mouth of Pelican River, was established June 19, 1909, to obtain data for use in connection with water power development of Red River.

Except Pelican River no tributary enters within several miles of the station. The drainage area above this point is 1,800 square miles.

The nearest dam above the station is at Fergus Falls. Although the intermittent operation of the mills at this point may cause a daily fluctuation, its effect is very slight at the station, as there is no consistent difference between the recorded morning and evening gage heights. Three or four miles below the vertical staff gage at the bridge section is the Dayton Hollow dam, which is the control for the gaging section, as is shown by the drop in the gage heights when the water level above the dam is lowered for repairs to that structure. When the station was established, it was believed that this control was reasonably permanent, but the data acquired showed such unsatisfactory conditions that the station was discontinued December 31, 1909.

Discharge measurements are made from the bridge.

Owing to the short time that the station has been operated it has not been completely rated; hence no estimate of daily flow can be given.

Discharge measurements of Red River near Fergus Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
1906.					
June 26	Chandler and Clark	127	435	a 7.22	1,350
1909.					
July 12	E. F. Chandler	124	320	6.28	499
August 4	do	123	284	6.01	404
September 3	do	124	390	6.98	676
October 3	do	124	365	6.79	724

a Gage height recomputed from recorded cross-section.

NOTE.—The discharge at this station is at times affected by back water from Dayton Hollow dam, 4 miles below.

Daily gage height, in feet, of Red River near Fergus Falls, Minn., for 1909.

[M. Dewey, observer.]

Day.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.52	6.08	6.99	6.82	6.31	6.80	16		6.14	6.58	7.07	6.44	8.66	7.70
2		6.34	6.09	6.99	6.76	6.29	5.91	17		6.03	6.56	7.00	6.54	8.58	
3		6.22	6.04	7.00	6.74	6.28	5.92	18		6.01	6.52	7.06	6.43	8.26	
4		6.11	6.05	6.86	6.71	6.26		19	6.13	6.07	6.54	7.08	6.42	8.16	
5		6.12	6.02	6.91	6.71	6.29		20	6.21	6.04	6.52	7.09	6.49	8.16	
6		6.14	6.10	6.98	6.66	6.25		21	6.22	6.46	6.64	7.02	6.46	8.16	
7		6.06	6.61	7.01	6.64	6.27		22	6.18	6.80	6.68	7.08	6.39	8.19	
8		6.06	6.34	7.01	6.59	6.21		23	6.18	6.55	6.84	7.06	6.42	8.25	
9		6.08	6.27	7.03	6.66	6.22	7.90	24	6.18	6.48	7.02	7.65	6.35	8.31	7.10
10		6.10	6.34	7.02	6.86	a5.74		25	6.29	6.58	6.89	7.04	6.39	8.31	
11		6.15	6.42	7.01	6.39	a5.88		26	6.19	6.54	7.09	6.96	6.33	8.06	
12		6.31	6.58	7.01	6.60	a5.96		27	6.16	6.30	7.07	6.90	6.32	7.82	
13		6.37	6.65	7.03	6.52	a5.95		28	6.01	6.26	7.01	6.86	6.34	7.33	
14		6.24	6.65	6.91	6.54	6.91		29	6.12	6.20	6.94	6.84	6.29	7.48	
15		6.16	6.56	7.02	6.51	8.58		30	6.25	6.12	6.96	6.82	6.34	7.54	
								31		5.99	6.98		6.31		7.00

a Dayton Hollow dam being repaired.

NOTE.—The river was frozen over during December.
The maximum recorded ice thickness of 1.4 feet occurred December 31.

RED RIVER AT FARGO, N. DAK.

This station, which is located at the highway bridge connecting Front street, Fargo, N. Dak., with Moorhead, Minn., was established May 23, 1901. Discharge measurements are made a half mile farther upstream, at the footbridge at the Fargo waterworks pumping station, except at very high stage, when the Front Street Bridge or the Northern Pacific Railway bridge is used.

The drainage area above this station is about 6,020 square miles, 3,770 being in Minnesota, 500 in South Dakota, and 1,750 in North Dakota. The nearest tributary is Sheyenne River, which enters Red River 10 miles below.

The vertical staff gage is attached to the breakwater for the center pier of the Front Street Bridge and is read from the bridge or the banks by the aid of a field glass.

The gage datum has not been changed since the establishment of the station. The channel is in clay and silt, and slight changes in depth occur from time to time. The fall is so small that any accidental obstruction in the channel is likely to cause an appreciable effect for a long distance upstream and to affect the rating. Hence, unless frequent discharge measurements are made, slight errors will enter, but there have been no very great changes in the rating curves for nine years, and the records are fairly good except when affected by ice, by which the stream is smoothly closed for about four months of the year. At the spring break-up, on account of the comparatively sluggish current and the fact that the river flows northward into a colder district, a pronounced backwater effect is usually caused by ice jams and partial ice jams, and the river is raised disproportionately high for several days or several weeks. At that season, therefore, the records can only be approximate unless daily discharge measurements are made.

Discharge measurements of Red River at Fargo, N. Dak., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 15	E. F. Chandler	112	456	9.54	887
June 26	do	109	459	9.25	757

NOTE.—These measurements were made at the Fargo waterworks footbridge.

Daily gage height, in feet, of Red River at Fargo, N. Dak., for 1909.

[H. R. Grasse, observer.]

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		12.6	9.5	11.8	8.9	8.6	9.3	9.3	8.9	9.6
2		12.3	9.5	11.9	8.7	8.5	9.2	9.4	8.9	9.4
3		12.0	9.6	12.0	8.0	8.5	9.2	9.4	8.9	9.4
4		11.9	9.7	12.0	8.5	8.5	9.3	9.4	8.9	
5		12.0	9.5	11.9	9.0	8.5	9.2	9.4	8.9	
6		12.0	9.4	11.6	9.0	8.5	9.1	9.4	8.9	
7		11.8	9.7	11.3	9.2	8.6	9.2	9.4	8.9	
8		11.8	9.8	11.2	9.0	8.5	9.0	9.4	8.9	
9		11.7	9.8	11.2	8.9	8.6	9.1	9.4	8.8	
10		11.5	9.7	11.1	8.4	8.6	9.2	9.4	8.8	
11		11.4	9.7	11.0	8.3	9.0	9.3	9.4	8.8	
12		11.3	9.6	10.8	8.5	9.6	9.3	9.4	8.8	
13		11.0	9.7	10.8	8.5	9.2	9.3	9.5	8.8	
14	8.0	11.0	9.7	10.7	8.5	8.8	9.3	9.5	8.8	
15	8.0	[a] 11.1	9.7	10.1	8.6	8.8	9.3	9.4	8.4	
16	8.0	[b] 11.4	9.6	10.0	8.5	9.2	9.3	9.3		
17	8.0	11.0	9.6	10.0	8.6	9.5	9.3	9.2		
18	8.0	10.2	9.7	9.9	8.6	9.6	9.3	9.2		
19	8.0	10.0	9.6	9.8	8.5	9.5	9.3	9.3		
20	8.2	9.9	9.7	9.8	8.6	9.2	9.4	9.3		
21	8.5	9.7	9.7	9.7	8.6	8.8	9.5	9.3		
22	8.5	9.7	9.6	9.6	8.7	8.8	9.5	9.2		
23	8.6	9.7	9.7	9.5	8.6	8.8	9.6	9.2		
24	9.0	9.6	9.8	9.4	8.6	8.4	9.6	9.2		
25	9.6	9.6	9.9	9.4	8.7	9.0	9.6	9.1		
26	11.2	9.6	10.0	9.3	8.8	9.1	9.6	9.0		
27	12.0	9.5	10.0	9.2	8.9	9.4	9.6	9.0		
28	12.5	9.3	10.1	9.3	8.9	9.5	10.0	9.0	8.4	
29	12.9	9.6	10.3	9.4	8.9	9.6	10.0	9.0	8.7	
30	13.0	9.8	12.5	9.4	8.8	9.4	9.3	9.0	9.5	
31	13.0		11.7		8.7	9.4		8.9		

[a] Ice running. [b] Ice all out.

NOTE.—Ice conditions prevailed during January, February, March, April 1 to 15, and after November 15.

Daily discharge, in second-feet, of Red River at Fargo, N. Dak., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		825	1,540	664	589	770	770	664
2		825	1,580	614	565	743	797	664
3		853	1,610	450	565	743	797	664
4		882	1,610	565	565	770	797	664
5		825	1,580	690	565	743	797	664
6		797	1,470	690	565	716	797	664
7		882	1,380	743	589	743	797	664
8		911	1,340	690	565	690	797	664
9		911	1,340	664	589	716	797	639
10		882	1,310	541	589	743	797	639
11		882	1,280	518	690	770	797	639
12		853	1,220	565	853	770	797	639
13		882	1,220	565	743	770	825	639
14		882	1,180	565	639	770	825	639
15		882	1,000	589	639	770	797	541
16		853	970	565	743	770	770	
17		853	970	589	825	770	743	
18	1,030	882	940	589	853	770	743	
19	970	853	911	565	825	770	770	
20	940	882	911	589	743	797	770	
21	882	882	882	589	639	825	770	
22	882	853	853	614	639	825	743	
23	882	882	825	589	639	853	743	
24	853	911	797	589	541	853	743	
25	853	940	797	614	690	853	716	
26	853	970	770	639	716	853	690	
27	825	970	743	664	797	853	690	
28	770	1,000	770	664	825	970	690	
29	853	1,060	797	664	853	970	690	
30	911	1,780	797	639	797	770	690	
31		1,510		614	797		664	

NOTE.—These discharges are based on a rating curve that is well defined between 250 and 4,700 second-feet. The following are estimates of flow during frozen conditions: March 14 to 31 equivalent to 523 second-feet per day; April 1 to 17 equivalent to 995 second-feet per day; November 16 to 30 equivalent to 503 second-feet per day. These estimates are based on observer's notes, ice thicknesses, and general knowledge of local conditions. They are only roughly approximate.

Monthly discharge of Red River at Fargo, N. Dak., for 1909.

[Drainage area, 6,020 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
March 14-31			a 523	0.087	0.06	18,700	D.
April			b 947	.157	.18	56,400	D.
May	1,780	797	937	.156	.18	57,600	B.
June	1,610	743	1,110	.184	.21	66,000	A.
July	743	450	609	.101	.12	37,400	A.
August	853	565	685	.114	.13	42,100	A.
September	970	690	791	.131	.15	47,100	A.
October	825	664	762	.127	.15	46,900	A.
November			b 574	.095	.11	34,200	C.
The period						406,000	

a Estimated. b Partly estimated.

RED RIVER AT GRAND FORKS, N. DAK.

This station, which is located at the Northern Pacific Railway bridge between Grand Forks, N. Dak., and East Grand Forks, Minn., was established May 26, 1901. Gage height records had, however, been kept by the United States Army engineers for many years at this point, their staff gage being located on the same breakwater as the original United States Geological Survey gage, but at a datum 5.00 feet higher. A chain gage was later installed on the downstream side of the bridge at the same datum, which has remained unchanged since the establishment of the station.

Discharge measurements are usually made from the Great Northern Railway bridge about 1,000 feet above the chain gage. The chain gage is one-half mile below the mouth of Red Lake River. The drainage area at this station includes about 13,400 square miles in Minnesota, 500 in South Dakota, and 11,100 in North Dakota, a total of 25,000 square miles. Red Lake River, which drains 5,680 square miles of the total area, is much more steady in its flow than Red River, so that at low stages (in winter, and often in late summer and fall) Red Lake River brings from one-half to three-fifths of all the water passing this station.

The channel is in clay and silt, and is subject to small gradual changes, but unusually precise gage records have been kept; the range of the river in height is so great—47 feet between the extremes of low and high water—that a change of 0.1 foot in gage height causes only a small percentage change in flow, and as frequent discharge measurements have been made the records are satisfactory, being as a rule excellent through the open season.

The river flows under smooth ice from about November 15 to April 10; the flow during the winter fluctuates little, and since 1905 enough discharge measurements have been made each winter to give fairly satisfactory summaries for the winter.

When the ice breaks up in the spring, because the river has only a gentle current and because it flows north into cooler regions where the river is not yet open, the gage reading is usually excessively and disproportionately high for a few days or weeks, so that the figures for quantity of flow must depend largely on estimation; actual measurements when the river appeared entirely open and clear of ice at this point have sometimes shown the gage reading to be 5 feet greater than would have been needed for the same discharge later in the season, after the whole length of the river was entirely open.

Discharge measurements of Red River at Grand Forks, N. Dak., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 25 [a]	E. F. Chandler	138	492	6.00	677
February 15 [a]	do	134	446	6.15	592
April 26	do	158	1,620	11.15	3,780
July 30	do	239	3,190	18.73	9,210
November 23 [a]	do	217	1,240	7.78	1,480

[a] Ice. Measurement made at a section above the Great Northern Railway bridge.

Daily gage height, in feet, of Red River at Grand Forks, N. Dak., for 1909.

[H. L. Hayes, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				10.9	10.1	12.85	8.65	16.3	13.0	8.7	8.6	
2	6.3			11.85	10.0	13.1	8.6	14.0	13.0	8.7	8.52	
3				12.88	9.7	13.2	8.55	13.6	12.82	8.68	8.52	
4				14.0	9.5	13.0	8.5	12.4	12.8	8.6	8.6	10.25
5				15.0	9.3	12.5	8.5	12.4	12.4	8.52	8.6	
6		5.3	6.4	15.7	9.35	11.7	8.45	12.22	12.0	8.5	8.6	
7				16.3	9.5	11.1	8.4	12.15	11.65	8.48	8.35	
8				16.5	9.6	10.8	8.4	12.38	11.15	8.4	8.3	
9	6.15			16.45	9.6	10.4	8.4	12.25	10.5	8.4	8.22	
10				16.4	9.55	10.3	8.4	12.2	9.6	8.4	8.14	
11				16.2	9.7	10.1	8.4	12.2	9.45	8.4	8.15	11.3
12				16.1	9.7	10.0	8.4	12.1	9.4	8.32	8.15	
13		6.1	6.65	16.0	9.6	9.7	8.2	12.05	9.25	8.3	8.02	
14				15.8	9.6	9.6	8.2	13.3	9.15	8.3	7.6	
15				15.55	9.7	9.35	8.2	15.55	9.0	8.3		
16	6.0			15.3	10.05	9.25	8.18	16.6	9.0	8.3		
17				15.0	10.3	9.2	8.1	17.3	9.0	8.25		
18				14.8	10.4	9.18	8.1	16.8	8.9	8.2		10.3
19				14.45	10.2	9.1	8.1	16.6	8.85	8.0		
20		6.0	7.0	13.3	10.1	9.0	8.0	16.35	9.1	8.0	6.4	
21				12.4	10.2	9.0	8.0	16.1	9.05	7.92		
22				12.05	10.15	9.0	9.55	15.15	9.0	7.9		
23	6.0			11.8	10.15	8.9	14.45	14.3	9.0	7.88		
24				11.45	10.1	8.75	14.85	14.0	9.0	7.8		
25				11.3	10.0	8.7	15.0	13.75	9.0	7.8		
26				11.2	9.7	8.6	15.5	13.5	8.9	7.78		
27		6.35	8.05	11.1	9.7	8.6	16.4	13.5	8.9	7.7	9.2	9.9
28				10.85	9.8	8.65	17.3	13.4	8.9	7.7		
29				10.4	9.8	8.6	17.3	13.22	8.82	7.6		
30	6.1			10.15	10.95	8.5	18.8	13.05	8.8	7.6		
31					11.0		17.6			8.1		

NOTE.—Ice conditions prevailed during January, February, March, April 1 to 20, and November 14 to December 31.

Daily discharge, in second-feet, of Red River at Grand Forks, N. Dak., for 1909.

Day.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		3,200	4,820	2,460	7,260	4,920	2,480	2,430
2		3,140	4,980	2,430	5,600	4,920	2,480	2,390
3		2,980	5,050	2,400	5,320	4,800	2,470	2,390
4		2,880	4,920	2,380	4,530	4,790	2,430	2,430
5		2,780	4,600	2,380	4,530	4,530	2,390	2,430
6		2,800	4,110	2,360	4,420	4,290	2,380	2,430
7		2,880	3,750	2,330	4,380	4,080	2,370	2,310
8		2,930	3,580	2,330	4,520	3,780	2,330	2,280
9		2,930	3,360	2,330	4,440	3,420	2,330	2,250
10		2,900	3,300	2,330	4,410	2,930	2,330	2,210
11		2,980	3,200	2,330	4,410	2,860	2,330	2,210
12		2,980	3,140	2,330	4,350	2,830	2,290	2,210
13		2,930	2,980	2,240	4,320	2,760	2,280	2,160
14		2,930	2,930	2,240	5,120	2,700	2,280	
15		2,980	2,800	2,240	6,700	2,630	2,280	
16		3,170	2,760	2,230	7,490	2,630	2,280	
17		3,300	2,730	2,200	8,040	2,630	2,260	
18		3,360	2,720	2,200	7,640	2,580	2,240	
19		3,250	2,680	2,200	7,490	2,560	2,150	
20		3,200	2,630	2,150	7,300	2,680	2,150	
21	4,530	3,250	2,630	2,150	7,110	2,660	2,110	
22	4,320	3,220	2,630	2,900	6,410	2,630	2,100	
23	4,170	3,220	2,580	5,920	5,810	2,630	2,100	
24	3,960	3,200	2,500	6,200	5,600	2,630	2,060	
25	3,870	3,140	2,480	6,300	5,420	2,630	2,060	
26	3,810	2,980	2,430	6,660	5,250	2,580	2,050	
27	3,750	2,980	2,430	7,330	5,250	2,580	2,020	
28	3,610	3,030	2,460	8,040	5,180	2,580	2,020	
29	3,360	3,030	2,430	8,040	5,060	2,540	1,970	
30	3,220	3,660	2,380	9,260	5,050	2,530	1,970	
31		3,690		8,280	4,950		2,200	

NOTE.—These discharges are based on a rating curve that is well defined.
Discharge April 1 to 20 estimated for ice conditions as equivalent to 4,580 second-feet per day. Discharge November 14 to 30 also estimated similarly as 1,580 second-feet per day.

Monthly discharge of Red River at Grand Forks, N. Dak., for 1909.

[Drainage area, 25,000 square miles.]

Month.	Discharge in second-feet.				Run-off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	Accuracy.
January			a 703	0.028	0.03	43,200	D.
February			a 564	.023	.02	31,300	D.
March			a 925	.037	.04	56,900	D.
April			b 4,340	.174	.19	258,000	D.
May	3,690	2,780	3,090	.124	.14	190,000	A.
June	5,050	2,380	3,200	.128	.14	185,000	A.
July	9,260	2,150	3,780	.151	.17	232,000	A.
August	8,040	4,320	5,590	.224	.26	344,000	A.
September	4,920	2,530	3,180	.127	.14	191,000	A.
October	2,480	1,970	2,230	.089	.10	137,000	A.
November			b 1,900	.076	.08	113,000	C.
December			a 2,430	.097	.11	149,000	D.
The period			2,660	.106	1.42	1,930,000	

a Estimated. b Partly estimated.

PELICAN RIVER NEAR FERGUS FALLS, MINN.

The station, which was established June 19, 1909, in connection with the general investigation of the water resources of Minnesota, is located 6 miles northwest of Fergus Falls, in sec. 18 of that township, at a private bridge, from which discharge measurements are made.

Pelican River enters Red River about 5 miles below the gaging station, and as the range of stage in Red River is small, there is no danger of backwater. The nearest dam is at Elizabeth 6 or 8 miles above the station, and the intermittent operation of the mill at that point causes a slight daily fluctuation in the gage heights. The staff gage at the bridge is read twice each day and the mean of these readings is taken as the mean for the day. The drainage area of the station is 433 square miles.

From the middle of November to the first of April, when the river is ice-bound, gage readings are taken through a hole in the ice.

Owing to the short time that the station has been operated, it has not been completely rated; hence no estimate of daily flow is presented.

Discharge measurements of Pelican River near Fergus Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec. ft.*
July 12	E. F. Chandler	29	53	6.26	126
August 4	do	29	48.1	5.99	74.6
September 3	do	29	66.1	6.54	193
October 4	do	29	68.5	6.56	195
December 12[a]	do	29	63	7.40	128

[a] Frozen.

Daily gage height, in feet, of Pelican River near Fergus Falls, Minn., for 1909.

[Henry W. Luther, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.20	6.09	6.46	6.54	6.35	7.28	16		6.01	6.44	6.58	6.44	7 05	
2		6.18	6.16	6.49	6.56	6.39	7.20	17		6.05	6.39	6.60	6.52	6.90	7.45
3		6.18	6.06	6.54	6.52	6.39	7.35	18		6.02	6.38	6.50	6.41	6.95	
4		6.11	6.00	6.50	6.50	6.38	7.54	19	6.46	6.02	6.35	6.55	6.34	7.05	
5		6.11	6.01	6.51	6.52	6.38		20	6.46	5.75	6.35	6.52	6.40	6.99	
6		5.90	6.06	6.54	6.50	6.35		21	6.35	6.48	6.31	6.58	6.45	7.05	
7		6.02	6.32	6.54	6.52	6.38		22	6.36	6.39	6.32	6.58	6.41	6.91	
8		6.05	6.36	6.50	6.51	6.38		23	6.34	6.35	6.45	6.54	6.45	6.91	7.45
9		5.96	6.35	6.51	6.58	6.38	7.75	24	6.28	6.30	6.54	6.56	6.50	7.05	
10		6.01	6.31	6.50	6.68	6.40		25	6.61	6.21	6.51	6.55	6.45	7.06	
11		6.11	6.39	6.54	6.45	6.38		26	6.32	6.15	6.56	6.58	6.45	7.02	
12		6.20	6.51	6.51	6.50	6.36		27	5.99	6.10	6.51	6.58	6.44	7.50	
13		6.24	6.65	6.50	6.45	6.38		28	6.00	6.11	6.50	6.60	6.36	7.76	
14		6.10	6.65	6.46	6.46	7.42		29	6.19	6.10	6.50	6.58	6.34	7.35	
15		6.04	6.52	6.52	6.45	7.62		30	6.21	6.06	6.49	6.55	6.41	7.48	
								31		6.09	6.46		6.45		7.62

NOTE.—Backwater at the gage November 14 to December 4 caused by ice conditions. The river was frozen over from December 5 to 31. The maximum recorded ice thickness was 1.25 feet on December 31.

WILD RICE RIVER AT TWIN VALLEY, MINN.

This station, which is located at the steel highway bridge at Twin Valley, Minn., was established June 30, 1909, to obtain data for use in determining available water power and in studying means of flood prevention, which are much needed in this valley.

The nearest tributary is at Heiberg, 2 miles below. The drainage area above the station is 805 square miles.

A staff gage is located at the bridge from which discharge measurements are made.

The river is dammed at Heiberg, but the highest backwater effect is at a point a mile below Twin Valley. At the outlet of Wild Rice Lake is a logging dam used to store the flow through the winter and early spring months for the purpose of driving the logs to Ada. During the winter period, therefore, the flow at Twin Valley is less than normal, and in the spring the flood flow is augmented by the stored water. There is also a dam at Twin Lake outlet which is used in the same way. An exceptionally severe flood in July, 1909, overflowed the lower part of the valley and wrecked the power dam at Faith by cutting around the end of it and greatly increasing the width of the channel.

Sufficient measurements have been made to enable computation of the daily flow. The estimate for the flood discharge above 14 feet is based on Kutter's formula in connection with the known area of the cross section and may be somewhat in error, but it is believed this error will not exceed 10 per cent.

Discharge measurements of Wild Rice River at Twin Valley, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 30	E. F. Chandler	63.5	144	6.20	345
July 13	.....do	63.5	146	6.17	323
July 26	.....do	366	968	12.94	3,290
July 27	.....do	95.5	782	12.26	2,990
July 28	.....do	83	623	11.89	2,670
August 5	.....do	74.5	421	9.32	1,520
September 10	.....do	60	149	6.14	318

Daily gage height, in feet, of Wild Rice River at Twin Valley, Minn., for 1909.

[William Lewis, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.00	9.91	6.20	5.25	5.2		16		5.85	8.16	5.90	5.2	5.2	
2		5.90	9.30	6.25	5.0	5.4		17		5.70	8.30	6.00	5.0	5.22	
3		6.05	8.92	6.10	4.75	5.4	5.6	18		5.40	7.95	6.05	5.05	5.2	5.2
4		5.90	8.90	6.00	4.85	5.4		19		5.40	7.75	5.80	5.15	5.2	
5		5.90	9.40	6.00	4.9	5.3		20		17.70	7.55	6.00	5.2		
6		5.60	8.92	6.00	4.75	5.32		21		18.00	7.45	6.15	5.0		
7		5.80	8.65	5.90	4.6	5.3		22		19.80	7.15	6.00	5.0		
8		5.70	8.90	6.05	4.9	5.2	5.4	23		17.20	6.75	6.00			
9		5.70	8.70	6.00	4.85	5.2		24		15.00	6.65	5.90	5.4	5.3	5.1
10		6.10	8.55	6.15	4.9	5.22		25		14.00	6.85	5.90	5.4		
11		6.20	8.90	6.00	4.9	5.2		26		12.85	6.75	5.80	5.3		
12		6.30	9.50	6.35	5.0	5.23		27		12.30	6.60	5.45	5.3		
13		6.10	9.20	6.10	5.0	5.35		28		11.90	6.45	5.50	5.2		
14		6.20	8.89	6.00	5.2	5.2		29		11.74	6.35	5.45	5.2		
15		5.80	8.50	6.05	5.0	5.2		30	6.28	10.35	6.20	5.60	5.3		5.1
								31		10.00	6.10				

NOTE.—The river was frozen over from the middle of November, 1909, to the end of January, 1910, during which time the ice thickness varied from 0.25 to 1.5 feet.

Daily discharge, in second-feet, of Wild Rice River at Twin Valley, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		295	1,750	343	138	129	16		261	979	272	129	129
2		272	1,480	355	92	168	17		228	1,040	295	92	133
3		307	1,300	319	52	168	18		170	895	307	101	129
4		272	1,300	295	67	168	19		170	816	250	120	129
5		272	1,520	295	75	148	20		7,230	740	295	129	129
6		208	1,300	295	52	152	21		7,500	705	331	92	129
7		250	1,180	272	32	148	22		9.120	606	295	92	129
8		228	1,300	307	75	129	23		6,780	487	295	130	129
9		228	1,210	295	67	129	24		4,820	459	272	168	129
10		319	1,140	331	75	133	25		4,020	516	272	168	129
11		343	1,300	295	75	129	26		3,250	487	250	148	129
12		367	1,560	380	92	135	27		2,920	445	179	148	129
13		319	1,430	319	92	158	28		2.700	406	188	129	129
14		343	1.290	295	129	129	29		2,620	380	179	129	129
15		250	1,120	307	92	129	30	362	1,950	343	208	148	129
							31		1,790	319		138	

NOTE.—These discharges are based on a rating curve that is well defined between 22 and 4,000 second-feet, except November 20 to 30, which are estimated because of ice conditions.

Monthly discharge of Wild Rice River at Twin Valley, Minn., for 1909.

[Drainage area, 805 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
July	9,120	170	1,930	2.40	2.77	119,000	A.
August	1,750	319	961	1.19	1.37	59,100	A.
September	355	179	286	.355	.40	17,000	B.
October	168	32	105	.130	.15	6,460	B.
November	168		136	.169	.19	8,090	C.
The period						210,000	

DEVILS LAKE NEAR DEVILS LAKE, N. DAK.[a]

Devils Lake, in the north-central part of North Dakota, affords an interesting example of the ratios between rainfall, evaporation, and run-off. This lake has no outlet, its size depending entirely upon the relations between the evaporation from its surface, the rainfall upon it, and inflow from the surrounding country. The total area draining to Devils Lake is theoretically somewhat more than 3,500 square miles. Surveys made about twenty-five years ago, when the region was first settled, showed the lake to have a length of 35 miles, a width ranging from 1 mile to 15 miles, and an area of approximately 120 square miles; because of its many bays and slender arms the shore line measured more than 200 miles. The present area of the lake is not precisely known, but is estimated as not more than 60 square miles.

Since June 8, 1901, the United States Geological Survey has maintained on Devils Lake a staff gage, which is attached to the piles of the pier at the Chautauqua grounds steamer landing, 6 miles southwest of the city of Devils Lake. This gage is read occasionally by Capt. E. E. Heerman. A standard United States Geological Survey bench mark post is set in the bank directly behind the gage and about 8 rods distant. The gage zero is 1,416.2 feet above sea level, and the bench mark is 22.90 feet above the gage zero.[b]

That the lake level is still being lowered is shown by the following gage heights, those at the close of the season being the lowest ever recorded.

Gage height of Devils Lake, N. Dak., in 1909.

	Feet.		Feet.
May 1	10.35	July 11	10.8
May 15	10.4	August 17	10.8
May 29	10.95	October 25	10.0
June 6	11.0	October 31	10.01

RED LAKE RIVER AT THIEF RIVER FALLS, MINN.

This station, which is located one-third mile below the dam at Thief River Falls, was established July 2, 1909, to obtain data for use in connection with the development of water power and the practicability of storage on upper Red Lake River as an aid to navigation and flood prevention.

The nearest tributary is Thief River, which enters a mile or more above the station. The drainage area above this point is 3,430 square miles.

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[a] For description of Devils Lake and all data available from 1867 to 1908 see Water-Supply Paper U. S. Geol. Survey No. 245, pp. 51-54.

[b] In the descriptions of the station published in Water-Supply Paper U. S. Geol. Survey No. 66, p. 14, and No. 85, p. 238, the statement of the elevation of the bench mark above mean sea level was in error.

The dam which supplies head to the Hansen and Barzen mills and the city lighting plant is a short distance above the station. The fluctuating loads on the turbines cause a slight fluctuation in the river below the dam. Logs are floated down Red Lake River and by jamming may cause backwater for a few days or may hold back the normal flow above the gage.

Discharge measurements are made by means of a car and cable located at the gage section. The gage is read morning and evening and the mean of the two readings is taken as the mean for the day.

From the latter part of November to the 1st of April the river is frozen over, and the gage heights taken through the ice.

As the station has not yet been completely rated, no estimates of daily flow can be given at present.

Discharge measurements of Red Lake River at Thief River Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 19	Chandler and Nomland	142	426	5.83	972
August 20	do	140	414	5.74	886
September 15	E. F. Chandler	139	442	5.96	906
September 27	J. O. Nomland	144	524	6.55	1,020

Daily gage height, in feet, of Red Lake River at Thief River Falls, Minn., for 1909.

[Chas. P. Quist, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.60	6.02	5.61	6.15	6.75	16	7.40	6.05	5.85	5.88	a3.00	
2	5.85	5.64	6.00	5.58	6.14	7.28	17	7.20	5.91	5.85	5.95	5.40	
3	5.55	5.68	6.00	5.52	6.11	7.55	18	7.00	5.85	5.95	5.96	5.70	7.0
4	5.50	5.68	5.95	5.65	6.15	7.50	19	8.45	5.72	5.90	6.01	5.60	
5	5.78	5.72	5.85	5.68	6.22	7.45	20	8.95	5.62	5.92	5.99	5.65	
6	6.22	5.65	5.80	5.62	6.28	7.65	21	8.40	5.60	6.15	6.20	5.75	6.9
7	6.06	5.68	5.75	5.65	6.24	7.85	22	7.15	5.65	6.30	6.30	6.00	
8	6.21	5.90	5.60	5.60	6.35	7.95	23	6.40	5.60	6.40	6.34	6.20	
9	6.32	5.96	5.46	5.60	6.28	8.25	24	6.22	6.10	6.55	6.25	6.18	
10	6.20	5.98	5.55	5.41	6.20	8.20	25	6.08	6.50	6.55	6.34	6.22	7.2
11	6.18	6.25	5.48	5.78	6.32	8.15	26	6.05	6.60	6.50	6.35	6.28	
12	7.05	6.26	5.55	6.10	6.28		27	6.18	6.45	6.50	6.18	6.30	
13	7.18	6.25	5.75	6.04	6.10	7.30	28	5.90	6.30	6.50	6.10	6.38	
14	7.30	6.15	5.80	5.94	a4.45		29	5.80	6.18	6.48	6.11	6.45	
15	7.35	5.96	5.80	5.90	a3.15		30	5.52	6.30	6.08	6.14	6.50	
							31	5.55	6.22		6.15		6.9

a Ice and log jam held water back.

NOTE.—Ice conditions during the latter part of November and all of December.

RED LAKE RIVER AT CROOKSTON, MINN.

This station, which is located a short distance below the dam in Crookston, was established May 19, 1901, to obtain data necessary in developing water power on Red Lake River and also in planning relief for the serious floods in the lower Red River valley.

No tributaries enter within several miles of Crookston. Less than a quarter of a mile above this station are the dam and power house of the Crookston Water Works, Power, and Light Company. As the power plant operates almost continuously, though with varying load, the gage heights below the dam fluctuate less than they would if the plant were shut down during a portion of the time with the water below the crest of the dam. The drainage area above the station is 5,320 square miles.[a]

Until July 1, 1909, the chain gage and auxiliary staff gages were located at the old Sampson's Addition bridge, but on that date a new chain gage was installed on the new steel bridge 20 rods below, and set to read the same as the original gage, whose datum has remained constant since the station was established. Discharge measurements are now made from this bridge.

The river channel at the old gaging section was wholly or part open during the winter, owing to the presence of the dam, but at the present section the river freezes entirely across from December to March, and discharge measurements are made through the ice to determine the approximate winter flow.

The daily fluctuation of the water surface may possibly cause a slight error in the daily mean gage height, but otherwise the records at this station should be considered good.

Discharge measurements of Red Lake River at Crookston, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 10 [b]	E. F. Chandler	132	256	4.95	323
June 18	Hoyt and Chandler	138	382	4.42	660
June 30	E. F. Chandler	158	709	6.20	1,660
August 5	do	163	820	6.53	1,980
September 4	do	162	749	6.09	1,810
November 16 [c]	do	140	305	3.75	321

[a] Revised.
[b] Ice measurement made at old bridge.
[c] Partly frozen below the bridge section.

NOTE.—Measurements beginning June 18 were made from new steel bridge.

Daily gage height, in feet, of Red Lake River at Crookston, Minn., for 1909.

[J. E. Carroll, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.7	5.25	5.35	6.5	5.75	6.0	6.2	6.75	6.65	5.35	6.0	5.7
2	4.75	5.2	5.2	7.2	5.5	6.2	5.8	6.9	6.5	5.35	5.9	5.7
3	4.5	5.0	5.1	7.55	5.5	5.65	5.95	6.88	6.1	5.25	5.8	5.95
4	4.7	4.4	5.2	8.12	5.35	5.7	5.15	7.0	6.1	5.4	5.7	5.85
5	4.6	5.0	5.4	8.3	5.4	4.95	4.9	6.6	6.3	5.3	5.9	6.55
6	4.4	5.0	5.3	8.2	5.55	4.9	4.5	6.0	6.0	5.2	5.9	6.75
7	4.7	5.0	5.2	8.2	5.8	5.4	4.7	6.68	5.6	5.3	5.55	6.95
8	4.75	5.2	5.4	7.8	5.55	5.3	5.05	6.8	5.35	5.42	5.75	6.95
9	4.85	4.9	5.2	7.55	5.7	5.2	4.1	6.58	5.3	5.32	5.80	6.95
10	4.85	5.0	5.2	7.4	5.82	5.45	4.3	6.9	5.25	5.15	5.7	7.05
11	4.75	5.0	5.2	7.5	5.8	5.35	4.1	6.65	4.5	5.3	5.6	6.75
12	5.0	4.95	5.1	7.12	5.75	4.95	4.9	6.6	5.0	5.35	5.2	6.55
13	5.0	5.05	5.05	6.9	5.8	4.6	4.55	7.0	5.05	5.75	5.2	6.65
14	4.95	5.0	5.2	6.85	5.95	5.0	4.8	7.6	5.0	6.2	......	6.35
15	5.0	5.1	5.3	6.4	6.2	4.8	4.3	7.3	5.15	6.1	3.35	6.35
16	5.05	5.15	5.15	6.3	5.9	4.95	4.4	7.0	5.2	6.05	3.75	6.45
17	5.2	5.2	5.05	6.25	6.45	5.05	5.05	6.8	5.2	5.8	3.75	6.55
18	5.3	5.2	5.15	6.25	6.4	4.68	4.65	6.55	5.2	5.95	3.95	6.55
19	5.2	5.2	5.05	6.1	6.5	4.7	4.0	6.5	5.25	6.0	4.0	6.05
20	5.1	5.2	5.5	6.5	6.3	4.2	6.2	6.4	5.25	6.05	4.7	6.15
21	5.1	5.2	5.9	7.05	6.5	4.68	8.71	6.4	5.3	6.0	4.7	6.15
22	5.3	5.0	6.9	6.55	6.4	4.55	8.7	6.6	5.35	5.95	4.5	6.15
23	5.35	5.0	6.95	6.35	6.3	4.35	8.55	6.7	5.95	6.2	5.4	6.0
24	4.6	5.0	5.7	6.45	6.0	4.35	8.48	7.0	5.9	6.4	5.5	5.75
25	5.6	5.3	5.5	6.35	6.15	4.15	8.1	7.8	6.2	6.45	5.95	5.65
26	5.4	5.2	5.8	6.58	5.7	4.2	8.55	8.25	5.75	6.4	5.6	5.7
27	5.1	5.1	5.6	6.22	5.25	4.2	7.92	8.2	5.7	6.3	5.5	5.7
28	5.1	5.15	5.85	6.1	5.25	4.3	7.6	7.7	5.75	6.2	5.5	5.55
29	5.0	......	5.9	6.15	5.65	4.60	7.2	7.25	5.6	6.05	5.6	5.7
30	5.05	......	5.7	5.9	5.3	6.15	7.08	6.95	5.45	6.05	5.7	5.65
31	5.2	......	6.05	......	5.7	......	6.3	6.7	......	5.95	......	5.65

NOTE.—More or less ice during January, February, and March. The river was entirely frozen over from about December 15 to 31. Gage heights November 15 to December 31 are to the under surface of the ice and are only approximate.

Daily discharge, in second-feet, of Red Lake River at Crookston, Minn., for 1909.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1,960	1,450	1,610	1,750	2,140	2,060	1,200	1,610
2	2,450	1,290	1,750	1,480	2,240	1,960	1,200	1,540
3	2,710	1,290	1,380	1,580	2,230	1,680	1,140	1,480
4	3,150	1,200	1,420	1,080	2,310	1,680	1,230	1,420
5	3,290	1,230	960	930	2,030	1,820	1,170	1,540
6	3,210	1,320	930	710	1,610	1,610	1,110	1,540
7	3,210	1,480	1,230	816	2,090	1,350	1,170	1,320
8	2,900	1,320	1,170	1,020	2,170	1,200	1,240	1,450
9	2,710	1,420	1,110	510	2,020	1,170	1,180	1,480
10	2,600	1,490	1,260	608	2,240	1,140	1,080	1,420
11	2,670	1,480	1,200	510	2,060	710	1,170	1,350
12	2,490	1,450	960	930	2,030	930	1,200	1,110
13	2,240	1,480	762	736	2,310	1,020	1,450	1,110
14	2,200	1,580	990	872	2,740	990	1,750	....
15	1,890	1,750	872	608	2,520	1,080	1,680	....
16	1,820	1,540	960	658	2,310	1,110	1,640	....
17	1,780	1,920	1,020	1,020	2,170	1,110	1,480	....
18	1,780	1,890	805	789	2,000	1,110	1,580	....
19	1,680	1,960	816	464	1,960	1,140	1,610	....
20	1,960	1,820	558	1,750	1,890	1,140	1,640	....
21	2,340	1,960	805	3,630	1,890	1,170	1,610	....
22	2,000	1,890	736	3,620	2,030	1,200	1,580	....
23	1,860	1,820	633	3,490	2,100	1,580	1,750	....
24	1,920	1,610	633	3,430	2,310	1,540	1,890	....
25	1,860	1,720	534	3,130	3,000	1,750	1,920	....
26	2,020	1,420	558	3,490	3,250	1,450	1,890	....
27	1,760	1,140	558	2,990	3,210	1,420	1,820	....
28	1,680	1,140	608	2,740	2,820	1,450	1,750	....
29	1,720	1,380	762	2,450	2,480	1,350	1,640	....
30	1,540	1,170	1,720	2,370	2,480	1,260	1,640	....
31	....	1,420	....	1,820	2,100	....	1,580	....

NOTE.—These discharges are based on a rating curve that is well defined above 338 second-feet.

Monthly discharge of Red Lake River at Crookston, Minn., for 1909.

[Drainage area, 5,320 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
January	....	....	[a] 480	0.090	0.10	29,500	D.
February	....	....	[a] 385	.072	.07	21,400	D.
March	....	....	[a] 660	.124	.14	40,600	D.
April	3,290	1,540	2,240	.421	.47	133,000	A.
May	1,960	1,140	1,520	.286	.33	93,500	A.
June	1,750	534	977	.184	.21	58,100	A.
July	3,630	464	1,680	.316	.36	103,000	A.
August	3,250	1,610	2,280	.429	.49	140,000	A.
September	2,060	710	1,340	.252	.28	79,700	A.
October	1,920	1,080	1,480	.278	.32	91,000	A.
November 1-13	1,610	1,110	1,410	.265	.13	36,400	B.
The period	....	....	....	....	....	826,000	

[a] Estimated.

NOTE.—The controlled flow at this station makes any estimates for the frozen period of November and December very uncertain, hence they have been omitted.

THIEF RIVER NEAR THIEF RIVER FALLS, MINN.

This station, which is located at the Drybrooke ford 6 miles north of Thief River Falls, in sec. 3, T. 154 N., R. 43 W., was established July 1, 1909, in connection with the general plan of investigating the water resources of Minnesota and also to determine the practicability of draining swamp lands in the basin.

The nearest tributary is the outlet of Mud Lake, which enters Thief River in the northeastern part of T. 156 N., R. 42 W. The drainage area above the gaging station is 1,010 square miles.

The nearest dam is at Thief River Falls at the mouth of Thief River. This dam backs up the water in Thief River for several miles, but produces no effect at the gage owing to rapids below the station.

The gage is an inclined rod on the right bank about 100 feet below the ford. Discharge measurements are made by means of a boat and cable a short distance below the staff gage, or by wading at the ford at very low stages.

From the middle of November to the 1st of April the river is entirely frozen over, and readings are taken through the ice.

As the station has not yet been completely rated no estimates of daily flow can be given at present.

Discharge measurements of Thief River near Thief River Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 1 [a]	E. F. Chandler	136	212	6.21	327
August 2 [b]	....do	111	248	6.36	381
August 16 [b]	Chandler and Nomland	82	233	6.36	371
August 19 [b]	....do	81	220	6.14	288
September 15 [b]	E. F. Chandler	81	227	6.25	324
October 1 [b]	J. O. Nomland	80	210	6.12	298

[a] Made by wading. [b] Made from boat and cable.

Daily gage height, in feet, of Thief River, near Thief River Falls, Minn., for 1909.

[H. J. Maland, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.22	6.28	6.10	6.10	6.32	6.9	16	5.72	6.39	6.20	6.32		6.75
2	5.96	6.24	6.10	6.10	6.32		17	5.60	6.30	6.14	6.34		
3	5.84	6.50	6.06	6.18	6.31		18	5.52	6.22	6.10	6.32		
4	5.70	6.41	6.12	6.20	6.30	6.65	19	10.60	6.15	6.20	6.32		
5	5.50	6.45	6.08	6.26	6.30		20	9.90	6.08	6.20	6.34	7.1	6.8
6	5.36	6.32	6.08	6.30	6.30		21	9.20	6.00	6.34	6.45		
7	5.30	6.25	6.01	6.35	6.28		22	8.15	6.16	6.32	6.42		
8	5.24	6.90	6.00	6.38	6.25	6.75	23	7.55	6.10	6.29	6.42		
9	5.20	6.78	6.00	6.38	6.25		24	7.35	6.55	6.22	6.42	7.0	
10	5.20	6.75	6.00	6.38	6.25		25	6.85	6.70	6.19	6.42		
11	5.20	6.80	6.00	6.36	6.22	6.75	26	6.68	6.62	6.16	6.40		
12	5.85	6.78	6.00	6.31	6.20		27	6.52	6.52	6.15	6.36		6.8
13	5.88	6.64	6.12	6.30	6.12		28	6.40	6.40	6.15	6.32		
14	5.80	6.60	6.22	6.30			29	6.32	6.28	6.11	6.34		
15	5.85	6.51	6.25	6.32			30	6.28	6.10	6.10	6.34		
							31	6.32	6.08		6.32		

NOTE.—Ice November 14 to December 31. The following comparative readings were made:

Date.	Gage height to water surface.	Gage height top of ice.	Thickness of ice. At gage.	Thickness of ice. Average.
	Feet.	*Feet.*	*Feet.*	*Feet.*
November 20	7.1	7.2	0.4	0.35
November 24	7.0	7.25	.6	.50
November 27	6.98	7.05	.56	.57
December 1	6.9	7.28	.65	.55
December 4	6.65	7.0	.55	.66
December 8	6.75	7.0	.62	.68
December 11	6.75	6.9	.80	.65
December 16	6.75	6.9	.80	.70
December 20	6.8	6.85	.83	.75
December 27	6.8	6.85	.92	.78

CLEARWATER RIVER AT RED LAKE FALLS, MINN.

This station, which is located 30 rods southeast of the Great Northern Railway station at Red Lake Falls, and 1½ miles above the mouth of the Clearwater, was established June 18, 1909, to determine the amount of available power on this stream.

The nearest tributary is 2 miles above Red Lake Falls. The station is at least half a mile above the influence of the Healy dam, which is located a short distance below the mouth of Clearwater River.

The gage is an inclined staff on the right bank. Discharge measurements are made at high stage from a car and cable located at a tag-wire section a short distance below the gage; during medium and low stages wading measurements are made at the tag-wire section.

From the middle of November to the 1st of April, when the river is frozen over, gage readings are taken through a hole in the ice.

Conditions at this station are excellent, and the records may be considered reliable.

Discharge measurements of Clearwater River at Red Lake Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 18 [a]	Hoyt and Chandler	109	164	6.52	146
June 18 [b]	do	111	115	6.53	150
July 2 [b]	E. F. Chandler	127	123	6.60	161
August 2 [c]	do	179	463	8.40	1,140
August 3 [c]	do	180	433	8.34	1,040
August 17 [c]	Chandler and Nomland	180	535	8.90	1,440
September 11 [a]	E. F. Chandler	123	229	6.99	281
September 15 [a]	do	123	227	6.97	274
November 29 [b d]	do	178	177	7.60	274
December 24 [b d]	do	175	194	7.88	305

[a] Made from footbridge.
[b] Made by wading at tag-wire section.
[c] Made from cable.
[d] Ice conditions.

Daily gage height, in feet, of Clearwater River at Red Lake Falls, Minn., for 1909.

[Jas. Benoit, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		[a]6.95	8.56	7.98	7.00	7.30	7.50	16		6.66	8.94	6.89	7.44	7.44	
2		6.65	8.41	7.97	7.04	7.32		17		6.60	8.90	6.90	7.49	7.36	
3		6.48	8.32	7.78	7.00	7.26		18	6.58	6.55	8.79	6.56	7.40	7.40	
4		6.50	8.24	7.62	6.80	7.20		19	6.56	6.55	8.63	6.85	7.35	7.41	
5		6.46	8.14	7.43	6.80	7.08		20	6.49	6.50	8.53	6.98	7.40	7.42	
6		6.44	8.05	7.23	6.80	7.00		21	6.35	6.60	8.42	7.10	7.25		
7		6.39	8.08	7.23	6.80	7.00		22	6.32	6.95	8.28	7.25	7.25		7.20
8		6.32	8.29	7.13	6.80	7.00	7.55	23	6.30	8.30	8.30	7.39	7.38	7.40	
9		6.30	8.14	7.06	6.80	6.90		24	6.29	9.38	8.68	7.45	7.35		7.88
10		6.24	8.20	6.98	6.80	6.90		25	6.30	9.28	8.90	7.50	7.52		
11		6.10	8.65	6.98	6.82	6.90		26	6.29	9.12	8.88	7.44	7.50		
12		6.30	8.50	6.93	7.00	6.90		27	6.26	8.84	8.62	7.25	7.44		
13		6.30	9.15	6.90	7.35	7.12		28	6.32	8.70	8.46	7.10	7.38		
14		6.42	9.28	6.88	7.49	7.32	7.30	29	[a]7.55	8.60	8.33	7.00	7.40	7.60	7.92
15		6.55	9.08	6.88	7.45	7.45		30	[a]7.25	8.60	8.20	6.99	7.32		
								31		8.60	8.10		7.20		

[a] Gage height estimated from high-water marks as the gage was destroyed.

NOTE.—Backwater due to ice conditions from November 13 to 20. River frozen over November 21 to December 31, gage readings being taken to water surface. The maximum ice thickness recorded was 0.9 foot.

Daily discharge, in second-feet, of Clearwater River at Red Lake Falls, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		[a] 268	1,210	832	286	420	16		180	1,480	247	499	250
2		178	1,110	826	302	431	17		166	1,450	250	529	250
3		140	1,050	703	286	400	18	162	155	1,370	157	475	250
4		144	1,000	607	218	370	19	157	155	1,260	234	448	250
5		135	936	493	218	318	20	142	144	1,190	279	475	250
6		131	878	385	218	286	21	112	166	1,120	326	395	250
7		120	897	385	218	286	22	107	268	1,030	395	395	250
8		107	1,030	339	218	286	23	103	1,040	1,040	470	464	250
9		103	936	310	218	250	24	101	1,790	1,300	505	448	250
10		93	975	279	218	250	25	103	1,720	1,450	535	547	260
11		74	1,280	279	224	250	26	101	1,600	1,440	499	535	260
12		103	1,170	261	286	250	27	97	1,410	1,250	395	499	270
13		103	1,620	250	448	250	28	107	1,310	1,140	326	464	270
14		126	1,720	244	529	250	29	[a] 565	1,240	1,060	286	475	270
15		155	1,580	244	505	250	30	[a] 395	1,240	975	282	431	274
							31		1,240	910		370	274

[a] Estimated.

NOTE.—These discharges are based on a rating curve that is well defined, except November 13 to 30, which are estimated because of ice conditions.

Monthly discharge of Clearwater River at Red Lake Falls, Minn., for 1909.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
June 18-30	a 565	97	173	0.132	0.06	4,460	A.
July	1,790	74	510	.389	.45	31,400	A.
August	1,720	878	1,190	.908	1.05	73,200	A.
September	832	157	387	.295	.33	23,000	A.
October	547	218	382	.292	.34	23,500	A.
November	431		280	.214	.24	16,700	C.
December			a 260	.198	.23	16,000	C.
The period						188,000	

a Estimated.

PEMBINA RIVER AT NECHE, N. DAK.

This station, which was established April 29, 1903, is located at the Great Northern Railway bridge two-thirds of a mile north of Neche, N. Dak.

The records of this stream are necessary to determine the value of the many water-power sites on the Pembina, and are valuable in connection with problems of navigation and flood damages on Red River and in drainage investigations.

The total drainage area above this station is about 2,940 square miles, of which 2,020 are in Manitoba, as the stream rises in Manitoba and flows for about 90 miles close to and nearly parallel with the international boundary before it crosses into North Dakota, 50 miles above its mouth at Pembina.

The staff gage used prior to September 1, 1909, is firmly spiked to the railway bridge abutment and its datum has not been changed. On account of difficulty in reading this gage at some stages a standard chain gage was installed on the highway bridge about 400 feet downstream and set to read the same as the staff gage. Discharge measurements are made from this bridge.

A loose-rock dam, about 3 feet high, at the railway water-tank intake pipe, one-third mile below the gage, raises the water at the gage from 1 to 2 feet at low stage. As the dam is changed somewhat by the ice each spring, the lower portion of the rating curve requires revision each year. Hence, unless several low-stage discharge measurements are made each season the summaries for the low-water season are merely approximate or fair.

Discharge measurements of Pembina River at Neche, N. Dak., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 8	E. F. Chandler	61	173	3.69	147
August 14	do	56	128	2.93	42
September 1 *a*	do	45	30	2.81	28

a Made by wading below Great Northern Railway dam.

Daily gage height, in feet, of Pembina River at Neche, N. Dak., for 1909.

[Roy O. Young, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1			3.3	2.75	2.9	3.1	16	4.6	3.5	2.9	2.8	2.9	
2			3.4	2.75	2.9	3.0	17		3.5	2.95	2.8	2.9	
3			3.3	2.8	2.9	3.05	18		3.4	2.9	2.8	2.95	
4	4.4		3.25	2.8	2.85	3.0	19		3.4	2.9	2.8	2.95	
5	5.5		3.2	2.85	2.9	2.95	20		3.4	2.9	2.8	3.0	
6	6.35		3.25	2.85	2.9	3.0	21		3.5	2.85	2.85	3.0	
7	5.8	3.8	3.2	3.8	2.85	3.15	22		3.5	2.8	2.85	3.0	
8	5.6	3.6	3.1	2.85	2.9	3.1	23		3.5	2.85	2.8	3.0	
9	5.5	3.7	3.1	2.8	2.9	3.0	24		3.5	2.8	2.8	3.1	
10	5.4	3.7	3.1	2.8	2.9	3.15	25		3.4	2.8	2.8	3.15	
11	5.2	3.7	3.1	2.75	2.9	3.0	26		3.4	2.8	2.8	3.2	
12	5.2	3.6	3.0	2.8	2.9	2.9	27		3.3	2.8	2.85	3.15	
13	5.0	3.6	2.95	2.85	2.9	2.95	28		3.3	2.75	2.8	3.15	
14	4.8	3.5	3.0	2.8	2.9	3.0	29		3.3	2.75	2.8	3.1	
15	4.7	3.5	2.95	2.8	2.9		30		3.2	2.8	2.8	3.1	
							31		3.3	2.75		3.0	

NOTE.—Ice November 14 to December 31. No observer June 17 to July 6.

Daily discharge, in second-feet, of Pembina River at Neche, N. Dak., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1			86	22	38	61	16	304	115	38	27	38	
2			100	22	38	49	17		115	44	27	38	
3			86	27	38	55	18		100	38	27	44	
4	268		80	27	32	49	19		100	38	27	44	
5	478		73	32	38	44	20		100	38	27	49	
6	654		80	32	38	49	21		115	32	32	49	
7	538	164	73	27	32	67	22		115	27	32	49	
8	498	131	61	32	38	61	23		115	32	27	49	
9	478	147	61	27	38	49	24		115	27	27	61	
10	458	147	61	27	38	67	25		100	27	27	67	
11	418	147	61	22	38	49	26		100	27	27	73	
12	418	131	49	27	38	38	27		86	27	32	67	
13	379	131	44	32	38	44	28		86	22	27	67	
14	341	115	49	27	38	*a* 44	29		86	22	27	61	
15	322	115	44	27	38		30		73	27	27	61	
							31		86	22		49	

a Estimated.

NOTE.—These discharges are based on a rating curve that is well defined.

Monthly discharge of Pembina River at Neche, N. Dak., for 1909.

[Drainage area, 2,940 square miles.]

Month.	Discharge in second-feet.				Run-off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	Accuracy.
June (13 days)	654	268	427	0.145	0.07	11,000	B.
July 7-31	164	73	113	.038	.04	5,600	A.
August	100	22	48.3	.016	.02	2,970	A.
September	32	22	27.7	.0094	.01	1,650	A.
October	73	32	45.9	.016	.02	2,970	A.
November 1-14	67	38	51.9	.018	.009	1,440	A.

MOUSE RIVER BASIN.

DESCRIPTION.

The Mouse (or Souris) River rises in the southeastern part of the Province of Saskatchewan, Canada, and flows southeastward 230 miles to the northern boundary of North Dakota; thence it continues in a southeasterly direction for 80 miles to the southwestern part of McHenry County, where it makes a loop by swinging to the northeast, north, and northwest, and in 90 miles reaches the Canadian boundary again; thence it flows north and east 120 miles through the Province of Manitoba to Assiniboine River, which discharges into Red River 120 miles farther east, at Winnipeg.

The drainage area above the point where the river enters the United States is about 7,200 square miles, nine-tenths of this area being in Saskatchewan and the remainder comprising a narrow strip along the northern edge of North Dakota. Above the point where the river leaves the United States the total drainage area is about 12,000 square miles.

The Mouse has only three important tributaries in North Dakota—Des Lacs River, draining about 700 square miles, and Cut Bank and Willow Creeks, draining each about 1,100 square miles. All three streams flow from a rolling prairie whose surface was left uneven by the ice of the glacial epoch and whose drainage is imperfectly developed. Hence in ordinary years the run-off from only a small portion of the drainage area, perhaps one-fourth, reaches the streams, but the water stands in scattered pools and lakelets that dry away through the season. In unusually wet or stormy years these pools and sloughs overflow, causing abnormal increases in the flow of the river.

The whole area is deeply covered with glacial drift, except a portion of the "Mouse River loop," which is covered with silt and is more level, having been in the glacial epoch the bottom of Lake Souris, an arm of Lake Agassiz, which filled the Red River valley at that time.

The elevation of this drainage basin is 1,450 feet above sea level at the lowest point in North Dakota and about 2,000 feet at its western margin in North Dakota.

In the upper part of its course the river occupies a valley a hundred feet deep and a mile wide; after turning north around the loop, it runs through a prairie scarcely above the water level. The whole stretch in North Dakota is very sluggish on account of its small fall, and in the last 40 miles before the river reenters Canada its total fall is only 8 feet.

The area is without forests or trees except small scattered clumps or groves on the steep hillsides and fringes along the streams. The mean annual rainfall is from 13 to 17 inches, half of which falls in the three months of May, June, and July.

During the winter the streams are closed for at least four months, and the flow beneath the ice is very small. Thaws sufficient to cause any considerable rise or flood in winter are unknown.

The stations in the Mouse River basin were established to determine the practicability of irrigation, and the records have shown that (except in years so wet that the irrigation would be of little value) the flow of the streams is too small to justify as expensive construction as would be necessary for extensive irrigation works in a country of such small slope. The station records are now found to be essential for investigating the methods of reclamation by drainage in the Mouse River loop, and for flood prevention.

The tributaries afford some storage sites, as, for example, at Des Lacs Lakes on Des Lacs River, but losses by evaporation would be so great that this storage would probably be uselesss except for flood prevention.

MOUSE RIVER AT MINOT, N. DAK.

This station which is located north of the Great Northern Railway roundhouse, at Minot, N. Dak., was established May 5, 1903.

Des Lacs River enters 7 miles above the station.

The vertical staff used previous to December 28, 1909, was attached to a pier of the private footbridge about 150 feet from the roundhouse. This bridge was removed June 28, 1909, but the gage was left undisturbed. On December 28, 1909, a new staff gage was installed at the Anne Street bridge about 40 rods downstream. Discharge measurements in the past have been made from the footbridge. In the future they will be made from the Anne Street bridge.

Except as just indicated the location and datum of the gage have not been changed. Channel conditions remain nearly constant. Gage heights at low stages are controlled by a 3-foot rock-filled dam with plank core wall at the "Soo" Railway water tank, a mile below the former location of the gage. At extreme low water this dam raises the water at the gage about 2 feet. During the summer of 1904 the dam was rebuilt and has since remained practically unchanged. It has an approximately level crest. Weir formulas have been found to apply satisfactorily except at extreme low stages, when the slight leakage has to be considered. A good rating curve for nearly all stages has been developed.

Discharge measurements of Mouse River at Minot, N. Dak., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 12	E. F. Chandler	105	715	[a] 10.34	1,040
September 8 [b]	do	48	41.7	3.89	24
December 28 [b]	Chandler and Clark	55	107	3.65	3.2
Do [c]	do			3.65	1.6

[a] Gage height possibly affected by temporary obstruction other than ice.
[b] Made by wading below Soo dam.
[c] Weir measurement at Soo dam.

NOTE.—Measurements on December 28 were unaffected by ice conditions. They are only approximate.

Daily gage height, in feet, of Mouse River at Minot, N. Dak., for 1909.

[Ephraim Cox, observer.]

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		5.75	5.65	5.1	4.65	4.0	4.0	3.2	3.25
2		5.85	5.5	5.1	4.6	3.9	4.0	3.2	3.25
3		5.95	5.45	5.15	4.6	4.0	3.95	3.2	3.25
4		6.0	5.4	5.2	4.55	3.8	4.1	3.2	3.2
5		6.1	5.35	5.35	4.55	3.8	4.1	3.2	3.2
6		6.2	5.2	5.6	4.5	3.85	4.05	3.2	3.2
7		6.45	5.15	5.82	4.5	4.0	4.0	3.2	3.2
8		6.85	5.0	5.92	4.45	4.0	4.0	3.2	3.2
9		7.1	4.95	6.1	4.45	3.9	3.85	3.2	3.2
10		7.65	5.0	6.0	4.4	3.8	3.85	3.2	3.2
11		8.55	5.05	5.82	4.4	3.8	3.8	3.2	3.2
12		9.1	5.1	5.62	4.35	3.9	3.8	3.2	3.2
13		9.4	5.05	5.4	4.35	4.0	3.8	3.2	3.2
14		9.45	5.2	5.25	4.3	4.1	3.8	3.2	
15		9.4	5.2	5.15	4.25	4.1	3.75	3.2	
16		9.3	5.1	5.1	4.2	4.1	3.75	3.2	
17		9.2	5.0	5.1	4.15	4.05	3.75	3.2	
18		8.8	5.1	5.2	4.15	4.0	3.7	3.2	
19		8.65	5.2	5.25	4.15	4.0	3.7	3.2	
20		7.9	5.25	5.35	4.1	4.1	3.7	3.2	
21	5.0	6.85	5.3	5.45	4.1	4.1	3.65	3.2	
22	5.15	6.65	5.35	5.3	4.05	4.1	3.65	3.2	
23	5.3	6.35	5.35	5.2	4.05	4.0	3.65	3.2	
24	5.5	6.25	5.25	5.1	4.0	4.05	3.65	3.2	
25	5.65	6.1	5.2	5.0	4.0	4.1	3.6	3.2	
26	5.8	5.9	5.1	4.95	4.0	4.2	3.55	3.2	
27	6.1	5.85	5.0	4.9	3.95	4.2	3.55	3.2	
28	6.0	5.8	5.0	4.75	3.95	4.1	3.4	3.25	
29	5.9	5.75	4.95	4.7	3.95	3.95	3.35	3.25	
30	5.75	5.7	5.0	4.7	4.0	4.1	3.2	3.25	
31	5.6		5.0		4.0	3.95		3.25	

NOTE.—Gage height for December 28 was 3.65 feet.
Ice conditions prevailed presumably during January, February, the first part of March, and after November 13. The river was frozen at the gage on November 14.

Daily discharge, in second-feet, of Mouse River at Minot, N. Dak., in 1909.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	450	422	268	163	36	36	0.5	0.57
2	....	478	378	268	152	22	36	.5	.57
3	....	506	364	281	152	36	29	.5	.57
4	....	519	349	294	141	11	52	.5	.5
5	....	546	335	335	141	11	52	.5	.5
6	....	572	294	407	130	16	44	.5	.5
7	....	632	281	470	130	36	36	.5	.5
8	....	716	243	497	120	36	36	.5	.5
9	....	761	231	546	120	22	16	.5	.5
10	....	848	243	519	109	11	16	.5	.5
11	....	977	256	470	109	11	11	.5	.5
12	....	1,050	268	413	99	22	11	.5	.5
13	....	1,090	256	349	99	36	11	.5	.5
14	....	1,090	294	308	89	52	11	.5	....
15	....	1,090	294	281	80	52	7.0	.5	....
16	....	1,080	268	268	70	52	7.0	.5	....
17	....	1,060	243	268	61	44	7.0	.5	....
18	....	1,010	268	294	61	36	4.5	.5	....
19	....	991	294	308	61	36	4.5	.5	....
20	....	886	308	335	52	52	4.5	.5	....
21	243	716	321	364	52	52	2.5	.5	....
22	281	676	335	321	44	52	2.5	.5	....
23	321	609	335	294	44	36	2.5	.5	....
24	378	584	308	268	36	44	2.5	.5	....
25	422	546	294	243	36	52	1.5	.5	....
26	464	492	268	231	36	70	1.0	.5	....
27	546	678	243	219	29	70	1.0	.5	....
28	519	464	243	185	29	52	.79	.57	....
29	492	450	231	174	29	29	.71	.57	....
30	450	436	243	174	36	52	.5	.57	....
31	407	....	243	....	36	29	....	.57	....

NOTE.—These discharges are based on a rating curve that is fairly well defined between 36 and 2,600 second-feet. Below 36 second-feet the curve is only approximate owing to leakage through dam and lack of reliable low water measurements.

Discharge November 14 to 30 estimated as equivalent to 0.5 second-foot per day.

Monthly discharge of Mouse River at Minot, N. Dak., for 1909.

[Drainage area, 8,400 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
March 21-30	546	243	411	0.049	0.02	8,970	A.
April	1,080	436	727	.087	.10	43,300	B.
May	422	231	289	.034	.04	17,800	A.
June	546	174	322	.038	.04	19,200	A.
July	163	29	82.1	.0098	.01	5,050	A.
August	70	11	37.7	.0045	.005	2,320	B.
September	52	.5	15.5	.0018	.002	922	C.
October	.57	.5	.509	.000061	.00007	31	D.
November	.57	.5	[a].507	.000060	.00007	30	D.
The period	....	....	....	....	....	97,600	

[a] Partly estimated.

EVAPORATION AT UNIVERSITY, N. DAK.[a]

The evaporation gage at University, N. Dak., was established April 17, 1905. It is located on a pool in a ravine called English Coulee,

[a] For complete description of this station and records of evaporation, rainfall, and temperature for 1905-1908, see Water-Supply Paper U. S. Geol. Survey No. 245, pp. 64-67.

which runs through the campus of the University of North Dakota, which is immediately west of Grand Forks, N. Dak., and 2 miles west of the Minnesota boundary.

The coulee drains about 60 square miles of very level prairie. Except for brief freshets the flow in the coulee is small, varying from 1 second-foot or less to 20 second-feet. In very dry weather the water lies in pools with scarcely any perceptible flow.

A heavy galvanized-iron tank, 3 feet square and 18 inches deep, is placed in the center of an anchored raft, so that the water in the tank is at the same level as the water surface outside. The tank is filled nearly to the top, to a height precisely marked by the pointed tip of a vertical rod in the center of the tank. Once each day, after the change produced by evaporation or rainfall, the water level is restored to the original height, the precise amount of water transferred being measured with a cup of such size that one cupful of water is equivalent to 0.01 inch depth in the tank.

A standard rain gage is located on the open prairie about 10 rods distant. On days of rainfall the difference (which is usually small) between the quantity measured by the rain gage and the surplus in the tank is considered the total evaporation for the day. Observations were made usually about 6 p. m. The water temperature is the mean temperature of the water at that hour; the air temperature is the mean of the maximum and minimum thermometer readings for each day.

Results of observations of evaporation, rainfall, and temperature for 1909 are presented in the following table:

Evaporation, rainfall, and temperature at University, N. Dak., for 1909.

[M. H. Smith and W. R. Holgate, observers.]

Date.	Evaporation.	Rainfall.	Temperature of—	
			Water.	Air.
	Inches.	*Inches.*	*° F.*	*° F.*
April 20 to 30	0.89	0.53	41	35
May 1 to 10	1.23	.05	49	47
May 11 to 20	1.03	.47	53	54
May 21 to 31	1.58	2.08	50	61
June[a]				
July 1 to 10	1.76	.09	72	67
July 11 to 20	1.53	.46	74	63
July 21 to 31	1.73	.41	74	69
August 1 to 10	1.44	1.86	74	71
August 11 to 20	1.42	.06	74	70
August 21 to 31	1.33	.67	67	65
September 1 to 10	1.00	.07	58	59
September 11 to 20	1.37	.50	63	61
September 21 to 30	1.31	.10	54	54
October 1 to 10	.91	.39	55	57
October 11 to 20	.30	.00	34	36
October 21 to 31	.30	.06	34	37
Total for period	19.13	7.80		

[a] Record for June defective.

RAINY RIVER DRAINAGE BASIN.

DESCRIPTION.

Rainy River, which rises in Rainy Lake and flows westward into Lake of the Woods, is an international stream, forming throughout its length a portion of the boundary between Minnesota and the Canadian province of Ontario. The ultimate source of the boundary waters flowing into Rainy Lake is North Lake, in T. 65 N., R. 2 W. The elevation of the source is nearly 440 feet above Rainy Lake.

From the Canadian side the principal tributaries are Turtle, Little Turtle, and Pipestone rivers, which flow into Rainy Lake, and La Vallee and Pine rivers, which flow into Rainy River; from the American side Vermilion and Rat Root rivers flow into Rainy Lake, and Little Fork, Big Fork, Black, Rapid, and Winter Road rivers flow into Rainy River. The entire drainage area above Lake of the Woods is 20,400 square miles.

From Rainy Lake, which has an approximate area of 344 square miles, to International Falls the banks of the river rise 10 to 12 feet above the water surface; below the falls the general surface level has remained unchanged, although the river has dropped 23 feet and the banks are correspondingly higher. During the glacial period a large portion of the drainage basin was covered by a lake which is known as Lake Agassiz, and in consequence this portion of the surface is very smooth. The country is for the most part flat, but a few hills rise 50 to 75 feet above the plain.

Above Rainy Lake there is an immense area, thickly dotted with lakes drained by streams that flow over bed rock and find their way through the lake into Rainy River; the tributaries to the west flow over the glacial drift without touching the underlying rock. In the area below Rainy Lake few lakes are found. The northward slope of the area south of Rainy River is not sufficient to afford good drainage, and consequently there are extensive areas of swamp. Dry land in general is found only along the banks of the streams which flow in very tortuous channels cut 5 to 40 feet below the surface. So wet is the country that very few settlers are found except near the rivers, and during the open season canoes afford the chief means of transportation. Very little reclamation work has been undertaken, but about 40,000 acres have been drained in Koochiching County.

Between the south end of Bow String Lake and the head of Big Fork River and Lake Winnibigoshish is a continuous river valley, which, during high-water stages, makes connection between Mississippi River and Hudson Bay. In the eastern part of area there is probable connection between North and South lakes in Rainy and Superior drainage, respectively. The range of elevations in the basin is from 1,025 to 2,000 feet above sea level.

The greater part of the drainage basin is heavily forested though it has been cut over extensively, at least in Minnesota. Very little of the land, however, has been cleared. Many of the streams are used for driving logs.

No rainfall stations have been maintained by the Weather Bureau in this basin, but at stations just south of the southern boundary of the basin the records show an annual rainfall of about 27 inches.

From November to April the streams are frozen entirely over and are much used as roadways. The snow is heavy and remains in the forests until late in the spring.

The lakes in the upper part of the basin afford many reservoir sites for the regulation of the stream flow. The high dam at Koochiching Falls backs the water up in Rainy Lake, which provides immense storage.

Water power is available at a number of places in the basin, as most of the streams have a good fall, but by far the largest and, at present, the only utilization is at International Falls where a plant, to be used largely in operating the wood pulp mills which are being erected at the power site, will develop 18,000 horsepower on the American side and a like amount on the Canadian.

RAINY RIVER AT INTERNATIONAL FALLS, MINN.

This station, which was established by the Minnesota and Ontario Power Company March 1, 1907, is located at its American power house, a short distance below its dam at International Falls and 2 miles below the outlet of Rainy Lake. The records represent the run-off from the Rainy Lake region and are important because of the power available on Rainy River. The drainage area above the gage is 14,200 square miles.

Observations of gage height, made on the staff gage installed by the company on the cofferdam surrounding the power house, have been furnished the United States Geological Survey gratis since the station was established. In the later part of 1909 the Geological Survey began a rating of the station, and when that is completed the daily discharge since the beginning of the gage-height observations can be computed, as the channel is permanent. The discharge measurements are made by means of a boat and cable at a section several hundred yards below the gage, where an island divides the river into two channels.

The flow at the gaging section is controlled to a certain extent by the dam of the power company. Owing to the filling of the reservoir above, which includes Rainy Lake itself, the flow for the latter part of 1909 was less than the natural run-off.

The presence of the dam prevents ice at the gaging section, and the open-water rating curve applies throughout the year.

Conditions at this station are excellent, and the records of flow should therefore be reliable.

Discharge measurements of Rainy River at International Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 29	G. A. Gray	520	7,310	464.97	8,560
November 27	C. R. Adams	466	6,390	462.92	5,190

Daily gage height, in feet, of Rainy River at International Falls, Minn., for 1907–1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1			464.0	463.0	463.3	466.0		467.7		470.6	469.7	
2			464.0	462.6		465.9		467.7		470.6	469.7	468.4
3			464.0	462.6	463.6	465.8	467.1			470.6		
4			464.0	462.5	463.8	465.6			470.2	470.5	469.6	468.9
5			464.0	462.4		465.5	467.2		470.2	470.5	469.6	468.9
6			464.0	462.4	464.0	465.4			470.2		469.6	469.0
7			464.0					467.8	470.2	470.6	469.5	
8			464.0	462.6	463.9	465.5	467.4	467.9		470.6	469.5	
9			464.0	462.5	464.0			467.9	470.3	470.5	469.5	
10				462.5	463.9	465.4		467.9	470.3	470.6		
11			463.9	462.6	464.0	465.4			470.3	470.5	469.4	
12			463.8	462.5		465.5		469.4	470.2	470.5	469.3	
13			463.7	462.5	464.0			469.5	470.3		469.2	
14			463.7	462.5	463.9	465.6		469.5	470.3	470.5	469.1	
15			463.7	462.4			467.6	469.5	470.3	470.4	469.1	
16			463.7	462.3	464.4		467.6	469.4	470.3	470.3	469.1	
17				462.3	464.9	465.7		469.2	470.3	470.3		
18			463.5	462.5	465.2	465.7		469.2	470.3	470.3		
19			463.5	462.6	465.5	465.8		469.5	470.3	470.3	468.9	
20			463.5	462.6	465.6	465.8		469.5	470.5		468.9	
21			463.3		465.6			469.6	470.5		468.8	
22			463.3	462.7	465.5			469.6			468.7	
23			463.0		465.5		468.0	469.6	470.8	469.9	468.6	
24					465.6	466.2		469.6	470.8	469.8		469.2
25			462.9	463.7	465.6	466.3			470.8	469.8	468.6	
26			462.5	463.7	465.7			469.7	470.8	469.8	468.5	
27			462.7	463.8	465.8			469.8	470.8		468.5	
28			462.8	463.5	466.2			469.8	470.8	469.7		
29			462.8	463.5		466.5				469.8		
30			462.8	463.4				469.9	470.7	469.8		
31								470.2		469.8		468.8
1908.												
1								468.5		466.3		465.5
2										466.2	464.8	465.8
3	468.8					467.2	467.7		467.3		464.7	465.7
4			466.1								464.6	465.5
5										466.1	464.6	465.4
6		467.6					467.7	468.3			464.5	
7				462.1							464.4	465.2
8	468.5						467.9		467.0			465.1
9						468.6					464.3	465.1
10											464.3	465.0
11			465.7				467.8	468.2	466.9		464.2	464.9
12											464.2	464.9
13	468.0	467.0				469.0					464.2	
14											464.2	464.7
15					466.6			468.2		465.5		464.7
16							468.0		466.6	465.5	464.0	464.6
17									466.6	465.4	464.0	464.6
18	468.0			464.1		467.3		468.2	466.5		464.0	
19			465.6						466.5	465.3	464.0	464.5
20		466.8					469.1				464.0	

Daily gage height, in feet, of Rainy River at International Falls, Minn., for 1907–1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
21								468.0	466.4	465.2	463.9	464.5
22												464.5
23	468.2										463.8	464.5
24										465.1	463.8	464.4
25							468.8				463.7	
26						467.6		467.3	466.3	465.1	463.7	464.3
27					468.2						463.7	
28		466.6					468.6			465.0	463.7	464.2
29										465.0		464.1
30			463.6	467.5						464.9	463.6	464.1
31	467.8							467.5		464.9		464.8
1909.												
1	464.3	464.1	463.7	462.8	460.4	459.2	466.3	465.3	464.9	464.9	465.0	463.0
2	464.2	464.1	463.7	462.6	460.5	460.0	466.3	465.3	464.6	464.8		463.0
3		464.0	463.6	462.5		461.0	466.4	465.4	464.9			463.9
4	464.2	464.0	463.6			462.2		465.8	465.3	464.8		
5	464.3	464.0	463.5	462.4		462.6	466.3	465.6		464.8		
6	464.3	463.9	463.4	462.0	460.6	462.9	466.4	465.7	465.4	465.6		466.4
7	464.3				460.9	462.1	466.3	465.8	464.7	465.6		468.1
8	464.3	464.0	463.3	461.9	461.2	462.3	466.4		464.4	465.6		468.6
9	464.3	464.0	463.2	461.8	461.5	463.1	466.4	465.9	465.1	465.6		468.6
10		464.0	463.2	461.7	461.6	463.2		466.2	465.4			
11	464.3	464.0	463.2		461.6	463.4	466.2	466.4	465.8	465.7		
12	464.3	464.0	463.1	461.5	461.6	463.2	466.2	466.4		465.8	462.2	
13	464.3	464.0	462.9	460.4	462.3		465.6	467.5	465.9	465.9	461.6	468.3
14	464.3			460.3	463.9	463.7	465.7	468.0	465.8			468.2
15	464.3	463.9	462.8	460.3	465.0	463.8	465.6		465.8		461.7	
16	464.3	463.9	462.8	460.3	465.3	463.9	465.9	467.9				468.0
17		463.9	463.6	460.2	465.0	463.8	465.9	467.6	465.8			
18	464.2	463.9	463.6		464.4	463.9		467.2	465.8		461.9	468.1
19	464.2	463.9	463.6	459.6	463.7		466.5	467.0		463.8	461.9	
20	464.2	463.9	463.6	459.6	463.1		466.5	466.9	464.8	463.9	462.0	468.0
21	464.1			458.7	462.4	463.9	466.5	467.2	464.8	464.2		
22	464.0	463.8	463.4	459.4	461.8	464.7	466.5		464.9	464.6	462.2	
23	463.9	463.8	463.3	459.5	461.3	464.8	466.3	466.8	464.9	464.8	462.5	467.6
24		463.8	463.3	459.7	460.9	465.1	466.0		465.0	465.2		
25	464.2	463.8	463.3		460.5	465.3		465.7	465.0	465.3	461.3	
26	464.1	463.8	463.3	459.9	460.0	465.4	465.8	464.0		465.6	461.6	
27	464.0	463.7	463.2	460.0	459.7	465.7	465.1	464.1	465.0	465.7	462.9	468.1
28	464.0			459.9	459.4	465.9	465.5		465.0	465.5		
29	464.2		463.2	460.0	459.1	466.1	465.6		465.0	465.5	463.0	468.1
30	464.3		463.1	460.2	458.9	466.3	465.4	464.5	464.9	465.3	463.0	468.1
31			462.9		459.0		465.4	464.4		465.2		

NOTE.—Owing to the presence of the falls, and later of the dam, there is very little ice effect at this station during the winter.

LITTLE FORK RIVER AT LITTLE FORK, MINN.

This station, which is located at the lower of the two highway bridges at Little Fork, Minn., was established June 23, 1909, in connection with the general investigation of the water resources of Minnesota. The data obtained will be of value also for power and drainage studies. The drainage area above the station is 1,720 square miles.

The nearest tributary is Beaver Brook, which enters the river 1½ miles below the station.

Little Fork is used extensively for log driving during the spring and summer months, although no dams are known to exist on the headwaters for the purpose of controlling the natural flow. The river is frozen over at the station and observations are discontinued from November to April.

The datum of the staff gage has remained unchanged since the station was established.

Discharge measurements are made from the bridge at ordinary stages and by wading at extreme low stages.

As the station has not yet been completely rated, no estimates of daily flow can be made.

Discharge measurements of Little Fork River at Little Fork, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 4	G. A. Gray	122	201	5.52	237
July 24	Robert Follansbee	122	184	5.41	190
August 26	G. A. Gray	133	452	7.66	910
September 30	do	132	445	7.50	824

Daily gage height, in feet, of Little Fork River at Little Fork, for 1909.

[Theo. La Chapelle, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		5.59	5.62	8.02	7.18	8.80	16		5.22	13.95	5.62	6.85	
2		5.58	5.52	7.70	6.96	8.54	17		5.20	13.35	5.60	6.95	
3		5.52	5.45	7.32	6.90	8.38	18		5.24	12.38	5.54	7.12	
4		5.45	5.48	7.06	6.60	8.18	19		5.36	10.32	5.58	7.15	
5		5.41	5.50	7.80	6.42	7.90	20		5.38	9.90	5.62	7.38	
6		5.38	5.80	6.58	6.18	7.78	21		5.38	8.60	5.71	8.52	
7		5.34	5.85	6.34	6.10	7.61	22		5.40	8.15	5.79	10.21	
8		5.34	6.55	6.22	6.00	7.45	23	6.12	5.38	7.78	6.08	10.85	
9		5.31	7.58	6.10	6.01	6.92	24	6.06	5.34	7.72	6.14	11.58	
10		5.25	7.69	5.95	6.12	7.10	25	5.96	5.64	7.72	6.98	11.59	
11		5.16	9.45	5.80	6.28	7.30	26	5.86	5.81	7.62	7.75	11.30	
12		5.10	13.55	5.78	6.45	7.14	27	5.82	5.86	7.58	7.92	11.00	
13		5.12	14.19	5.70	6.50	6.85	28	5.76	6.01	7.62	7.92	10.55	
14		5.25	14.61	5.70	6.50		29	5.71	6.05	8.08	7.75	9.90	
15		5.22	14.39	5.65	6.60		30	5.68	5.94	8.15	7.45	9.35	
							31		5.78	8.30		9.10	

NOTE.—The river was frozen November 14 to December 31.

BIG FORK RIVER AT BIG FALLS, MINN.

This station, which is located on the Minnesota & International Railroad bridge crossing Big Fork River from Big Falls to Grand Falls, was established August 27, 1909, for the purpose of obtaining data concerning the power available at the falls, a short distance below the station.

The nearest important tributary is Sturgeon River, which enters Big Fork about 3 miles below Big Falls. The drainage area above the station is 1,320 square miles.

Like most of the streams in northern Minnesota, Big Fork is used in the spring for log driving, and the log jams that frequently occur may cause temporary backwater at the gage and render it impossible to make discharge measurements. The stream is ice bound from December to April.

The bridge from which the discharge measurements are made is oblique to the current. The datum of the staff gage, which is located at the measuring section, has remained unchanged since the gage was installed.

As the station has not yet been rated no record of daily flow can be given.

Discharge measurements of Big Fork River at Big Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 27	G. A. Gray	266	1,510	4.66	960
October 1	do	246	1,210	4.01	535

Daily gage height, in feet, of Big Fork River at Big Falls, Minn., for 1909.

[Chas. P. Benbow, observer.]

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1		4.46	4.02	4.90	16		3.73	4.55	4.00
2		4.34	3.94	4.81	17		3.75	4.60	4.05
3		4.18	3.90	4.72	18		3.71	4.60	4.09
4		4.09	3.89	4.66	19		3.82	4.65	4.14
5		4.01	3.88	4.61	20		3.90	4.85	4.22
6		3.92	3.88	4.52	21		3.98	5.15	4.34
7		3.89	3.85	4.45	22		4.16	5.70	4.35
8		3.79	3.85	4.40	23		4.35	6.05	4.35
9		3.76	3.90	4.40	24		4.42	6.05	4.35
10		3.71	4.05	4.35	25		4.41	6.01	4.35
11		3.69	4.26	4.31	26		4.32	5.85	4.35
12		3.65	4.42	4.18	27	4.69	4.22	5.65	4.35
13		3.68	4.50	4.10	28	4.78	4.14	5.45	4.35
14		3.68	4.50	4.05	29	4.86	4.10	5.25	4.35
15		3.71	4.50	4.00	30	4.80	4.05	5.11	4.35
					31	4.65		4.99	

NOTE.—Ice during the latter half of November and all of December.

BIG FORK RIVER NEAR LAUREL, MINN.

A station was established June 22, 1909, on Big Fork River near Laurel. Because of the inaccessibility of the station and the expense of maintenance, it was discontinued September 12, 1909, the station at Big Falls taking its place. Sufficient data were not obtained to enable estimates of flow to be made. The gage heights were read on a staff gage.

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

July 1, 1909: Width, 150 feet; area, 381 square feet; gage height, 5.45 feet; discharge, 191 second-feet. This measurement was made by wading.

Daily gage height, in feet, of Big Fork River at Laurel, Minn., for 1909.

[Tharread Berg, observer.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1		5.45	5.05	8.38	16		5.04	10.55	
2		5.42	5.05	8.28	17		5.04	10.10	
3		5.30	5.12	7.90	18		5.05	9.50	
4		5.21	5.14	7.65	19		5.18	9.25	
5		5.28	5.28	7.40	20		5.14	9.05	
6		5.30	5.40	7.38	21		5.11	8.85	
7		5.20	5.54	7.32	22	5.92	5.12	8.50	
8		5.16	5.58	7.25	23	5.85	5.10	8.25	
9		5.12	6.30	7.20	24	5.76	5.05	8.20	
10		5.20	6.95	7.08	25	5.72	5.08	8.78	
11		5.15	7.35	7.00	26	5.64	5.11	8.95	
12		5.14	9.55	7.00	27	5.58	5.10	9.12	
13		5.10	11.25		28	5.51	5.10	9.22	
14		5.08	11.15		29	5.48	5.09	9.40	
15		5.05	11.05		30	5.45	5.10	9.20	
					31		5.06	9.05	

BLACK RIVER NEAR LOMAN, MINN.

A station was established June 23, 1909, on Black River near Loman. Because of the small flow of the stream the station was discontinued September 4, 1909. The gage heights were read on a staff gage. Sufficient data were not obtained to enable estimates of flow to be made.

Discharge measurements of Black River near Loman, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 1	G. A. Gray	29	22.8	5.18	11.9
Do	do	29	22.8	5.18	11.8

Daily gage height, in feet, of Black River near Loman, Minn., for 1909.

[George Norman, observer.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1		5.18	4.81	5.85	16		4.95	7.54	
2		5.20	4.80	5.65	17		4.92	7.12	
3		5.16	4.80	5.50	18		4.89	6.65	
4		5.09	4.85	5.50	19		5.05	6.30	
5		5.12	4.82		20		5.00	6.00	
6		5.12	4.95		21		5.02	5.95	
7		5.02	4.95		22		5.06	5.90	
8		5.00	5.22		23	5.70	5.04	6.22	
9		4.99	5.69		24	5.55	5.00	6.28	
10		4.96	6.00		25	5.50	4.98	7.05	
11		4.95	6.08		26	5.40	4.98	7.39	
12		4.92	6.75		27	5.30	4.96	7.30	
13		5.02	7.30		28	5.30	4.96	7.05	
14		5.06	7.80		29	5.50	4.89	6.75	
15		5.00	7.72		30	5.20	4.86	6.60	
					31		4.85	6.22	

UPPER MISSISSIPPI RIVER DRAINAGE BASIN.

GENERAL DESCRIPTION.

Mississippi River drains the greater part of the territory of the United States lying between the Allegheny and the Rocky Mountains. Its basin, irregular in shape, occupies the central part of the United States, and is best described as an oblong, with the major axis, 1,700 miles in length, running southeastward from the northwestern part of Montana, through North Dakota, Nebraska, Missouri, and Tennessee, into the northwestern corner of Alabama. On each side of this line the basin spreads out from 300 to 500 miles, and on the east is a large protuberance from the general outline extending to the Alleghenies. The basin comprises about 1,240,000 square miles, and includes wholly or in part 30 States, besides a small area in the Dominion of Canada. Of the total area, about 527,000 square miles drain to the Missouri, about 171,500 square miles to the upper Mississippi above the mouth of the Missouri, and about 204,000 square miles to the Ohio. The mean annual flow of the Missouri is about 100,000 second-feet; of the upper Mississippi, about 125,000 second-feet; of the Ohio, about 300,000 second-feet.

Immediately beneath the covering of drift at the sources of the Mississippi lie the oldest rocks known to the geologist. Its mouth is surrounded by the soft marshes of its own delta now forming. Between these two extremes rocks of all geologic ages are represented.

All varieties of topography are likewise exhibited in the drainage basin, mountain and prairie, arid plain, and alluvial bottom covered with vegetation, being fully represented; but the greater part of its broad extent is very uniform in contour.

For convenience in publication the basin of Mississippi River has been divided into the upper Mississippi, Missouri River, lower Mississippi, and Ohio drainage basins. The upper Mississippi basin, as considered in this discussion, is that portion lying above the mouth of the Missouri. The upper Mississippi basin therefore occupies the north-central part of the United States, including Minnesota, Wisconsin, Iowa, Illinois, Indiana, Missouri, and a few square miles in South Dakota and the northern peninsula of Michigan. The sources of this branch of the great river are almost exactly in the center of the continent on an east and west line.

The Mississippi rises, not in Lake Itasca, so long considered the source, but in a smaller lake called Hernando de Soto, which is situated in the northeastern part of Becker County, Minn., and which drains into Lake Itasca through Nicollet Creek. From these lakes to the mouth of Crow Wing River it flows almost in a circle, as at this point it is only 75 miles from its sources, while the distance following the river is 350 miles. Leaving the lakes its course is northward, but below the junction with the Crow Wing it turns to the south and continues in this direction until it finally reaches the Gulf of Mexico.

The total length of the river is about 2,555 miles; from the source to the mouth of the Ohio is about 1,500 miles.[a]

The important tributaries of the upper Mississippi, beginning at the source and following down the west bank, are Leech Lake, Willow, Pine, Crow Wing, Sauk, Crow, Minnesota, Cannon, Zumbro, Root, Turkey, Wapsipinicon, Iowa, Des Moines, and Missouri Rivers; on the east bank are Prairie, Elk, Rum, St. Croix, Chippewa, Black, La Crosse, Wisconsin, Rock, Illinois, Kaskaskia, Big Muddy, and Ohio rivers.

From Lake Hernando de Soto to the Falls of St. Anthony the river flows almost exclusively through a drift-covered region. Down to Pokegama Falls it occupies a valley which is in some places narrow, in others broad and savanna-like, with many rapids in the narrower and with gentle or sluggish currents in the broader portions. In this part of its course it drains a number of lakes, among which Bemidji, Cass, Winnibigoshish, and Leech are the most important. The first rock in place is at Pokegama Falls, and thence to the mouth of Crow Wing River, which enters from the west, the average width of the stream is 300 feet, the valley is less winding, and the current is good, with many rapids of small extent.

Below the mouth of the Crow Wing the river flows in a general southeasterly direction for about 475 miles. Within this stretch are several rapids—the chief being Little Falls and Sauk Rapids—and many timbered islands. The banks are abrupt, of clay or sandy loam, and lead to meadows that stand 60 feet above the river. At the falls of St. Anthony the river pitches down a vertical fall and rapids amounting to 80 feet in half a mile, and in so doing leaves the prairie and clay banks for a channel that lies between rocky bluffs of limestone and sandstone, which continue for many miles down the river, gradually increasing to a height of 500 feet as the bed sinks below the general prairie level. The sides of the bluff are not vertical, bare surfaces of rock, but are composed of easily eroded stone and drift, which form well-wooded or grassy slopes. It is believed by geologists that the gorge from the mouth of the Minnesota River to St. Anthony Falls was caused by the gradual wearing away of the falls, which were originally at the mouth of the Minnesota.

Minnesota River enters the Mississippi about 16 miles below St. Anthony Falls, and below its mouth the width of the main stream averages 1,000 feet. From this point to the mouth of the Missouri it

[a] The Twenty-second Annual Report of the United States Geological Survey, pt. 4, p. 210, contains a detailed description of the Mississippi from the sources to St. Paul, taken from the Reports of the Chief of Engineers, U. S. Army. The hydrographic investigations of the United States Engineer Corps on the upper Mississippi extend over a period of thirty-two years, from 1866 to 1898, and form, according to the Report of the Chief of Engineers for 1897, "the largest continuous record over large drainage areas that has been made in the United States."

is a broad, placid stream, containing innumerable islands, the entire width of the valley averaging 1 mile. In many places, especially where tributaries enter, fertile flats lie between the river and the bluffs. Fifty-five miles below the mouth of the Minnesota is Lake Pepin, an expansion of the river apparently caused by the immense quantities of sand brought down by the Chippewa. At two places exceptions occur to the otherwise placid character of the river. At Rock Island, Ill., 384 miles from St. Paul, there are rapids by which the river falls about 20 feet in 12 miles; and at Keokuk, Iowa, 509 miles from St. Paul, is the foot of the Des Moines Rapids, where in a distance of 11 miles the river falls about 22 feet.

The following table, compiled chiefly from the charts of the Mississippi River Commission, shows the elevations at different points of the upper river. (The distances are measured along the river channel.)

Elevations and distances along Mississippi River.

	Distance below Lake Itasca.	Elevation.
	Miles.	*Feet.*
Lake Itasca	0	1,472
Lake Bemidji, above dam	42	1,340
Winnibigoshish Lake, above dam	85	1,304
Leech Lake River	117	1,285
Ball Club River	120	1,282
Vermilion River	142	1,278
Rice Creek	149	1,277
Above Pokegama dam	158	1,277
Above Grand Rapids dam	161	1,268
Prairie River	164	1,246
Swan River	203	1,229
Dinky Rapids	215	1,225
Oxbow Rapids	226	1,217
Sandy River	234	1,212
Willow River	262	1,203
Aitkin	282	1,194
Indian Lake outlet	309	1,189
Pine River	313	1,180
Above Brainerd dam	334	1,172
Buffalo Creek	340	1,152
Crow Wing River	347	1,149
Pipe Island	358	1,138
Above Little Falls dam	372	1,102
Pike Creek	374	1,078
Two Rivers	383	1,032
Above Sartell dam	404	1,014
Sauk River	407	992
Above St. Cloud dam	410	978
Clearwater River	422	936
Silver Creek	430	929
Monticello	439	897
Elk River	450	859
Crow River	456	843
Rum River	464	827
Above St. Anthony Falls, upper dam	473	796
Below St. Anthony Falls, lower dam	473	718
Below United States Lock and Dam No. 2	478	702
Minnesota River	490	692
St. Paul	496	689
Lake St. Croix	522	673
Red Wing	542	668
Frontenac	553	667
Chippewa River	570	664
Wabasha	574	663
Whitewater River	590	652
Winona	608	643
Root River	638	628
State line	658	615

The headwaters of the main stream and its tributaries which lie in Wisconsin and in Minnesota north of a line drawn diagonally through Douglas, Stevens, Meeker, McLeod, Sibley, Lesueur, Rice, and Dakota counties are in a region that was originally forested. Most of this area has been cut over extensively, though a comparatively small proportion has been cleared except in the southern part of the area where agriculture is making rapid strides. The remainder of the drainage area is prairie land.

The entire basin, at least as far south as the southern boundary of Minnesota, is covered with glacial drift of varying thickness. The tributaries north of St. Anthony Falls at Minneapolis flow over the drift without uncovering the underlying rock, while those farther south have worn deep valleys through both the drift and the rock. Along these bluffs are found many springs.

Rainfall records have been kept in the upper basin for many years and from them the following data have been compiled:

Mean annual rainfall at points in upper Mississippi basin.

	Inches.
Lake Winnibigoshish, 1888–1909	26.5
Leech Lake, 1888–1909	27.4
Pokegama Falls, 1888–1909	27.9
Sandy Lake, 1893–1909	27.1
Pine River dam, 1888–1909	28.2
Park Rapids, 1885–1909	26.7
Long Prairie, 1893–1909	26.1
Collegeville, 1893–1909	23.3
New London, 1897–1909	23.8
St. Paul, 1837–1909	27.8
Red Wing, 1886–1909	30.2
Wabasha, 1893–1909	30.5
Winona, 1886–1909	30.5

The winters in Wisconsin, Minnesota, and Iowa are severe; snowfall is heavy throughout the greater part of this area, the snow lasts for considerable periods, ice forms to thickness of one to two feet, and lasts for three to four months. In other parts of the drainage basin the winters are milder.

According to some authorities the basin of the upper Mississippi contains from 5,000 to 6,000 lakes, nearly all of which are near the sources of the main river and its northern tributaries. In addition there are vast swamp areas in this region, so that there is great natural storage for steadying the flow of the river. Practically none of this swamp land has been drained at the present time. By building comparatively low dams it will be possible to create reservoirs on many of the lakes.

The river is navigable as far up as St. Anthony Falls, and above that there are navigable stretches from 10 miles below Brainerd to

Grand Rapids; from Cohasset to Pokegama Lake and Ball Club; on Winnibigoshish and Cass lakes, and on Lake Bemidji, Lake Irving, and Lake Plantagenet.

The Army Engineer Corps has built five reservoirs on the Mississippi headwaters for the purpose of aiding navigation during the low water open season. These reservoirs have the following storage capacity:

	Feet head.	Cubic feet.
Winnibigoshish	14	44,000,000,000
Leech Lake	5.7	33,000,000,000
Pokegama Lake	7.5	5,300,000,000
Sandy Lake	9.4	3,200,000,000
Pine River dam	16.2	7,700,000,000

Although the reservoirs are operated primarily in the interest of navigation, water power and flood control are also benefited. The operation during the winter, or nonnavigation season, is based on the necessity for having 39,000,000,000 cubic feet empty storage capacity on April 1 to take care of the spring high water. Thns if the preceding year has been very dry and the storage has been nearly exhausted, the reservoirs allow only the normal minimum winter flow (as determined previous to building the reservoirs) to pass down the river. If the preceding navigation season has not drawn heavily on the reservoirs, the winter flow is increased by a sufficient amount to make possible the required empty storage capacity April 1.

That there are valuable power sites on Mississippi River is shown by the fact that plants at Bemidji, Grand Rapids, Brainerd, Little Falls, Sartell, St. Cloud, and Minneapolis develop about 80,000 horsepower. Besides these there are several other points where a heavy fall occurs within a comparatively short distance, especially between Minneapolis and Brainerd.

The river is used extensively for logging as far down as Minneapolis, and log jams frequently occur on the various bars, that cause more or less backwater for short periods. (See Pl. V, *A*.)

MISSISSIPPI RIVER.

MISSISSIPPI RIVER NEAR FORT RIPLEY, MINN.

This station, which is located at the highway bridge 1 mile north of Fort Ripley, was established June 25, 1909, to obtain data for use in determining the power available on the upper Mississippi.

The nearest tributary, Nokasippi River, enters the main stream a short distance below the bridge. There is no dam nearer than Little Falls below and Brainerd above Fort Ripley.

The flow at Fort Ripley, as at all stations on the upper Mississippi, is controlled by the Government dams on the headwaters for the purpose of increasing the low-water open flow for navigation.

During the open-water season the river is used extensively for driving logs which are likely to form jams on the rapids a few hundred feet below the bridge and cause temporary backwater at the gage. The occurrence of this condition is noted, however, and an allowance is made for such backwater during the period. Ice conditions prevail and observations at this station are discontinued from December to March.

Discharge measurements are made from the bridge to which the staff gage is attached. A gage belonging to the United States Weather Bureau is also fastened to the pier that holds the Geological Survey gage. The datum of the Weather Bureau gage is 1.40 feet higher than that of the Survey gage. The datum of the staff gage has remained unchanged since the station was established.

Conditions at this station are favorable for good results except when the flow is obstructed by log jams. The station has not yet been rated.

Discharge measurements of Mississippi River near Fort Ripley, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 25	Gray and Gibson	358	1,740	6.02	5,360
August 6	Follansbee and Emerson	351	1,610	5.63	4,260
August 31	C. J. Emerson	368	2,280	7.38	7,630
September 9	G. A. Gray	358	1,800	6.22	5,220
November 4	do	352	1,830	6.10	4,790

Daily gage height, in feet, of Mississippi River near Fort Ripley, Minn., for 1909.

[L. A. White, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.62	6.40	7.25	6.35	6.02	6.29	16		5.30	8.62	6.02	5.90	6.00	
2		5.66	6.29	7.16	6.34	6.12	6.38	17		5.40	8.00	5.98	5.85	6.10	
3		5.65	6.48	6.98	6.25	6.15	6.45	18		5.31	8.59	5.88	5.82		
4		5.35	6.05	6.80	6.24	6.15	6.67	19		5.16	8.38	5.81	5.82		
5		5.11	5.72	6.58	6.38	6.10	6.32	20		5.68	8.22	5.89	5.94	6.05	
6		5.31	5.58	6.48	6.35	6.09	7.64	21		6.15	8.00	6.18	6.00	6.05	
7		5.48	5.55	6.50	6.31	6.02	7.65	22		6.98	7.88	6.21	6.07	5.82	
8		5.49	5.50	6.34	6.31	5.98	7.98	23		7.72	7.92	6.29	6.08	6.02	
9		5.35	5.68	6.24	6.38	6.10	8.10	24		7.90	8.10	6.35	6.05	5.99	
10		5.25	5.88	6.22	6.22	6.05		25	6.01	7.68	8.02	6.38	6.05	5.87	
11		5.12	6.26	6.24	6.06	6.05		26	5.96	7.60	7.92	6.31	6.08	5.85	
12		4.95	7.47	6.12	6.12	5.99		27	5.85	7.56	7.79	6.34	6.10	5.95	
13		5.18	7.22	6.10	6.01	5.98		28		7.25	7.61	6.35	6.05	5.94	
14		5.42	8.45	6.16	5.95	6.04		29		7.02	7.55	6.44	6.08	6.01	
15		5.38	8.62	6.06	5.95	5.98		30	5.68	6.76	7.42	6.35	6.18	6.18	
								31		6.61	7.32		6.10		

NOTE.—Ice during December.

MISSISSIPPI RIVER AT ANOKA, MINN.

This station, which is located at the highway bridge connecting Anoka with Champlin, Minn., from which the discharge measurements are made, was established May 8, 1905, to obtain data for use in studies of power and navigation problems. The station was temporarily discontinued from July 20 to August 10, 1906.

Rum River enters a short distance below the station.

The nearest dam is at Minneapolis, but owing to the intervening fall of the river the influence of the dam does not extend to the Anoka station. The first dam above Anoka is at St. Cloud. The flow of the river is controlled by Government dams on the upper river for the purpose of increasing the low-water open-season flow in the interest of navigation.

Although the river is used extensively for log driving there is very little backwater except for a few days due to jams forming below the station. Ice conditions obtain from December to March, inclusive. During this period the river is frozen and observations are discontinued.

The winter flow at this station can be estimated very closely from the records of Mississippi River at Minneapolis as kept by the St. Anthony Falls Water Power Co., by rating the spillway as a weir and noting the amount of water passing the wheels. From these records a quantity varying from 200 to 250 second-feet, depending on the year, has been subtracted to allow for the flow of Rum River and a few other small streams which enter the Mississippi between the Anoka station and Minneapolis.

The original United States Geological Survey staff gage was set to read the same as the United States engineer's gage placed on the same pier in 1896. This latter gage was read for one year, and during that time frequent discharge measurements were made. The staff has since been replaced by a chain gage attached to the bridge. No change in gage datum has been made since the station was established. Although no measurements were made during 1907 and 1908, those made in 1909 indicate no change in the rating curve as developed in 1905 and 1906, and it can therefore be applied to all gage heights since the station was established.[a] (See Pl. III.) This permanence of condition indicates that the records of flow are reliable.

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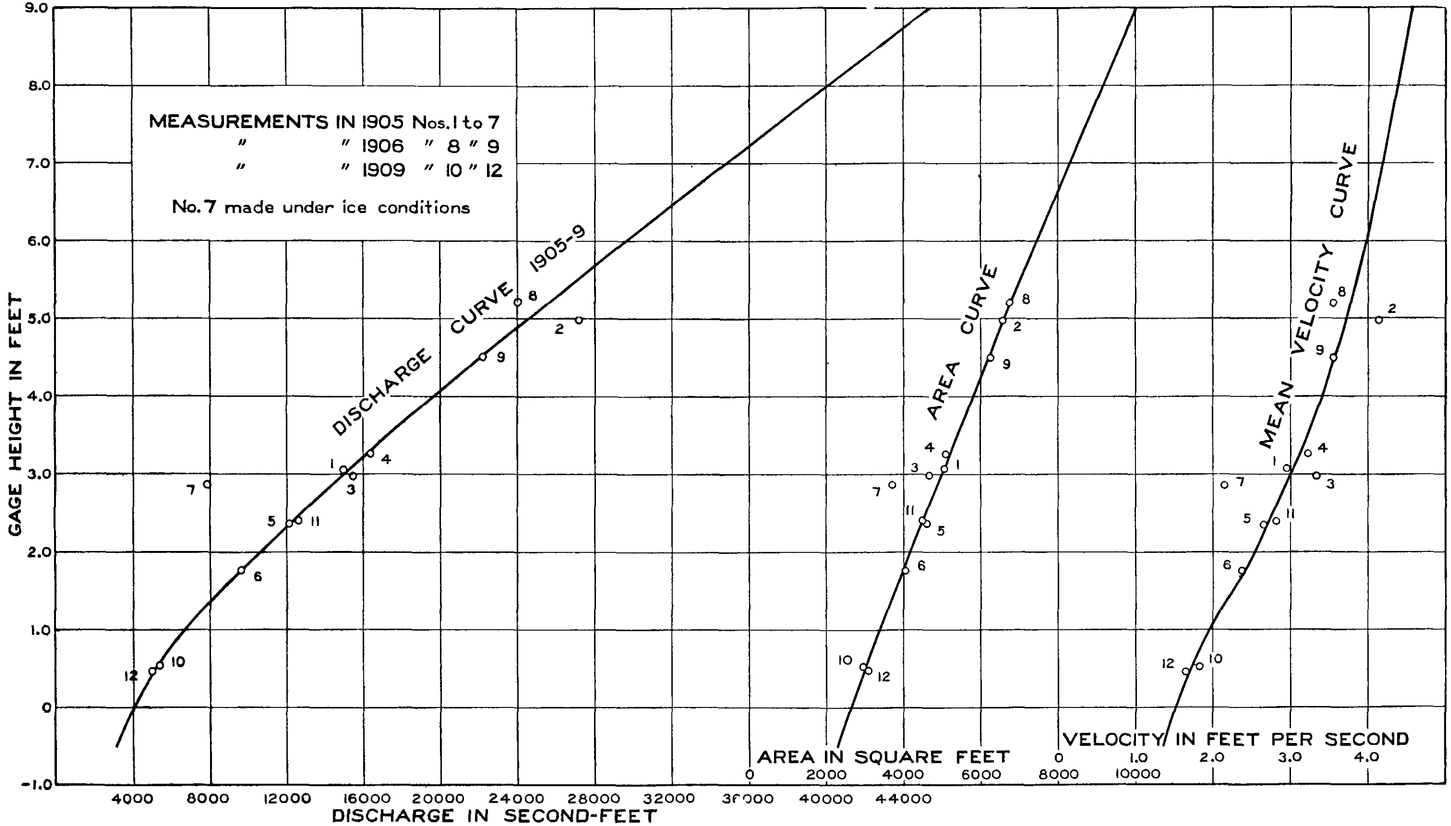
[a] Gage heights for 1905 to 1908 have been published in Water-Supply Papers 171, p. 53; 207, p. 44, and 245, pp. 71 and 72.



DISCHARGE, AREA. AND MEAN VELOCITY CURVES FOR MISSISSIPPI RIVER AT ANOKA, MINN

Discharge measurements of Mississippi River at Anoka, Minn., in 1905, 1906, and 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 8	E. F. Chandler	762	5,050	3.08	15,000
July 21	Raymond Richards	785	6,580	4.98	27,200
August 1	E. F. Chandler	772	4,670	2.97	15,600
August 15	.....do	774	5,090	3.26	16,400
September 16	Raymond Richards	764	4,600	2.36	12,200
November 3	E. F. Chandler	756	4,060	1.77	9,650
December 27 [a]	Raymond Richards	755	3,700	2.86	7,910
1906.					
April 12	Horton and Brennan	776	6,740	5.20	24,000
May 25	M. S. Brennan	781	6,250	4.50	22,200
1909.					
August 7 [b]	Follansbee and Emerson	725	2,980	.52	5,460
August 19 [b]	C. J. Emerson	754	4,500	2.40	12,700
October 18 [b]	G. A. Gray	724	3,100	.48	5,010

[a] Ice measurement made at section 600 feet below bridge. Lower surface of ice at gage height 1.90 feet; average thickness of ice 1.06 feet.
[b] Logs running.

Daily gage height, in feet, of Mississippi River at Anoka, Minn., for 1909.

[Bernard Witte, jr., observer.]

Day.	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1			1.80	1.70	2.20	1.20	1.00	1.40	0.80	0.68
2			2.50	1.70	2.40	1.15	.80	1.35	.90	.78
3			2.50	1.70	2.60	1.00	.80	1.20	.90	.62
4			2.60	1.80	2.60	1.00	.60	1.20	.60	.72
5			3.00	1.80	2.50	.90	.80	1.20	.80	.74
6			3.00	1.80	3.00	.85	.60	1.00	.80	.80
7			3.00	2.10	2.90	.80	.58	.80	.80	.74
8			3.00	2.20	2.40	.70	.70	.75	.80	.70
9			3.00	2.20	2.40	.40	.80	.65	.80	.80
10			3.00	2.40	2.20	.40	.90	.80	.85	.70
11			2.80	2.40	2.00	.30	.80	.70	.90	.65
12			2.60	2.40	1.90	.45	.95	.80	.90	.68
13			2.50	2.20	2.00	.50	1.85	.95	.90	.60
14			2.20	2.00	2.00	.40	2.00	.65	.90	.90
15			2.00	2.00	2.00	.30	2.00	.55	.85	.65
16			1.80	2.20	2.00	.35	2.30	.50	.75	.66
17			2.00	2.20	2.20	.40	2.40	.55	.90	.94
18			1.80	2.20	2.20	.30	2.40	.50	.65	.58
19			1.60	2.20	2.20	.20	2.40	.60	.72	.45
20			1.50	2.20	1.90	.20	2.25		.68	.60
21			1.40	2.20	1.90	.20	2.20	.80	.58	.80
22			1.50	2.20	2.00	.50	2.00	.90	.60	.75
23			1.60	2.10	2.00	.60	1.80	.90	.80	.80
24			1.50	2.10	2.00	1.30	1.90	.95	.64	.76
25			1.50	2.10	2.00	1.80	1.95	.90	.69	.80
26			1.60	2.10	1.90	1.60	1.90	1.00	.68	.92
27			1.60	2.10	1.80	1.40	1.90	.95	.65	.81
28		2.00	1.60	2.00	1.80	1.60	1.80	1.00	.68	1.00
29		2.00	1.60	2.00	1.40	1.40	1.60	.85	.68	.95
30	1.40	1.50	1.70	2.00	1.20	1.20	1.60	.80	.62	.89
31		1.60		2.00		1.10	1.60		.70	

NOTE.—Ice conditions January 1 to about March 27 and during December.

Daily discharge, in second-feet, of Mississippi River at Anoka, Minn, for 1905–1909.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1905.[a]									
1				13,500	32,700	15,000	13,200	11,700	10,700
2				12,400	32,700	15,000	13,000	11,300	9,840
3				11,500	32,700	15,000	12,800	11,300	9,640
4				11,500	33,200	15,000	12,400	10,900	9,640
5				15,000	34,300	14,800	12,400	10,900	9,640
6				15,900	37,400	14,800	12,400	10,700	9,640
7				17,300	41,100	15,000	12,400	10,300	9,640
8				18,300	43,800	15,200	12,400	10,300	10,300
9			15,400	19,200	44,300	15,200	12,200	10,300	10,300
10			17,100	19,700	43,200	15,200	12,200	10,300	10,300
11			18,700	19,700	42,200	15,200	11,900	10,300	10,300
12			21,900	19,700	40,000	15,900	11,500	8,820	10,300
13			26,000	19,700	39,000	16,100	11,500	8,820	9,640
14			28,100	19,700	37,400	16,100	11,500	8,820	9,640
15			30,100	19,700	33,200	16,100	11,700	8,820	9,020
16			30,600	21,100	31,200	16,800	12,200	8,820	8,820
17			32,700	22,600	29,600	19,200	11,700	8,820	8,820
18			31,700	26,100	27,600	19,000	12,800	8,820	8,820
19			29,900	28,600	26,800	[b]18,500	14,100	8,820	8,210
20			27,400	29,100	24,600	17,800	15,000	8,820	8,210
21			25,600	29,400	24,600	18,700	15,700	11,500	8,210
22			24,800	29,100	24,100	18,000	15,000	11,500	8,210
23			24,100	28,600	[b]23,600	16,800	14,800	11,500	7,810
24			23,600	28,100	23,100	16,800	15,400	12,400	[c]7,810
25			22,100	28,600	21,900	16,800	15,400	12,400	[c]7,810
26			21,400	29,900	19,700	15,700	15,400	12,400	[c]7,810
27			19,500	31,700	19,000	16,400	13,200	13,200	[c]7,810
28			18,000	32,700	18,000	16,100	13,200	13,200	[c]7,810
29			17,300	[b]32,700	17,500	15,000	12,400	12,400	[c]7,710
30			15,900	32,700	17,300	14,600	12,200	12,400	[c]7,810
31			14,800		16,400	13,700		11,900	
1906.[d]									
1		11,900	20,900	29,600	23,600	6,900	14,100	17,300	[b]14,700
2		12,400	20,900	28,600	23,800	6,900	14,100	16,600	[b]14,600
3		16,800	20,900	27,600	24,800	7,000	14,100	16,600	[b]14,500
4		26,600	20,900	29,600	24,600	7,100	14,100	15,900	[b]14,400
5		27,100	18,700	29,600	24,800	7,200	13,700	15,000	[b]14,300
6		22,100	18,700	31,900	24,100	7,400	13,500	15,000	[b]14,200
7		27,600	18,700	33,800	23,800	7,600	13,500	14,100	14,100
8		29,600	18,700	34,800	24,600	8,000	13,200	14,100	14,100
9		27,100	18,700	35,800	24,600	8,400	11,900	13,200	13,900
10		26,600	19,700	36,600	23,600	8,610	10,700	11,900	13,700
11		27,100	20,700	36,100	23,600	8,610	8,610	11,900	13,700
12		26,100	20,900	35,800	20,900	8,600	8,610	11,500	13,700
13		26,100	20,700	33,800	20,700	8,820	8,610	11,500	13,200
14		26,600	20,700	32,200	19,700	9,220	8,610	11,500	12,800
15		28,600	18,700	30,100	18,700	9,840	9,840	9,840	12,400
16		29,400	16,800	27,600	17,500	9,840	9,840	9,840	12,400
17		29,400	16,800	25,400	17,300	9,840	9,840	9,840	12,200
18		28,800	16,100	24,100	15,000	9,840	9,840	10,500	11,100
19		28,600	15,900	23,800	14,100	9,840	10,000	10,700	10,300
20		27,600	16,800	23,800	13,000	10,000	10,000	10,700	10,000
21		26,600	17,300	22,100	115,000	10,000	10,300	10,900	9,800
22		26,600	17,500	22,100	10,000	10,000	10,700	10,300	9,600
23		25,100	19,000	23,600	8,700	10,000	10,700	9,840	9,400
24		23,600	20,600	23,800	8,500	10,000	12,200	9,840	9,300
25		20,900	22,100	23,100	8,200	10,000	12,800	9,840	9,200
26		20,900	22,100	22,400	8,000	10,700	14,100	11,900	9,100
27		20,900	22,100	22,400	7,800	11,100	14,300	12,800	9,000
28		21,100	26,600	23,600	7,600	12,800	15,000	14,100	8,900
29		23,600	29,600	23,800	7,400	13,200	15,000	15,000	8,800
30		20,900	29,600	23,800	7,200	14,100	15,000	[b]14,900	8,700
31			29,600		6,900	14,100		[b]14,800	

[a] These discharges are based on a rating curve that is well defined below and 25,000 second-feet, except as indicated.

[b] Interpolated.

[c] Estimated.

[d] These discharges are based on a rating curve that is well defined below 25,000 second-feet, except as noted. Discharges July 21 to August 14 and November 20 to 30 were obtained from a hydrograph furnished by the St. Anthony Falls Power Co. at Minneapolis, allowance being made for inflow between the two points. See description.

Daily discharge, in second-feet, of Mississipi River at Anoka, Minn., for 1905–1909—Continued.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1907.[a]									
1	....	36,900	13,700	19,200	11,900	6,340	7,040	8,210	6,340
2	....	34,800	13,700	18,700	11,100	6,020	6,680	8,210	6,340
3	....	37,400	13,200	17,800	10,300	5,450	6,340	8,210	6,340
4	....	33,800	13,200	17,300	9,430	5,450	6,020	8,210	6,340
5	....	30,600	12,800	16,800	9,020	5,450	5,720	8,210	6,680
6	....	29,600	12,400	16,400	9,020	5,450	5,450	7,810	7,040
7	....	28,600	12,400	15,000	9,430	6,020	5,200	7,420	6,680
8	....	27,600	11,500	14,100	8,210	6,340	4,960	7,420	6,680
9	....	27,100	11,500	13,700	7,810	6,680	4,960	7,420	6,680
10	....	25,600	11,100	14,100	7,420	6,340	4,730	7,420	6,340
11	....	24,600	11,100	15,000	6,680	6,020	4,730	7,040	6,680
12	....	24,100	9,430	18,300	6,340	5,450	4,960	6,680	7,040
13	....	23,100	8,610	20,200	6,020	6,020	4,730	6,340	7,420
14	....	22,100	9,020	21,100	6,340	6,020	4,730	6,020	6,680
15	....	21,100	9,430	22,100	6,680	6,020	4,960	7,420	6,340
16	....	20,200	9,840	22,600	6,680	6,680	5,200	6,680	6,020
17	....	19,700	9,430	21,600	7,420	6,340	5,450	6,340	5,720
18	....	18,700	9,840	20,700	7,420	6,020	5,450	6,340	6,020
19	....	18,300	9,840	19,700	7,040	5,450	5,720	6,340	6,340
20	....	17,800	9,020	18,700	6,680	7,420	6,340	6,340	6,020
21	....	17,300	9,430	17,800	6,340	10,300	7,810	6,340	6,020
22	....	16,800	9,840	16,800	5,450	9,840	8,610	6,340	6,020
23	....	16,400	9,020	16,800	7,040	9,020	10,300	6,340	6,020
24	....	16,400	8,610	15,900	6,680	8,610	9,840	6,020	6,020
25	....	15,000	9,020	15,000	6,020	8,610	9,840	5,720	6,020
26	24,100	15,000	10,300	15,000	5,720	8,210	9,430	6,020	6,020
27	23,100	14,600	11,500	14,100	5,720	8,210	9,020	5,450	5,720
28	25,100	14,100	13,700	13,200	5,720	8,210	9,430	5,200	5,720
29	28,600	13,700	16,400	13,200	5,720	8,210	9,430	5,720	5,720
30	32,200	13,700	18,300	12,400	5,720	7,810	9,020	6,340	5,720
31	37,400	....	19,700	....	6,680	7,810	....	5,720	....
1908.[a]									
1	....	9,430	13,200	26,600	24,100	8,210	5,720	6,680	6,020
2	....	9,430	13,200	28,100	23,100	8,210	5,450	6,340	5,720
3	....	9,430	12,400	29,100	22,100	7,810	5,450	6,680	5,720
4	....	9,020	11,500	28,600	20,700	7,810	5,450	6,020	5,450
5	....	9,020	11,100	27,600	19,700	7,810	5,450	5,450	5,720
6	....	9,020	11,100	27,100	18,700	7,810	5,720	6,680	5,450
7	....	9,020	10,300	27,100	17,800	7,420	5,720	6,020	5,450
8	....	9,430	9,840	27,100	16,800	7,420	5,450	5,450	5,450
9	....	9,430	9,430	29,600	15,900	7,420	5,450	5,450	4,960
10	....	9,020	9,020	32,200	14,600	6,680	5,450	5,450	4,960
11	....	9,020	8,610	34,800	13,700	7,040	5,200	5,200	4,960
12	....	9,020	8,610	39,000	12,800	6,680	5,200	5,200	5,450
13	....	9,020	8,610	37,900	11,900	6,680	5,450	5,720	4,960
14	....	8,610	9,020	35,800	11,100	6,340	5,450	5,450	4,960
15	....	8,210	9,430	33,800	10,700	6,020	4,960	5,450	4,960
16	....	8,210	9,840	31,700	10,700	6,020	5,720	5,450	4,960
17	....	7,420	9,840	29,600	10,300	5,720	6,020	4,960	4,960
18	....	7,420	10,300	28,100	9,840	5,720	6,340	4,960	4,960
19	....	7,040	10,300	26,600	9,840	6,680	6,680	4,960	4,730
20	....	6,340	10,700	24,600	9,840	6,340	6,020	4,960	4,730
21	....	7,040	10,700	24,100	9,430	6,020	6,020	4,960	4,960
22	....	6,680	10,700	24,100	9,430	6,020	6,680	5,200	4,730
23	....	6,340	11,100	24,600	9,430	5,720	5,200	5,200	4,730
24	....	6,680	12,400	24,600	9,020	5,720	5,450	5,450	4,730
25	....	7,420	14,100	24,600	9,020	6,340	5,450	5,720	4,510
26	....	8,210	15,900	25,100	9,020	7,040	5,450	6,020	4,510
27	....	9,020	17,800	25,100	9,020	7,040	5,200	6,020	4,730
28	....	10,300	19,700	25,100	9,020	7,040	5,450	6,020	4,510
29	....	11,500	21,600	25,100	9,020	6,680	6,340	6,680	4,510
30	9,840	12,400	23,600	25,100	8,610	6,020	6,680	6,340	4,510
31	9,840	....	25,600	....	8,610	5,720	....	6,020	....

[a] These discharges are based on a rating curve that is well defined below 25,000 second-feet.

Daily discharge, in second-feet, of Mississippi River at Anoka, Minn., for 1905–1909—Continued.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1909.[a]									
1		9,840	9,430	11,500	7,420	6,680	8,210	6,020	5,670
2		12,800	9,430	12,400	7,230	6,020	8,010	6,340	5,960
3		12,800	9,430	13,200	6,680	6,020	7,420	6,340	5,500
4		13,200	9,840	13,200	6,680	5,450	7,420	5,450	5,780
5		15,000	9,840	12,800	6,340	6,020	7,420	6,020	5,840
6		15,000	9,840	15,000	6,180	5,450	6,680	6,020	6,020
7		15,000	11,100	14,600	6,020	5,400	6,020	6,020	5,840
8		15,000	11,500	12,400	5,720	5,720	5,870	6,020	5,720
9		15,000	11,500	12,400	4,960	6,020	5,580	6,020	6,020
10		15,000	12,400	11,500	4,960	6,340	6,020	6,180	5,720
11		14,100	12,400	10,700	4,730	6,020	5,720	6,340	5,580
12		13,200	12,400	10,300	5,080	6,510	6,020	6,340	5,670
13		12,800	11,500	10,700	5,200	10,000	6,510	6,340	5,450
14		11,500	10,700	10,700	4,960	10,700	5,580	6,340	6,340
15		10,700	10,700	10,700	4,730	10,700	5,320	6,180	5,580
16		9,840	11,500	10,700	4,840	11,900	5,200	5,870	5,610
17		10,700	11,500	11,500	4,960	12,400	5,320	6,340	6,480
18		9,840	11,500	11,500	4,730	12,400	5,200	5,580	5,400
19		9,020	11,500	11,500	4,510	12,400	5,450	5,780	5,080
20		8,610	11,500	10,300	4,510	11,700	[b] 5,740	5,670	5,450
21		8,210	11,500	10,300	4,510	11,500	6,020	5,400	6,020
22		8,610	11,500	10,700	5,200	10,700	6,340	5,450	5,870
23		9,020	11,100	10,700	5,450	9,840	6,340	6,020	6,020
24		8,610	11,100	10,700	7,810	10,300	6,510	5,560	5,900
25		8,610	11,100	10,700	9,840	10,500	6,340	5,690	6,020
26		9,020	11,100	10,300	9,020	10,300	6,680	5,670	6,410
27		9,020	11,100	9,840	8,210	10,300	6,510	5,580	6,050
28	10,700	9,020	10,700	9,840	9,020	9,840	6,680	5,670	6,680
29	10,700	9,020	10,700	8,210	8,210	9,020	6,180	5,670	6,510
30	8,610	9,430	10,700	7,420	7,420	9,020	6,020	5,500	6,310
31	9,020		10,700		7,040	9,020		5,720	

[a] These discharges are based on a rating curve that is well defined below 25,000 second-feet.
[b] Interpolated.

Monthly discharge of Mississippi River at Anoka, Minn., for 1905–1909.

[Drainage area, 17,100 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
1905.							
May 9–31	32,700	14,800	23,300	1.36	1.16	1,060,000	A.
June	32,700	11,500	22,800	1.33	1.48	1,360,000	A.
July	44,300	16,400	30,100	1.76	2.03	1,850,000	B.
August	19,200	13,700	16,100	.942	1.09	990,000	A.
September	15,700	11,500	13,100	.766	.85	780,000	A.
October	13,200	8,820	10,700	.626	.72	658,000	A.
November	10,700		9,010	.527	.59	536,000	B.
December			a 7,190	.420	.48	442,000	C.
The period						7,680,000	
1906.							
January			a 6,020	.352	.41	370,000	C.
February			a 5,340	.312	.32	297,000	C.
March			a 6,580	.385	.44	405,000	C.
April	29,600	11,900	24,500	1.43	1.60	1,460,000	B.
May	29,600	15,900	20,500	1.20	1.38	1,260,000	A.
June	36,600	22,100	28,000	1.64	1.83	1,670,000	A.
July	24,800	6,900	b 16,600	.971	1.12	1,020,000	B.
August	14,100	6,900	b 9,530	.557	.64	586,000	B.
September	15,000	8,610	11,900	.696	.78	708,000	A.
October	17,300	9,840	12,600	.737	.85	775,000	A.
November			b 11,900	.696	.78	708,000	B.
December			a 7,580	.443	.51	466,000	C.
The year	36,600		13,400	.785	10.66	9,720,000	
1907.							
January			a 6,700	.392	.45	412,000	C.
February			a 6,480	.379	.39	360,000	C.
March			a 12,300	.719	.83	756,000	C.
April	37,400	13,700	2,500	1.32	1.47	1,340,000	A.
May	19,700	8,610	11,500	.672	.77	707,000	A.
June	22,600	12,400	17,100	1.00	1.12	1,020,000	A.
July	11,900	5,450	7,350	.430	.50	452,000	A.
August	10,300	5,450	6,960	.407	.47	428,000	A.
September	10,300	4,730	6,740	.394	.44	401,000	A.
October	8,210	5,200	6,750	.395	.46	415,000	A.
November	7,420	5,720	6,290	.368	.41	374,000	B.
December			a 3,600	.211	.24	221,000	C.
The year	37,400		9,520	.557	7.55	6,890,000	
1908.							
January			a 2,590	.151	.17	159,000	C.
February			a 2,740	.160	.17	158,000	C.
March			a 4,340	.254	.29	267,000	C.
April	12,400	6,340	8,600	.503	.56	512,000	A.
May	25,600	8,610	12,600	.737	.85	775,000	A.
June	39,000	24,100	28,400	1.66	1.85	1,690,000	A.
July	24,100	8,610	13,000	.760	.88	799,000	A.
August	8,210	5,720	6,750	.395	.46	415,000	A.
September	6,680	4,960	5,680	.332	.37	338,000	B.
October	6,680	4,960	5,680	.332	.38	349,000	B.
November	6,020	4,510	5,030	.294	.33	299,000	B.
December			a 3,380	.198	.23	208,000	C.
The year	39,000		8,230	.481	6.54	5,970,000	
1909.							
January			a 2,750	.161	.19	169,000	C.
February			a 2,600	.152	.16	144,000	C.
March			a 4,300	.251	.29	264,000	C.
April	15,000	8,210	11,300	.661	.74	672,000	A.
May	12,400	9,430	11,000	.643	.74	676,000	A.
June	15,000	7,420	11,200	.655	.73	666,000	A.
July	9,840	4,510	6,200	.363	.42	381,000	A.
August	12,400	5,400	8,840	.517	.60	544,000	A.
September	8,210	5,200	6,280	.367	.41	374,000	A.
October	6,340	5,400	5,910	.346	.40	363,000	A.
November	6,680	5,080	5,880	.344	.38	350,000	B.
December			a 5,300	.310	.36	326,000	C.
The year	15,000		6,800	.398	5.42	4,930,000	

a Estimated from records kept by the St. Anthony Falls Water Power Company at Minneapolis. See description.

PRAIRIE RIVER DRAINAGE BASIN.

DESCRIPTION.

Prairie River, which empties into the Mississippi about 2 miles below Grand Rapids, drains an area comprising 501 square miles located chiefly in the southeastern part of Itasca County.

The basin is covered with glacial drift, and its surface is comparatively level; consequently the drainage is very poor and lakes and swamps are numerous.

The entire area is forested, though much of it has been cut over, as logging is one of the chief industries in the northern part of the State. Prairie River is used for log driving and its flow is controlled for that purpose by a dam at the outlet of Prairie Lake. The annual rainfall is about 27.5 inches. Storage reservoirs can be created by building low dams across the outlets of the various lakes. No water power is developed in the basin, though the fall of the river affords moderate head at different points.

PRAIRIE RIVER NEAR GRAND RAPIDS, MINN.

This station, which is located at the highway bridge on the State road from Grand Rapids to Bovey, about 5 miles from Grand Rapids, Minn., and about a mile below the outlet of Prairie Lake, was established June 29, 1909, in connection with the general plan of investigating the water resources of Minnesota.

A chain gage is attached to the new bridge just below the old bridge, to which a staff gage is attached, and from which the discharge measurements are made. The datum of the staff gage is 7 feet lower than that of the chain gage. The 1909 gage heights refer to the staff gage. The drainage area above the station is 485 square miles.

Owing to the isolation of the locality, it was not possible to secure an observer after September 11, at which date observations ceased.

Discharge measurements of Prairie River near Grand Rapids, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 8	Hoyt and Gibson	55	128	....	187
June 29	G. A. Gray	55	183	9.68	509
August 4	.....do	55	111	8.35	120
August 25	.....do	65	249	10.55	1,220
October 2	.....do	56	157	9 05	293

Daily gage height, in feet, of Prairie River near Grand Rapids, Minn., for 1909.

[J. C. Hager, observer.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	....	9.38	8.40	9.80	16	....	8.31	10.79	....
2	....	9.25	8.37	9.68	17	....	8.29	10.98	....
3	....	9.12	8.39	9.56	18	....	8.26	11.12	....
4	....	9.02	8.38	9.48	19	....	8.28	11.09	....
5	....	8.95	8.35	9.38	20	....	8.28	11.04	....
6	....	8.82	8.32	9.26	21	....	8.32	11.02	....
7	....	8.72	8.35	9.12	22	....	8.38	10.94	....
8	....	8.61	8.52	9.04	23	....	8.38	10.89	....
9	....	8.55	8.55	8.99	24	....	8.38	10.80	....
10	....	8.46	8.64	8.96	25	....	8.38	10.60	....
11	....	8.41	9.40	8.91	26	....	8.38	10.48	....
12	....	8.39	9.84	....	27	....	8.38	10.44	....
13	....	8.36	10.32	....	28	....	8.38	10.31	....
14	....	8.38	10.43	....	29	9.68	8.38	10.17	....
15	....	8.36	10.72	....	30	9.64	8.38	10.02	....
					31	....	8.36	9.92	....

NOTE.—Gage heights stopped for lack of an observer.

CROW WING RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Crow Wing River lies a little northwest of the center of Minnesota and embraces part or all of Cass, Hubbard, Wadena, Becker, Ottertail, Douglas, and Todd counties. The Crow Wing rises in the southern part of Hubbard County, in a remarkable chain of a dozen lakes, of considerable size, that lie in a river-like valley with abrupt sides 20 to 40 feet high and extend about 30 miles in a northeast-southwest direction. From the most southern of the lakes Crow Wing River flows southward, and after crossing the line into Wadena County receives the waters of Shell River, which heads in Shell Lake in Becker County. Below Shell River the Crow Wing takes a general southerly though very winding course till it is joined by Leaf and Partridge rivers, and then bends to the southeast and enters the Mississippi on the boundary line between Cass and Morrison counties. Aside from the streams above mentioned the only important tributaries are Long Prairie River, which enters from the south, and Gull River, which enters from the north near its mouth. The length of the river, from the outlet of the lakes to the mouth, is 89 miles.

For 20 miles below the lake outlet the river flows between low, swampy banks and has an average width of 175 feet; in its lower course the width of the river gradually increases to about 400 feet, and the banks become gradually higher until at the mouth of the stream they are some 30 feet above the water. The total area drained by the Crow Wing is 3,580 square miles.

Elevations within the basin range from 1,200 to 1,500 feet above sea level. The surface of the country is drift-covered and gently undulating and is elevated but little above the streams. None of the streams have worn their channels through to the underlying rock. Many springs deriving their waters from the porous modified drift are found along the ravines and valleys and on the banks of the lakes.

The basin lies in the original forested section of the State, but much timber has been cut off and very little of the cut-over waste land has been cleared.

Records of rainfall have been kept in this drainage area since 1885, and the mean of the records for the entire period shows the annual rainfall to be about 28 inches. During the winter the streams are covered with ice from 1 to 1.5 feet thick for three or four months.

The basin contains many lakes, some of which, notably the chain of lakes in which the Crow Wing heads, would afford excellent reservoir sites. A logging dam is maintained at the outlet of these lakes for the purpose of driving the logs down the river in the spring. This dam raises the water 7 or 8 feet.

In order to determine the availability of Crow Wing River for power development a survey was made during 1909 from the outlet of the Crow Wing Lakes to the mouth of the river. From the data collected on this survey sheets have been prepared showing a profile of the water surface, a plan of the river, and the contours along the river bank. The results of this survey have been published on separate sheets and may be had upon application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn. From this survey the following table of elevations and distances has been compiled:

Elevations and distances along Crow Wing River.

	Distance above mouth.	Elevation.
	Miles.	*Feet.*
Mississippi River	0	1,148
Gull River	4	1,156
Pillager Bridge	11	1,177
	15	1,188
Long Prairie River	20	1,205
Motley Bridge	22	1,212
	27	1,221
Swan Creek	32	1,230
Red Crow Wing Bridge	37	1,238
Thomastown Bridge	41	1,243
Farnum Creek	49	1,253
Township line, 135-136 N	54	1,261
Oyelen Bridge	57	1,276
Beaver Creek	61	1,300
Nimrod Bridge	65	1,317
Westers Rapids, foot	66	1,320
Westers Rapids, head	67	1,330
Carters Ford	72	1,346
Fivemile bend	78	1,352
Huntersville Bridge	82	1,356
Crow Wing dam, tail-water	89	1,362

None of the available horsepower on the river has been developed.

Areas of swamp, which add to the natural storage of the many lakes, are scattered throughout the drainage basin. It is estimated from the reports of county officials that about 60,000 acres of land have been benefited by drainage.

CROW WING RIVER AT MOTLEY, MINN.

This station, which is located at the highway bridge at Motley, was established June 10, 1909, because of the power available on Crow Wing River and also as a check, in connection with the Long Prairie station, on the records of the station at Pillager.

The nearest tributary is Long Prairie River, which enters Crow Wing River 2 miles below the station. The drainage area above Motley is 2,140 square miles.

The only dam on the river is the logging dam at the outlet of Lower Crow Wing Lake, more than 60 miles above the station. A few hundred yards above the station is a sawmill to which logs are transported by the river. During high water the logs may escape from the log boom at the mill and lodge at the bridge section and on the rapids a short distance below. When lodged at the rapids they may cause slight backwater effect at the gage; when at the bridge they obstruct a portion of the measuring section, making it difficult to secure a satisfactory measurement. Owing to these unsatisfactory conditions the station was discontinued November 30, 1909.

A staff gage was read prior to September 1, on which date a chain gage at the same datum was installed on the bridge.

Discharge measurements are made from the bridge.

During the latter part of the summer the river contains considerable floating grass, which probably somewhat retards the flow, as shown by measurements made during that period, and thus cause backwater at the gage.

The datum of the chain gage has remained unchanged since the station was established.

Owing to the effect of the logging operations, the conditions at this station can not be considered better than fair and the records are not as reliable as those at the Pillager station, which is practically free from logging.

As the station has not been completely rated, no estimates of daily flow can be given.

Discharge measurements of Crow Wing River at Motley, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 24	G. A. Gray	228	656	6.70	1,230
Do	C. B. Gibson	228	656	6.72	1,240
August 4	Follansbee and Emerson	228	662	6.74	1,000
September 1	C. J. Emerson	236	569	6.92	1,130
September 10	G. A. Gray	225	428	6.55	745
October 20	Robt. Follansbee	225	537	6.60	918

Daily gage height, in feet, of Crow Wing River at Motley, Minn., for 1909.

[S. W. Jacobs, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.42	6.84	6.91	6.65	6.60		16	6.88	6.00	8.50	6.55	6.65	6.19	
2		6.40	6.79	6.90	6.59	6.60		17	6.85	6.29	8.48	6.52	6.62	6.52	
3		6.32	6.72	6.85	6.54	6.60		18	6.82	7.00	8.34	6.48	6.62	6.82	
4		6.18	6.72	6.80	6.50	6.58		19	6.90	7.00	8.14	6.49	6.60	6.70	
5		6.05	6.72	6.75	6.50	6.58		20	6.90	7.28	7.80	6.50	6.60	6.64	
6		6.00	6.71	6.69	6.50	6.58		21	6.85	7.44	7.58	6.62	6.65	6.88	
7		5.92	6.71	6.65	6.50	6.55		22	6.88	7.56	7.51	6.82	6.75	6.89	
8		5.88	6.86	6.65	6.50	6.55		23	7.12	7.85	7.40	6.88	6.75	6.75	
9		5.90	7.01	6.62	6.51	6.55		24	7.02	7.62	7.45	6.84	6.75	6.60	
10	6.50	5.88	7.00	6.62	6.66	6.58		25	6.68	7.55	7.44	6.81	6.75	6.62	
11	6.42	5.81	7.36	6.60	6.75	6.56		26	6.59	7.58	7.41	6.80	6.72	6.85	
12	6.40	5.81	7.84	6.60	6.72	6.55		27	6.54	7.44	7.36	6.71	6.70	6.84	
13	6.45	5.84	8.00	6.58	6.70	6.55		28	6.50	7.22	7.22	6.70	6.65	6.85	
14	6.58	5.85	8.06	6.56	6.68	6.58		29	6.50	7.10	7.11	6.68	6.60	7.01	
15	6.82	5.85	8.26	6.55	6.65	6.44		30	6.46	7.04	7.02	6.66	6.60	6.80	
								31		6.96	6.96		6.60		

NOTE.—It is probable that there was backwater from ice during the latter part of November.

CROW WING RIVER AT PILLAGER, MINN.

This station, which is located at the highway bridge half a mile south of Pillager, was established June 11, 1909, on account of the power available on Crow Wing River.

The nearest tributary is Pillager Creek, which enters the river a short distance below the station. The drainage area at this point is 3,230 square miles.

There are no dams near the station, as the only one on the river is a logging dam at the outlet of Lower Crow Wing Lake.

During the latter part of the summer the river contains considerable floating grass, which, as shown by measurements made during that period, somewhat retards and thus causes backwater at the gage. From December to March the river is frozen over at the gage and discharge measurements are made through the ice to determine the winter discharge. The staff gage is located at the bridge from which measurements are made. The datum of the gage has remained unchanged since the station was established.

Conditions at this station are favorable for good results except in the late summer, when the flow may be retarded by floating grass, although the river bed may shift somewhat during high water and thus necessitate the use of more than one rating curve. The records should, therefore, be reliable. As the station has not been completely rated, no estimates of daily discharge can be given at present.

Discharge measurements of Crow Wing River at Pillager, Minn., in 1909.

Date.	Hydrographer.	Width	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 23	G. A. Gray	215	1,000	6.84	1,670
Do	C. B. Gibson	215	1,000	6.82	1,660
August 5	Follansbee and Emerson	215	865	6.33	1,260
September 1	C. J. Emerson	215	837	6.61	1,320
September 10	G. A. Gray	211	716	6.05	904
November 3	do	211	642	6.10	976

Daily gage height, in feet, of Crow Wing River at Pillager, Minn., for 1909.

[Miss Augusta Sterling, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.11	6.49	6.59	6.04	6.12	6.50	16	6.90	5.44	8.89	6.00	6.25	5.72	7.20
2		6.10	6.40	6.54	6.04	6.12	6.62	17	6.90	5.65	8.80	5.98	6.25	6.22	
3		5.88	6.35	6.46	6.00	6.10	6.72	18	6.85	5.40	8.57	5.91	6.21	6.40	7.20
4		5.70	6.29	6.44	5.96	6.10		19	6.95	5.35	8.24	6.00	6.19	6.48	
5		5.62	6.30	6.34	5.95	6.06		20	6.90	5.60	7.82	6.09	6.19	6.40	
6		5.58	6.25	6.31	5.91	6.05		21	6.92	6.50	7.55	6.18	6.26	6.20	
7		5.51	6.18	6.25	5.95	6.05		22	6.85	7.38	7.35	6.50	6.34	6.42	
8		5.45	6.29	6.19	5.98	6.02	7.40	23	6.81	8.05	7.20	6.61	6.35		7.00
9		5.40	6.75	6.14	6.04	6.00		24	6.78	7.95	7.24	6.55	6.30		
10		5.42	6.79	6.11	6.18	6.00		25	6.70	7.79	7.28	6.51	6.32		
11	6.75	5.42	7.30	6.05	6.32	6.00	7.60	26	6.56	7.75	7.18	6.48	6.30	6.35	7.00
12	6.50	5.40	7.98	6.00	6.36	6.00		27	6.42	7.50	7.06	6.38	6.25	6.40	
13	6.45	5.40	8.40	5.98	6.31	6.06		28	6.36	7.22	6.96	6.31	6.19	6.58	
14	6.40	5.40	8.60	5.98	6.30	6.24		29	6.26	6.95	6.82	6.21	6.18	6.42	
15	6.75	5.39	8.77	6.00	6.28	5.58		30	6.18	6.72	6.72	6.11	6.15	6.32	7.00
								31		6.62	6.64		6.12		

NOTE.—Probable ice conditions during the latter part of November and all of December.

The following comparative readings were made:

Date.	Gage height to water surface.	Gage height top of ice.	Thickness of ice.		Remarks.
			At gage.	average.	
	Feet.	*Feet.*	*Feet.*	*Feet.*	
December 8	7.6	7.2	0.5	0.4	Water overflowed ice.
December 11	7.4	7.5	.4	.5	Do.
December 16	7.2	7.6	.7	.7	River frozen entirely across.
December 18	7.2	7.6	.7	.8	Do.
December 23	7.0	7.6	.7	.8	Do.
December 25	7.0	7.6	.7	.8	Narrow open channel.
December 30	7.0	7.6	.8	.8	River frozen entirely across.

LONG PRAIRIE RIVER NEAR MOTLEY, MINN.

This station, which is located at the highway bridge 1 mile south of Motley, in sec. 19, T. 133 N., R. 31 W., was established June 10, 1909, as a check, in connection with the records of the station on the Crow

Wing at Motley, on the records of the Crow Wing at Pillager, a few miles below. The drainage area above this point is 973 square miles.

Long Prairie River enters Crow Wing River 2 miles below the gaging station, but owing to the fall of the Long Prairie no backwater effect is recorded at the gage except possibly for a few days in the spring, when the Crow Wing is ice gorged.

Discharge measurements are made from the bridge except during low stages, when they are made by wading a short distance upstream.

The datum of the staff gage, which is located about 200 feet above the bridge on the left bank, has remained unchanged since the gage was installed.

Conditions at this station are favorable for good results and the records should be reliable.

Discharge measurements of Long Prairie River near Motley, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 24	C. B. Gibson	110	268	5.88	439
August 4	Follansbee and Emerson	103	135	5.12	153
September 1	C. J. Emerson	102	131	5.16	128
September 11	G. A. Gray	97	111	5.08	113

NOTE.—These measurements were made by wading at various sections.

Daily gage height, in feet, of Long Prairie River near Motley, Minn., for 1909.

[John Greene, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.52	5.18	5.15	5.21	5.14	5.45	16	5.72	5.25	5.62	5.10	5.20	5.38	
2		5.50	5.15	5.14	5.19	5.14	5.52	17	5.80	5.25	5.56	5.09	5.18	5.29	
3		5.48	5.14	5.14	5.17	5.14	5.48	18	5.80	5.22	5.48	5.08	5.17	5.31	
4		5.45	5.12	5.14	5.15	5.12	5.45	19	5.82	5.22	5.44	5.10	5.15	5.32	
5		5.42	5.10	5.14	5.15	5.11	5.32	20	5.90	5.28	5.39	5.11	5.22	5.46	
6		5.42	5.10	5.10	5.12	5.10	5.34	21	5.95	5.40	5.35	5.25	5.20	5.31	
7		5.40	5.11	5.11	5.14	5.11	5.38	22	5.98	5.56	5.32	5.38	5.20	5.25	
8		5.40	5.25	5.10	5.15	5.10	5.38	23	6.00	5.54	5.30	5.40	5.19	5.20	
9		5.36	5.35	5.10	5.18	5.10	5.22	24	5.86	5.41	5.32	5.40	5.18	5.17	
10	6.15	5.34	5.34	5.10	5.25	5.12	5.28	25	5.75	5.36	5.30	5.42	5.19	5.19	
11	6.08	5.32	5.60	5.09	5.29	5.11		26	5.69	5.31	5.29	5.40	5.18	5.22	
12	5.95	5.31	5.82	5.08	5.30	5.10		27	5.64	5.29	5.25	5.41	5.12	5.38	
13	5.85	5.30	5.88	5.05	5.28	5.10		28	5.61	5.24	5.22	5.35	5.12	5.41	
14	5.80	5.28	5.82	5.06	5.25	5.25		29	5.59	5.22	5.20	5.29	5.12	5.38	
15	5.72	5.25	5.72	5.08	5.24	5.24		30	5.55	5.20	5.19	5.25	5.14	5.30	
								31		5.20	5.15		5.15		

NOTE.—Ice conditions during the latter part of November and all of December.

SAUK RIVER DRAINAGE BASIN.

DESCRIPTION.

Sauk River drains an area comprising 821 square miles lying south of the basin of Crow Wing River and north of that of the Crow. The Sauk rises in Osakis Lake, in the southwestern part of Todd County, and takes a generally southeasterly course to its junction with the Mississippi about 2 miles above St. Cloud. Its tributaries are not important. In its upper course the river passes through a number of small lakes, and throughout the basin there are many small lakes, some of which have no visible outlet. The entire surface is covered with glacial drift, and is moderately rolling, being from 40 to 80 feet above the level of the Sauk. Elevations within the basin range from 1,050 to 1,400 feet above sea level.

For half its length the Sauk forms the dividing line between the prairie region and the section of original forest which lies north of the river as far south as Richmond. The country below Richmond was formerly included in the timbered belt, but the proportion of forested area has been greatly reduced by clearing.

The mean annual rainfall at three points in this basin has been compiled from records covering periods of more than ten years.

Mean annual rainfall in Sauk River basin.

	Inches.
Long Prairie, 1893–1909	26.1
Collegeville, 1893–1909	23.3
New London, 1897–1909	23.8

The mean derived from the observations at Collegeville and New London indicate an area of abnormally low rainfall in this basin, as records at other stations in the State show a precipitation of 27 inches and upward. The river is frozen over from December to March, and snow remains for considerable periods.

Storage reservoirs may be provided by building dams across the lakes through which the Sauk flows, but at present there are no large reservoirs in the basin.

Water power is developed at Melrose, Sauk Center, Cold Spring, and near the mouth of the river, and a small amount of power may be available at other points on the river.

SAUK RIVER NEAR ST. CLOUD, MINN.

This station, which is located at the highway bridge 3 miles west of St. Cloud and about 2 miles above the mouth of the river, was established July 8, 1909, in connection with the general investigation of the water resources of Minnesota.

The nearest tributary enters Sauk River at Rockville, 10 miles or more above the station. The nearest dam is at the mouth of the river and is 9 feet high. Not only is the station above the influence of this dam, but the dam itself prevents backwater from Mississippi River reaching the station. The first dam above the station is at Cold Springs, 15 miles distant. The opening and shutting of the turbine gates at Cold Springs affect the flow at the gaging station during the low-water season. The drainage area above the station is 816 square miles.

Discharge measurements are made at the bridge section, where is located the chain gage. Gage heights from a temporary staff gage located one-eighth mile above the bridge and used until August 2 have been corrected to the datum of the chain gage. Gage heights are read twice a day, and the mean of the readings is taken as the mean for the day.

From December to March the river is frozen completely over in the vicinity of the gaging station and discharge measurements are made through the ice to develop an approximate winter rating.

On account of the daily fluctuations of the stage of the river due to control of flow by dams above the station, the mean daily gage height during the low-water season is subject to some error, and the records for that period can not be considered better than fair.

Discharge measurements of Sauk River near St. Cloud, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.		Discharge.
				Staff gage.	Chain gage.	
		Feet.	*Sq. ft.*	*Feet.*	*Feet.*	*Sec.-ft.*
July 8	Gray and Gibson	94	176	a 6.22	....	224
August 3	Follansbee and Emerson	94	166	6.14	6.14	174
August 18	C. J. Emerson	94	171	6.20	6.27	217
September 2	.....do	92	143	6.05	5.93	145
October 19	G. A. Gray	87	108	....	5.74	889

a Gage height refers to old staff gage.

NOTE.—Beginning August 3 new chain gage was used.

Daily gage height, in feet, of Sauk River near St. Cloud, Minn., for 1909.

[Ida Waite observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	6.05	5.84	5.80	5.60	6.29	16	6.80	5.57	5.64	5.74	5.75	......
2	......	6.10	5.79	5.75	5.70	6.05	17	6.80	5.65	5.74	5.56	5.90	6.9
3	......	6.10	5.79	5.70	5.76	5.90	18	6.45	5.57	5.79	5.59	5.95	......
4	......	6.40	5.76	5.60	5.78	5.90	19	6.60	5.62	5.84	5.54	6.15	......
5	......	6.08	5.76	5.60	5.75	5.90	20	6.60	5.62	6.04	5.62	6.25	......
6	......	5.65	5.44	5.65	5.81	......	21	7.00	5.62	5.64	5.70	6.30	......
7	......	5.85	5.59	5.70	5.79	......	22	7.00	5.62	5.54	5.70	6.30	6.9
8	6.45	6.00	5.82	5.70	5.75	......	23	6.75	5.59	5.64	5.68	6.28	......
9	6.80	6.30	5.64	5.70	6.08	......	24	6.75	5.62	5.64	5.70	6.30	......
10	6.85	6.27	5.74	5.70	5.86	......	25	6.60	6.14	5.74	5.70	6.20	7.15
11	6.80	6.32	5.54	5.72	5.89	......	26	6.40	6.04	5.69	5.65	6.25	......
12	7.30	6.32	5.34	5.75	5.78	......	27	6.40	5.54	5.66	5.68	6.30	......
13	6.80	6.25	5.34	5.8	5.80	......	28	6.40	5.44	5.69	5.50	6.30	7.15
14	6.85	6.25	5.54	5.75	5.72	......	29	6 30	5.44	5.69	5.65	6.30	......
15	7.10	5.97	5.54	5.76	5.70	......	30	6.10	5.14	5.69	5.65	6.30	......
							31	6.05	5.54	......	5.50	......	......

NOTE.—The river was frozen entirely across during the greater part of December, the maximum thickness of ice being 1.1 feet. The gage readings are to water surface. It is probable that the high stage during the latter part of November was due to backwater.

CROW RIVER DRAINAGE BASIN.

DESCRIPTION.

Crow River drains an area comprising 2,590 square miles, situated in Stevens, Kandiyohi, Meeker, Renville, McLeod, Wright, and Hennepin counties, south of the basin of the Sauk and north of that of the Minnesota. Crow River itself is a short stream, which is formed by the union of its north and south forks 2 or 3 miles above Rockford and discharges into the Mississippi at Dayton. Throughout its course it forms the boundary between Hennepin and Wright counties.

The North Fork, which is the larger of the two upper branches, rises in the eastern part of Pope County in McLeod and Grove lakes. These lakes together are about 4 miles long and one-third mile in average width. From the outlet of the lakes the North Fork flows southeasterly, passing through Rice and Cedar lakes (both of considerable size) and at Manannah receiving the waters of the Middle Fork. The Middle Fork rises in Crow Lake, in the southwestern part of Stevens County, flows southward to and through Green Lake (which has an area of several square miles), and then takes an easterly course to its junction with the North Fork. Below the mouth of Middle Fork the North Fork has one or two small tributaries which also head in lakes.

The South Fork rises in a number of lakes in the southeastern part of Kandiyohi County, from which it takes a general easterly course, flowing through Otter Lake.

The surface varies from nearly flat to undulating, and the entire area is covered with glacial drift, through which the streams flow in very winding but not deeply eroded channels. The valley of the North Fork lies 40 to 50 feet below the general surface level; that of the South Fork, which is one-fourth to one-half mile wide, 30 to 40 feet below. The basin is thickly dotted with lakes of size which tend to equalize the flow of the rivers. Elevations range from 900 to 1,300 feet above sea level.

The upper part of the basin lies in the prairie region; the lower part, east of the west line of Wright County, lies in the area that was originally forested, but the greater part of the timber has been cut; very little forest remains at the present time.

The annual mean rainfall in the Crow River region is indicated by the following table, compiled from records covering periods of more than ten years:

Mean annual rainfall in Crow River region.

	Inches.
Morris, 1894–1909	23. 3
Collegeville, 1893–1909	23. 3
New London, 1897–1909	23. 8
St. Paul, 1837–1909	27. 8
St. Peter, 1894–1909	27. 3

From December to March the rivers are frozen entirely over with ice of a foot or more thick.

Good reservoirs could readily be obtained by building low dams across the outlets of lakes, some of which are in the channels of the streams.

Water power has been developed at a number of points on Crow River, though all the plants are small. In the flatter portions of the basin considerable drainage work has been done, more than 50,000 acres having been drained, of which nearly 40,000 are in Kandiyohi County.

NORTH FORK OF CROW RIVER NEAR ROCKFORD, MINN.

This station, which is located 3 miles west of Rockford at the first highway bridge above the forks, 1½ miles distant, was established June 15, 1909, because of the power available on the river and also to obtain records to check (in connection with the South Fork Station) the records at Rockford on the main stream. The drainage area above this station is 1,310 square miles.

No tributaries enter the North Fork within several miles of the station. The nearest dam is that at Rockford, which backs the water up to a point beyond the gage, but since the establishment of the station this control has remained permanent except as noted below, and the water has not fallen below the crest of the dam.

The river is icebound from December to March, inclusive, and during that period observations are discontinued. The minimum flow during the frozen period can be roughly estimated by comparing drainage areas and records of the minimum run-off per square mile of drainage area at the Rockford station.

The datum of the staff gage, which is located at the bridge, has remained unchanged since the station was established; but from July 27 to August 10, 1909, when the dam at Rockford was open for repairs, the conditions of flow were temporarily changed.

As the station has not been completely rated, records of daily flow for 1909 can not be given.

Discharge measurements of North Fork of Crow River near Rockford, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 15	G. A. Gray	148	817	6.88	1,200
July 22	Follansbee and Gibson	135	521	4.72	438
July 31 [a]	Follansbee and Gray	119	286	2.89	303
August 11 [b]	G. A. Gray	134	483	4.41	329
September 23	do	134	500	4.53	262

[a] Control temporarily changed. [b] Original control restored.

Daily gage height, in feet, of North Fork of Crow River near Rockford, Minn., for 1909.

[Miss Grace Wandersee, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.70	2.97	3.99	4.28	4.35	4.63	16	7.10	5.38	4.34	4.45	4.43	4.48	4.23
2		5.58	2.91	3.99	4.25	4.38	4.69	17	7.20	5.15	4.34	4.35	4.43		4.31
3		5.48	2.83	3.98	4.27	4.35	4.73	18	7.20	5.05	4.42	4.35	4.41		4.28
4		5.39	2.91	4.04	4.25	4.33	4.83	19	7.14	4.90	4.35	4.33	4.41		4.28
5		5.30	2.81	4.13	4.35	4.38	4.58	20	7.15	4.70	4.33	4.23	4.43		4.28
6		5.22	2.75	4.04	4.35	4.35	4.41	21	6.88	4.60	4.29	4.41	4.39		4.33
7		5.12	2.73	4.01	4.38	4.33	4.39	22	6.65	4.71	4.24	4.48	4.41		4.31
8		5.00	2.78	3.89	4.35	4.33	4.38	23	6.52	4.71	4.28	4.59	4.39	4.58	4.28
9		(a)	2.97	3.93	4.41	4.35	4.38	24	6.48	4.63	4.21	4.53	4.43	4.51	
10		(a)	3.85	3.93	4.43	4.35	4.43	25	6.36	4.61	4.15	4.47	4.38	4.53	
11		(a)	4.38	3.91	4.43	4.32	4.35	26	6.25	4.52	4.14	4.43	4.38	4.61	
12		5.08	4.48	4.11	4.43	4.32	4.25	27	6.12	3.43	4.13	4.38	4.34	4.68	
13		5.35	4.47	4.63	4.43	4.39	4.23	28	6.00	2.98	4.08	4.33	4.33	4.73	
14		5.54	4.43	4.55	4.43	4.48	4.23	29	5.95	2.94	4.03	4.31	4.28	4.61	
15	6.92	5.45	4.41	4.53	4.43	4.48	4.25	30	5.82	2.85	4.02	4.28	4.31	4.68	
								31		2.91	4.01		4.33		

[a] Below gage height 5.0 feet.

NOTE.—From July 27 to August 10 the dam at Rockford was open. This caused the control at this station to change. Original control restored August 11. It is probable there were ice conditions during the latter part of November and all of December.

CROW RIVER AT ROCKFORD, MINN.

This station, which is located at the highway bridge at Rockford, was established June 4, 1909, to determine the power available on Crow River.

A little more than a mile above the station is the junction of the North and South forks. Between the forks and the station two very small streams—the outlets of Rebecca Lake and Lake Sarah—enter the river. As stations have been established on both forks above their junction, the combined records may be used as a check on the Rockford record.

About 400 feet above the station is the 7-foot dam of a flour mill which operates intermittently. (See Pl. IV, *A*.) As the turbine has used but a small portion of the flow since the establishment of the station the effect of shutting it down is inappreciable at the gage.

Owing to the proximity of the dam to the station, ice conditions are not severe, the stream remaining open through the greater part of the section and for a distance of several hundred yards below.

During high and medium stages discharge measurements are made from the bridge at which the staff gage is located; at low stages measurements are made from a boat and cable several hundred yards downstream.

The datum of the gage has remained unchanged since the station was established.

Conditions at this station are favorable for excellent results and the records should be reliable.

Discharge measurements of Crow River at Rockford, Minn., in 1909.

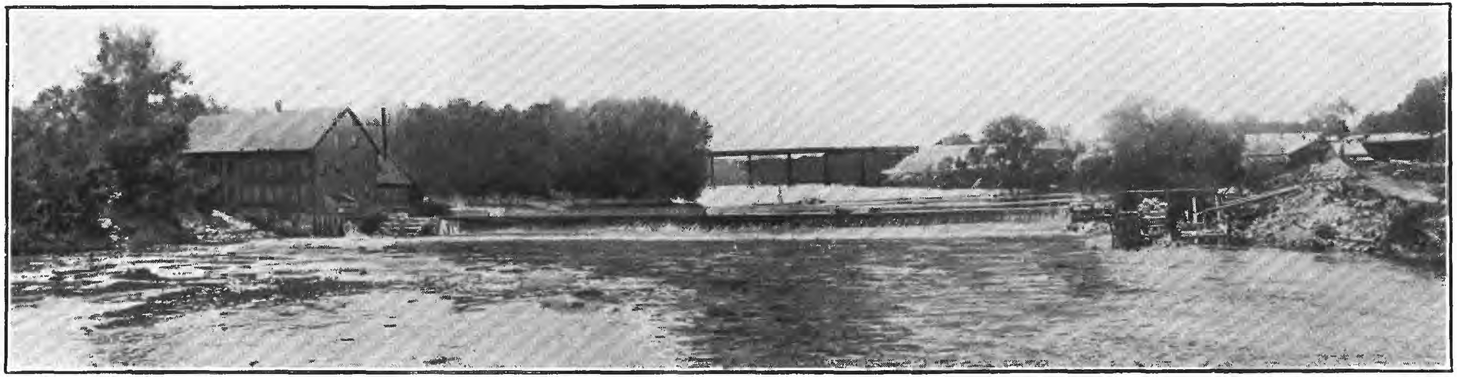
Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 4	Hoyt and Gibson	276	657	6.95	1,150
June 15	C. B. Gibson	287	1,390	9.65	3,330
July 22	Follansbee and Gibson	267	415	6.18	744
July 31 [a]	Follansbee and Gray	225	251	5.54	347
August 11 [b]	G. A. Gray	176	435	5.72	470
September 23 [b]	do	183	446	5.75	461

[a] Very poor low-water section. [b] Boat measurement 1,200 feet below regular section.

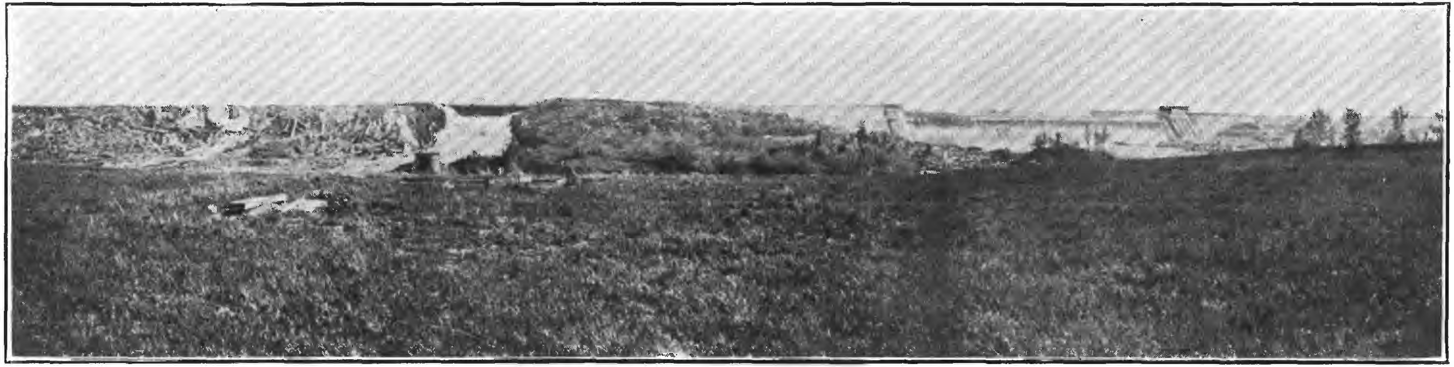
Daily gage-height, in feet, of Crow River at Rockford, Minn., for 1909.

[George W. Florida, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		7.68	5.64	5.18	5.35	5.20	5.75	16	9.98	7.15	5.55	5.69	5.30	5.34	5.42
2		7.45	5.56	5.15	5.35	5.20	5.76	17	10.09	6.85	5.54	5.52	5.28	5.20	5.39
3		7.38	5.52	5.12	5.34	5.18	5.84	18	10.05	6.62	5.58	5.43	5.25	5.30	5.36
4	6.95	7.25	5.50	5.18	5.38	5.20	6.00	19	9.90	6.45	5.57	5.40	5.24	5.38	5.38
5	6.90	7.12	5.45	5.22	5.43	5.20	5.66	20	9.70	6.25	5.55	5.33	5.24	5.48	5.39
6	7.65	7.00	5.42	5.22	5.32	5.20	5.47	21	9.40	6.20	5.42	5.46	5.30	5.50	5.38
7	7.75	6.80	5.40	5.18	5.30	5.19	5.40	22	9.12	6.16	5.40	5.71	5.27	5.50	5.37
8	7.85	6.60	5.48	5.14	5.30	5.18	5.37	23	8.85	6.12	5.36	5.76	5.25	5.23	5.36
9	7.90	6.45	5.52	5.10	5.30	5.18	5.42	24	8.72	6.00	5.36	5.75	5.24	5.41	5.36
10	7.82	6.35	5.45	5.12	5.32	5.16	5.38	25	8.72	5.92	5.34	5.79	5.24	5.45	5.40
11	7.65	6.35	5.55	5.08	5.36	5.17	5.39	26	8.55	5.84	5.31	5.59	5.23	5.58	5.39
12	7.58	6.68	5.74	5.32	5.35	5.18	5.35	27	8.20	6.35	5.30	5.48	5.22	5.74	5.39
13	8.20	7.32	5.70	6.00	5.32	5.18	5.39	28	8.02	5.78	5.27	5.40	5.24	5.84	5.40
14	9.40	7.45	5.67	5.86	5.32	5.35	5.38	29	7.98	5.70	5.24	5.39	5.24	5.75	5.38
15	9.68	7.35	5.65	5.78	5.30	5.36	5.40	30	7.85	5.61	5.21	5.38	5.20	5.76	5.38
								31		5.59	5.20		5.19		5.38



A. TYPICAL LOW-HEAD DEVELOPMENT, CROW RIVER, AT ROCKFORD, MINN.



B. DAM OF ST. LOUIS RIVER POWER COMPANY, THOMPSON, MINN.

Daily discharge, in second-feet, of Crow River at Rockford, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	1,700	415	209	278	217	472	16	3,650	1,320	370	440	257	274	309
2	......	1,540	375	198	278	217	478	17	3,750	1,130	365	355	249	217	296
3	......	1,490	355	187	274	209	522	18	3,720	978	385	314	237	257	283
4	1,190	1,400	345	209	291	217	610	19	3,580	875	380	300	233	291	291
5	1,160	1,300	322	225	314	217	425	20	3,400	755	365	270	233	336	296
6	1,680	1,220	309	225	266	217	332	21	3,130	725	309	327	257	345	291
7	1,750	1,100	300	209	257	213	300	22	2,880	701	300	450	245	345	287
8	1,830	965	336	194	257	209	287	23	2,640	677	283	478	237	229	283
9	1,870	875	355	179	257	209	309	24	2,530	610	283	472	233	304	283
10	1,810	815	322	187	266	202	291	25	2,530	566	274	494	233	322	300
11	1,680	815	370	172	283	206	296	26	2,390	522	261	390	229	385	296
12	1,630	1,020	467	266	278	209	278	27	2,110	815	257	336	225	467	296
13	2,110	1,440	445	610	266	209	296	28	1,970	489	245	300	233	522	300
14	3,130	1,540	430	533	266	278	291	29	1,930	445	233	296	233	472	291
15	3,380	1,460	420	489	257	283	300	30	1,830	400	221	291	217	478	291
								31	......	390	217	......	213	......	291

NOTE.—These discharges are based on a rating curve that is well defined.

Monthly discharge of Crow River at Rockford, Minn., for 1909.

[Drainage area, 2,520 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
June 4–30	3,750	1,160	2,420	0.960	0.96	A.
July	1,700	390	970	.385	.44	A.
August	467	217	333	.132	.15	A.
September	494	172	320	.127	.14	A.
October	314	213	253	.100	.12	A.
November	522	202	285	.113	.13	A.
December	610	278	328	.130	.15	A.

SOUTH FORK OF CROW RIVER NEAR ROCKFORD, MINN.

This station, which is located at the highway bridge 3½ miles southwest of Rockford and 2 miles above the junction of the North and South forks, was established June 15, 1909, on account of power available on the river, and also to obtain a check (in connection with the North Fork station) on the records at Rockford on the main stream. During all stages except low, discharge measurements are made from the bridge at which the staff gage is located; at low stages measurements are made by wading a short distance upstream.

No tributaries enter within several miles of the station. The nearest dam is that at Delano, which is used merely as a diversion dam for the Great Northern Railway. The station is slightly within the influence of the dam at Rockford on the main river, but as there are no flashboards on this dam, and no sluice gates, the control is nearly permanent as long as the dam remains unchanged.

Ice conditions prevail at this station from December to March, inclusive, and observations are then discontinued. The minimum flow during the frozen period can be roughly determined by comparing drainage areas and records of the minimum run-off per square mile of drainage area at the Rockford station.

The datum of the gage has remained unchanged since the gage was installed, but from July 27 to August 10, 1909, when the dam at Rockford was open for repairs, conditions of flow were temporarily changed.

Conditions at this station are favorable for excellent results, and the records should be reliable.

Discharge measurements of South Fork of Crow River near Rockford, Minn., 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 15	G. A. Gray	140	803	7.68	2,110
June 29	C. B. Gibson	113	412	4.60	704
July 22	Follansbee and Gibson	105	227	2.73	235
July 31 [a]	Follansbee and Gray	96	119	1.62	136
August 11 [b]	G. A. Gray	103	171	2.20	111
September 23	do	100	262	2.60	204

[a] Control temporarily changed. [b] Original control restored.

Daily gage height, in feet, of South Fork of Crow River near Rockford, Minn., for 1909.

[Jacob Horsch, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.28	1.60	1.70	2.16	2.13	2.60	16	7.84	3.88	2.11	2.65	2.22	2.40	
2		4.24	1.58	1.71	2.15	2.12	2.64	17	7.89	3.50	2.11	2.45	2.24	2.22	
3		4.15	1.45	1.72	2.10	2.10	2.82	18	7.75	3.25	2.12	2.30	2.15	2.34	
4		4.01	1.44	1.82	2.14	2.11	3.10	19	7.46	3.35	2.11	2.28	2.14	2.35	
5		3.92	1.41	1.88	2.20	2.14	2.62	20	7.15	2.85	2.08	2.22	2.16	2.42	
6		3.75	1.35	1.84	2.20	2.11	2.35	21	6.72	2.76	2.01	2.32	2.19	2.44	
7		3.56	1.30	1.86	2.20	2.10		22	6.20	2.71	2.00	2.55	2.18	2.45	
8		3.38	1.30	1.66	2.20	2.10		23	5.78	2.66	1.98	2.61	2.20	2.40	
9		3.24	1.30	1.69	2.20	2.10		24	5.45	2.56	1.92	2.56	2.18	2.36	
10		3.07	1.60	1.70	2.28	2.08		25	5.10	2.45	1.90	2.48	2.14	2.36	
11		3.08	2.19	1.70	2.29	2.05		26	4.82	2.40	1.90	2.38	2.12	2.46	
12		3.68	2.29	2.15	2.28	2.09		27	4.65	1.94	1.90	2.30	2.11	2.65	
13		4.48	2.26	3.48	2.28	2.14		28	4.65	1.75	1.86	2.19	2.10	2.85	
14		4.52	2.19	3.04	2.25	2.28		29	4.59	1.70	1.80	2.20	2.12	2.74	
15	7.65	4.20	2.16	2.85	2.24	2.39		30	4.45	1.65	1.76	2.20	2.10	2.69	
								31		1.61	1.72		2.10		

NOTE.—From July 27 to August 10 the dam at Rockford was opened by dynamite which changed the control during this period. Ice conditions during December.

Daily discharge, in second-feet, of South Fork of Crow River near Rockford, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		614	130	45	118	113	16	2,200	500	110	214	129	162
2		502	128	46	116	111	17	2,220	407	110	172	132	129
3		575	115	48	108	108	18	2,150	348	111	143	116	151
4		533	114	63	115	110	19	1,990	371	110	139	115	152
5		510	111	73	125	115	20	1,820	257	105	129	118	166
6		468	105	66	125	110	21	1,610	237	94	147	123	170
7		421	100	70	125	108	22	1,350	226	92	192	122	172
8		378	100	39	125	108	23	1,160	216	89	205	125	162
9		345	100	44	125	108	24	1,030	195	79	195	122	154
10		306	130	45	139	105	25	890	172	76	178	115	154
11		308	123	45	141	100	26	787	162	76	158	111	174
12		450	141	116	139	106	27	728	176	76	143	110	214
13		674	136	402	139	115	28	728	148	70	123	108	257
14		686	123	299	134	139	29	707	140	60	125	111	233
15	2,090	590	118	257	132	160	30	665	135	54	125	108	222
							31		131	48		108	

NOTE.—These discharges, except for period July 27 to August 10, are based on a rating curve that is fairly well defined. Discharges for period July 27 to August 10, 1909, when the control was changed, are based on a curve defined by one measurement made on July 31.

Monthly discharge of South Fork of Crow River near Rockford, Minn., for 1909.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
June 15-30	2,220	665	1,380	1.19	0.71	43,800	B.
July	686	131	361	.311	.36	22,200	B.
August	141	48	101	.087	.10	6,210	C.
September	402	39	135	.116	.13	8,030	C.
October	141	108	122	.105	.12	7,500	B.
November	257	100	146	.126	.14	8,690	C.

RUM RIVER DRAINAGE BASIN.

DESCRIPTION.

Rum River drains an area comprising 1,550 square miles, situated east of the central part of Minnesota, chiefly in Mille Lacs, Isanti, and Anoka counties. The Rum rises in Mille Lacs Lake (which has an area of about 207 square miles), and for a distance of 16 or 18 miles flows through a chain of three lakes, beyond which it pursues a winding but, in general, southerly course as far as Princeton, where it is joined by the West Branch; below Princeton it flows easterly in a still more winding course until it reaches Cambridge, where it resumes its southerly course. It enters the Mississippi at Anoka. In addition to the West Branch, the larger tributaries of Rum River are Tibbetts, Bogus, Spencer Brooks, and Upper and Lower Stanchfield creeks, and Cedar Creek.

The surface of the basin is for the most part level or slightly undulating and the entire area is covered with glacial drift, but granite outcrops at many places along the valley of the Rum. Altitudes range from 850 to 1,300 feet above sea level, and the stream beds are cut 20 to 30 feet below the general level. With the exception of Mille Lacs Lake and the chain of lakes at its outlet there are no lakes in the drainage basin.

Below Princeton the greater part of the drainage basin is under cultivation, but between Princeton and Milaca the proportion of cleared and cultivated land becomes smaller, and above Milaca, except for isolated clearings and farms along the river, the country is cut-over timber land covered with a second growth.

The annual rainfall in the basin is about 27 inches. From December to March the river is covered with ice about a foot thick.

Mille Lacs Lake forms a natural reservoir for Rum River and tends to equalize its flow throughout the year. Of the area above the outlet about half is comprised in the lake itself. As the shores of Mille Lacs are low in many places, and large areas of swamp lie back of them, it would not be feasible to increase the storage capacity of the lake by raising the water level. The more feasible plan would be to dredge the outlet of the lake and thus allow the level to be drawn down the necessary amount, giving as storage the range between normal level and the new low level. A survey made of the lake by the United States Geological Survey shows the lake to have a nearly uniform depth of 30 feet with a maximum depth measured of 43 feet. In addition to Mille Lacs Lake, a number of good reservoir sites exist on the upper part of Rum River.

In order to determine the storage possibilities of Mille Lacs Lake a survey was made in 1909. From the data collected on this survey a map has been prepared, showing the shore line of the lake, adjacent topography, and the depth of the lake in many places. This map may be had on application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn.

In order to determine the availability of Rum River for power development, a survey was made during 1909 from Anoka to the outlet of Lake Onamia, at Onamia. From the data collected on this survey sheets have been prepared showing a profile of the water surface, a plan of the river, and the contours along the river bank. The results of this survey have been published on separate sheets and may be had upon application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn. From this survey the following table of elevations and distances has been compiled:

Elevation and distances along Rum River.

	Distance above Anoka.	Elevation.
	Miles.	*Feet.*
Anoka, tail-water	0	833
Anoka, headwater	0	845
Range line, 24–25 W	10	848
Gillespie Bridge	16	865
Seely Brook	19	873
St. Francis, tail-water	22	885
St. Francis, headwater	22	894
Bethel Bridge	27	895
Isanti Bridge	34	896
Cambridge Bridge	42	899
Lower Stanchfield Creek	49	903
Range line, 23–24 W	53	907
Findell Bridge	59	912
Range line	65	919
Spencer Brook	72	930
Isanti-Sherburne County line	78	938
Sherburne-Mille Lacs County line	84	947
Princeton Bridge	87	951
Section line, 9–16	93	960
Bogus Brook	100	973
Section line, 15–22	103	987
Vandell Brook	105	996
Township line, 37–38 N	110	1,028
Milaca, tail-water	112	1,040
Milaca, headwater	112	1,045
Highway Bridge	114	1,057
Mike Dreur Brook	117	1,085
Whitney Brook	122	1,121
Page Bridge	126	1,152
Hanson Brook	132	1,193
Highway Bridge	136	1,225
Onamia Bridge	142	1,249

At the present time power is developed at only two points—Anoka and St. Francis. A number of logging dams exist at different points, but these have all been abandoned as logs are no longer driven down Rum River.

RUM RIVER AT ONAMIA, MINN.

This station, which is located at the wooden highway bridge a few yards below the "Soo" Railway bridge at Onamia and at the outlet of Lake Onamia, was established September 24, 1909, to ascertain the run-off from Mille Lacs Lake and the chain of three lakes into which it flows. A station was established at the outlet of Mille Lacs proper, but conditions of flow were so unstable that the gage heights did not serve as a true index of the flow and that station was therefore abandoned in favor of the station at Onamia.[a] The records will show the run-off from Lake Onamia that would be available for storage and indicate the flow throughout the upper portion of Rum River—the section of river having the greatest fall—available for hydraulic development.

The nearest important tributary is Bradbury Brook, which enters Rum River 5 miles below the station. The drainage area above

[a] For discharge measurements made at Mille Lacs outlet in 1909, see p. 220.

Onamia is 414 square miles, of which 207 square miles are taken up by the water surface of Mille Lacs Lake.

Two miles below Onamia is an abandoned logging dam which raises the water level about 3 feet, but does not control the flow, and owing to the fall of the river the influences of this dam do not reach the gaging station.

Discharge measurements are made from the steel highway bridge 250 feet below the gage.

The staff gage is fastened to the upstream side of an abandoned logging dam that is now used as a highway bridge. This dam controls the flow above it by raising the water level slightly. The water flows through the old sluiceway of the dam, which is composed of two rectangular openings with a sloping wooden flume and vertical walls; the flow is therefore very uniform. Owing to the natural storage afforded by the lakes the range of stage at Onamia is slight.

As the current through the sluiceways is swift the water does not freeze, and although a narrow fringe of ice forms near the gage the readings are taken to the water surface.

Conditions of flow should be permanent at Onamia as long as the wooden bridge remains, and the records of flow should therefore be reliable when the section is finally rated.

Discharge measurements of Rum River at Onamia, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 24	Follansbee and Adams	39	29.0	0.72	103
November 8	C. J. Emerson	72	66.3	.73	98.4

Daily gage height, in feet, of Rum River at Onamia, Minn., for 1909.

[R. Swedburg, observer.]

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1		0.72	0.72	0.85	16		0.90	0.85	0.62
2		.72	.72	.85	17		.88	.85	.62
3		.72	.72	.90	18		.85	.85	.62
4		.72	.72	.90	19		.85	.85	
5		.72	.72		20		.82	.82	
6		.72	.72		21		.82	.82	
7		.72	.72		22		.80	.82	.60
8		.72	.72	.80	23		.78	.82	
9		.72	.72		24	0.72	.75	.82	
10		.72	.75		25	.72	.72	.80	
11		.75	.75	.65	26	.72	.72	.80	.60
12		.75	.75	.65	27	.72	.72	.80	
13		.80	.75	.65	28	.72	.72	.80	
14		.90	.78	.65	29	.72	.72	.82	.58
15		1.00	.82	.62	30	.72	.72	.82	
					31		.72		

NOTE.—There were practically no ice effects at this station during 1909.

RUM RIVER AT CAMBRIDGE, MINN.

This station, which is located at the highway bridge one-half mile west of Cambridge, was established June 12, 1909, on account of the power available on Rum River.

No tributary enters within several miles of Cambridge. At St. Francis, 20 miles below Cambridge by river, there is a 10-foot dam and power plant. Between the crest of the dam and the water surface at the gaging station there is a difference in elevation of about 6 feet. The fact that the morning and evening gage heights during the low-water period show no consistent change, being for the most part the same, indicates that the St. Francis dam has little effect on the flow at this point, even though the flow may fall below the crest during certain portions of the day. The only dam above Cambridge is one at Milaca, which is used to form a pool from which water is pumped. The drainage area above the station is 1,160 square miles.

From December to March discharge measurements are made through the ice to develop an approximate winter-rating curve.

The staff gage is located at the bridge from which the discharge measurements are made. Its datum has remained unchanged since the station was established. As conditions at this station are favorable the results should be good and the records should be reliable.

Discharge measurements of Rum River at Cambridge, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 12	G. A. Gray	111	599	6.45	1,040
July 10	Gray and Gibson	97	319	3.90	330
August 31	Robert Follansbee	80	227	3.14	146

Daily gage height, in feet, of Rum River at Cambridge, Minn., for 1909.

[Martin Lofstrom, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	5.35	3.85	3.15	3.78	3.48	4.19	16	5.70	3.69	4.16	3.22	3.75	4.31	......
2	......	5.15	3.71	3.15	3.75	3.54	4.32	17	5.65	3.61	4.00	3.18	3.70	4.50	......
3	......	4.85	3.62	3.15	3.70	3.55	4.30	18	5.60	3.55	3.85	3.19	3.70	......	4.28
4	......	4.65	3.59	3.12	3.68	3.52	4.32	19	5.60	3.48	3.72	3.30	3.66	......	......
5	......	4.50	3.52	3.14	3.68	3.52	......	20	5.45	3.56	3.59	3.29	3.61	......	......
6	......	4.40	3.45	3.16	3.64	3.52	......	21	5.25	4.22	3.54	3.72	3.65	......	......
7	......	4.25	3.40	3.10	3.58	3.50	......	22	5.15	4.44	3.42	4.68	3.60	......	4.25
8	......	4.15	3.48	3.10	3.55	3.48	4.25	23	5.85	4.30	3.38	4.72	3.58	......	......
9	......	4.00	3.49	3.18	3.56	3.45	......	24	6.40	4.45	3.36	4.71	3.58	......	......
10	......	3.90	3.58	3.15	3.60	3.48	......	25	6.75	4.56	3.32	4.59	3.58	......	......
11	......	3.86	3.76	3.15	3.62	3.48	4.28	26	6.85	4.42	3.30	4.35	3.55	4.15	......
12	6.45	3.94	3.80	3.20	3.72	3.45	......	27	6.75	4.22	3.28	4.19	3.51	4.34	......
13	6.15	3.91	3.86	3.21	3.66	3.45	......	28	6.50	4.05	3.28	4.05	3.48	4.39	......
14	5.95	3.85	4.18	3.26	3.68	3.80	......	29	6.10	4.09	3.28	3.95	3.48	4.11	4.25
15	5.80	3.79	4.29	3.28	3.75	4.08	4.28	30	5.75	4.00	3.25	3.88	3.50	4.15	......
								31	......	3.92	3.15	......	3.48	......	......

NOTE.—The river was frozen from November 18 to December 31. The following comparative readings were made:

Date.	Gage height to water surface.	Gage height top of ice.	Thickness of ice.	
			At gage.	Average.
	Feet.	*Feet.*	*Feet.*	*Feet.*
December 8	4.25	4.3	0.32	0.33
December 11	4.28	4.32	.40	.54
December 15	4.28	4.32	.33	.50
December 18	4.28	4.32	.42	.50
December 22	4.25	4.32	.54	.54
December 29	4.25	4.32	1.00	.75

RUM RIVER NEAR ANOKA, MINN.

This station, which is located at the highway bridge 6 miles north of Anoka, on the line between ranges 24 and 25 west, was established May 8, 1905, but was discontinued July 21, 1906. On June 22, 1909, it was reestablished for the purpose of obtaining data relative to the water power available on Rum River; it was finally discontinued November 23, 1909, the station at Cambridge being substituted.

The nearest tributary, Cedar Creek, enters Rum River 2½ miles above the bridge. The drainage area above this point is 1,430 square miles.

Between the crest of the 13-foot dam at Anoka and the river at the gage (which is located at the measuring section at the bridge), a distance of 10 miles measured along the river, there is a fall of 3 feet at low-water stage. It is probable that the station is slightly within the influence of the dam, as shown by the profile of the river. At St. Francis, which is 12 miles above the gaging station, there is a dam and water-power plant. During the low-water season the flow is held back somewhat by this plant, as the morning gage readings are usually about one-tenth lower than those of the evening.

Since the installation of the staff gage in 1905, its datum has remained unchanged.

Discharge measurements of Rum River near Anoka, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 22	C. B. Gibson	152	808	12.00	837
June 22	G. A. Gray	152	805	12.00	846
August 7	Follansbee and Emerson	92	545	10.98	346

Daily gage height, in feet, of Rum River near Anoka, Minn., for 1909.

[H. E. Faherty, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		12.52	11.30	10.80	11.08	10.84	16		11.05	11.64	10.76	10.94	11.25
2		12.15	11.25	10.75	11.05	10.84	17		11.00	11.56	10.10	10.95	11.35
3		11.70	11.30	10.70	10.85	10.88	18		11.00	11.45	10.22	10.90	12.20
4		11.72	11.25	10.66	10.68	10.85	19		10.90	11.31	10.28	10.84	11.85
5		11.80	11.20	10.66	10.31	10.72	20		10.85	11.15	10.58	10.85	11.88
6		11.70	11.45	10.70	10.84	10.84	21		11.20	11.18	10.90	10.86	11.95
7		11.65	11.02	10.96	10.78	10.84	22	12.02	11.95	11.08	11.65	10.88	11.88
8		11.52	11.12	10.80	10.72	10.76	23	11.82	11.92	11.12	11.92	10.85	11.75
9		11.40	11.11	10.76	10.65	10.68	24	12.40	11.75	11.06	11.82	10.82	
10		11.32	11.14	10.72	10.76	10.74	25	12.70	11.80	11.08	11.76	10.85	
11		11.50	11.18	10.75	10.90	10.76	26	12.90	11.85	10.98	11.55	10.80	
12		11.45	11.28	10.68	10.90	10.76	27	13.10	11.75	10.90	11.42	10.76	
13		11.50	11.26	10.81	10.89	10.85	28	13.05	11.65	10.84	11.31	10.74	
14		11.30	11.32	10.88	10.90	11.12	29	12.85	11.70	10.85	11.20	10.70	
15		11.20	11.55	10.79	10.92	11.38	30	12.70	11.60	10.84	11.15	10.65	
							31		11.30	10.79		10.64	

Daily discharge, in second-feet, of Rum River near Anoka, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		913	474	322	404	333	16		395	586	312	362	458
2		772	458	309	395	353	17		380	559	182	365	490
3		606	474	296	336	344	18		380	522	199	350	791
4		613	458	286	291	336	19		350	477	209	333	659
5		641	442	286	214	301	20		336	426	268	336	670
6		606	522	296	333	333	21		442	436	350	339	696
7		589	386	368	317	333	22	723	696	404	589	344	670
8		546	416	322	301	312	23	648	685	416	685	336	624
9		506	413	312	284	291	24	867	624	398	648	328	
10		480	423	301	312	306	25	985	641	404	627	336	
11		539	436	309	350	312	26	1,080	659	374	556	322	
12		522	468	291	350	312	27	1,170	624	350	513	312	
13		539	461	325	347	336	28	1,140	589	333	477	306	
14		474	480	344	350	416	29	1,050	606	336	442	296	
15		442	556	319	356	500	30	985	572	333	426	284	
							31		474	319		282	

NOTE.—These discharges are based on a rating curve that is not well defined.

Monthly discharge of Rum River near Anoka, Minn., for 1909.

[Drainage area, 1,430 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
June 22-30	1,170	648	950	0.664	0.22	17,000	C.
July	913	336	556	.389	.45	34,200	C.
August	586	319	437	.306	.35	26,900	C.
September	685	182	372	.260	.29	22,100	C.
October	404	214	328	.229	.26	20,200	C.
November 1-23	791	291	442	.309	.26	20,200	C.

MINNESOTA RIVER DRAINAGE BASIN.

DESCRIPTION.

Minnesota River, by far the largest tributary of the Mississippi in the State of Minnesota, drains an area comprising 16,600 square miles, and extending nearly across the southern part of the State from west to east. The river rises on the eastern slope of the Dakota foothills (Coteau des Prairies) in the northeastern part of Marshall County, S. Dak., about 30 miles west of Lake Traverse, at an approximate elevation of 1,896 feet above sea level, and flows southeastward to the State border where it enters Bigstone Lake, a body of water 26 miles long, 1 to 1½ miles wide, and exceeding 15 feet in depth at only a few places. In this portion of its course the river is a mere mountain torrent, whose fall in 40 miles is about 900 feet and whose bed is often entirely dry; for this reason, perhaps, Bigstone Lake has commonly been considered its source. Emerging from Bigstone Lake at Ortonville the Minnesota flows southeastward 225 miles to Mankato, where it turns abruptly and flows northeastward to its junction with the Mississippi a few miles below the falls of St. Anthony, between the cities of Minneapolis and St. Paul.

About 29 miles below Bigstone Lake the river is joined by the Pomme de Terre, which drains lakes lying in the Ottertail region and which has deposited near its mouth sufficient alluvium to form a sort of natural dam behind which the Minnesota expands into the shallow water body, 4 miles long by 1 mile wide, known as Marsh Lake. Lac qui Parle, which begins 35 miles below Bigstone Lake and extends some 10 miles with a width varying from one-fourth to 1 mile and a maximum depth of 12 feet, is a similar expansion caused by deposits brought from the south by Lac qui Parle River.

At Granite Falls and at Minnesota Falls, where granite outcrops in the channel, the river descends in falls and rapids 41 feet within a distance of 4 miles.

The valley of the Minnesota ranges in width from 1 mile to 2 miles and lies 125 to 225 feet below the general level of the country. The soil within the valley is alluvium. Below Minneopa the river occupies a preglacial gorge whose bottom, filled with gravel and sand, lies 100 to 200 feet below the bed of the river.

During the glacial epoch a vast lake, now known as Lake Agassiz, occupied the northwestern portion of the State and had outlet through Lake Traverse into Bigstone Lake, which lies at an elevation 8 feet lower than Lake Traverse at the present time, and finally into the present valley of the Minnesota. Owing to the presence of ice barriers the Minnesota did not follow its present course, but was deflected southward and reached the Mississippi through the valley of the Cannon and other rivers.

Except in the immediate valley of the Minnesota, the Blue Earth, and one or two other tributaries, the drainage basin is covered with glacial drift, and rock outcrops are rare. The country is flat or gently undulating except along the southern boundary of the basin, where the surface rises several hundred feet to a table-land, which is from 20 to 30 miles wide and extends from southeast to northwest across the southwestern part of the State.

Elevations in the basin range from 1,000 in the valleys to 1,900 feet above sea level on the high plateau.

The chief tributaries are Pomme de Terre and Chippewa rivers and Chetamba Creek from the north and Lac qui Parle, Redwood, Cottonwood, and Blue Earth rivers from the south.

Above Mankato the drainage area is prairie land; below Mankato the land was originally forested, but the greater part of it is now under cultivation.

Rainfall records covering periods exceeding 15 years are available for different sections of the drainage basin. These records indicate that the annual rainfall increases from 24 or 25 inches in the upper part to 27 or 28 inches in the central and lower parts. From December to March the rivers in the basin are covered with ice.

Bigstone Lake, which takes its name from the conspicuous granite outcrops found in the valley 1 to 3 miles below, is nearly surrounded by bluffs, and were it not for the small tributary drainage area and the correspondingly small run-off it would make an excellent reservoir site. Marsh Lake and Lac qui Parle afford reservoir sites with considerably larger tributary drainage areas than Bigstone Lake.

The following table of elevations and distances, compiled from surveys by the Army Engineer Corps, will give an idea of the opportunities for power development on the river. Elevations are reduced to approximately 1 foot on gage at Mankato, ordinary low water.

Water surface elevations and distances along Minnesota River.

	Distance below Bigstone Lake.	Elevation.
	Miles.	*Feet.*
Bigstone Lake	0	966
Whetstone River	2	956
Bridge southwest of Odessa	11	944
Yellow Bank River	15	940
Marsh Lake bridge	22	936
Pomme de Terre River	29	935
Bridge southwest of Appleton	31	931
Lac qui Parle bridge	36	926
Lac qui Parle River	46	924
First bridge below Lac qui Parle	48	923
Bridge southwest of Watson	51	921
Bridge northwest of Montevideo	55	917
Chippewa River	62	913
Bridge at Montevideo	62	913
Bridge at Myers	70	910
Great Northern Rwy. above Granite Falls	79	907
Pond above dam	80	906
Highway bridge, Granite Falls	81	891
Pond above dam, Minnesota Falls	84	883
Yellow Medicine River	96	861
Hawk Creek	96	860
Sacred Heart bridge	103	848
Sacred Heart Creek	109	835
Bridge north of Delhi	111	831
North Redwood bridge	122	820
Morton	132	810
Bridge south of Franklin	141	803
Fort Ridgely bridge	158	793
Henderman bridge	164	791
Bridge below New Ulm	189	784
Cottonwood River	192	780
Courtland bridge	198	774
Judson bridge	212	762
Blue Earth River	224	757
St. Peter	243	730
Ottawa	250	723
Le Sueur	258	716
Henderson	268	710
Faxon	282	700
Belle Plaine	289	696
Crest of Little Rapids	303	693
Carver	308	690
Bloomington ferry	323	690
Mendota bridge	339	690

About 600 horsepower is now developed at Granite Falls and Minnesota Falls.

The bottom land of the Minnesota Valley is so greatly subject to severe overflow that a considerable portion of it is not under cultivation at the present time. The flood of 1908, which did an immense amount of damage in the valley, was unusually severe. At that time the Weather Bureau gage at Mankato recorded 21.2 feet, the maximum reading since the establishment of the station in 1903. The state drainage commission has made a topographic survey of the valley for the purpose of devising means to protect the overflowed lands. The United States army engineers have also made a topographic survey for the purpose of improving the river for navigation, as the Minnesota is a navigable stream, although it carries very little traffic.

Because of the extreme flatness of much of the basin it has been necessary to resort to artificial drainage for the purpose of aiding the natural channels; about 500,000 acres have been ditched.

MINNESOTA RIVER NEAR ODESSA, MINN.

This station, which is located at the highway bridge 1 mile southwest of Odessa, was established July 4, 1909, for the purpose of determining the run-off from Bigstone Lake available for storage on Whetstone River, which enters the Minnesota above Odessa. A station was also established on that stream for the purpose of determining the amount of water passing Odessa from that source.

Owing to its extreme flatness the valley immediately below Bigstone Lake is subject to severe overflow during high water and it was therefore not possible to locate a satisfactory gaging station above Odessa. Even at this station some water overflows around one end of the bridge at extremely high stages, but this is only a small percentage of the entire flow.

The nearest tributary is Stony Run, a very small stream that enters from the north a half mile above the station.

The flow at Odessa is entirely uncontrolled, as the nearest dam is at Granite Falls. The river is frozen over and observations are discontinued from December to March. The flow during that period may be roughly estimated by utilizing the run-off per square mile of drainage area above Montevideo.

A staff gage was used until July 24, when a chain gage was installed at the same datum. Since the establishment of the chain gage, which is attached to the bridge from which the discharge measurements are made, the datum has remained unchanged.

Conditions at this station are favorable for reliable records.

Discharge measurements of Minnesota River near Odessa, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 4	Follansbee and Gibson	36	76.5	2.98	52.7
July 24	G. A. Gray	33	36.9	2.65	32.8
August 15	C. J. Emerson	34	40.6	2.78	42.2
September 17	G. A. Gray	34	47.0	2.88	44.9

Daily gage height, in feet, of Minnesota River near Odessa, Minn., for 1909.

[Claud Shellenbarger, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	2.53	2.60	2.99	3.19	3.81	16	2.86	2.75	2.98	3.15	4.02	......
2	......	2.45	2.60	3.10	3.18	3.78	17	2.80	2.79	2.89	3.20	3.82	......
3	......	2.57	2.66	3.10	3.15	3.70	18	2.75	2.80	2.89	3.12	3.75	......
4	3.00	2.60	2.71	3.06	3.14	3.62	19	2.64	2.76	2.96	3.04	3.62	......
5	2.91	2.51	2.70	3.08	3.17	3.62	20	2.62	2.71	2.82	3.16	3.62	......
6	2.91	2.42	2.69	3.02	3.07	3.68	21	2.65	2.75	2.98	3.19	3.62	......
7	2.86	2.80	2.70	3.05	3.16	3.85	22	2.79	2.72	3.15	3.10	3.61	......
8	2.92	3.06	2.70	3.08	3.09	4.05	23	2.72	2.71	3.09	3.20	3.60	......
9	2.98	3.04	2.70	3.38	2.96	4.12	24	2.60	2.61	3.08	3.06	3.68	......
10	2.96	2.91	2.76	3.54	3.05	4.05	25	2.52	2.64	3.05	3.18	3.70	......
11	2.90	2.83	2.70	3.70	3.06	4.02	26	2.55	2.56	2.98	3.18	3.69	......
12	3.16	2.77	2.60	3.94	3.09	....	27	2.54	2.66	2.94	3.15	3.68	......
13	3.05	2.78	2.62	3.56	3.17	....	28	2.45	2.62	3.06	3.09	3.68	......
14	2.99	2.82	2.72	3.34	......	....	29	2.53	2.62	3.09	2.95	3.71	......
15	2.95	2.85	2.88	3.19	4.44	....	30	2.47	2.56	3.08	3.04	3.75	......
							31	2.53	2.59	......	3.20	......	......

NOTE.—Ice during latter part of November and all of December.

MINNESOTA RIVER NEAR MONTEVIDEO, MINN.

This station, which is located at the highway bridge about 1 mile south of Montevideo, was established July 23, 1909, to obtain information concerning the power available on Minnesota River at Granite Falls, a few miles below. The records will also afford data of value in connection with studies of flood prevention.

Chippewa River enters the Minnesota a short distance above the station. The nearest dam, that above Granite Falls, is not more than 6 or 8 feet high, and its influence does not extend to the Montevideo station. There is no dam above the station.

The river is frozen entirely across at this station from December to March, during which period discharge measurements are made through the ice to develop an approximate frozen-season rating curve.

The chain gage is attached to the bridge from which the discharge measurements are made. The datum of the gage was lowered 2 feet September 16, 1909, and again lowered 1 foot in 1910. All readings have been corrected to conform to the datum established in 1910.

Conditions at this station are excellent and the results should therefore be reliable.

Discharge measurements of Minnesota River near Montevideo, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 23	G. A. Gray	100	396	5.40	803
August 14	C. J. Emerson	96	320	4.63	576
September 16	G. A. Gray	82	167	3.05	205

Daily gage height, in feet, of Minnesota River near Montevideo, Minn., for 1909.

[Miss May Hendricks, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.14	3.30	3.24	3.49		16		4.51	3.06	3.42	3.48	
2		4.09	3.30	3.21	3.53		17		4.42	3.09	3.46	3.89	4.17
3		4.06	3.32	3.18	3.45		18		4.36	2.95	3.48	3.92	
4		4.04	3.25	3.14	3.43		19		4.22	2.92	3.52	3.86	
5		3.96	3.21	3.11	3.40		20		4.12	3.02	3.45	3.63	
6		3.86	3.21	3.05	3.40		21		4.01	3.41	3.50	4.34	4.22
7		4.00	3.18	2.99	3.38	4.30	22	5.40	3.96	3.60	3.55	4.22	
8		4.22	3.19	2.95	3.47		23	5.26	3.86	3.62	3.56	3.97	
9		4.31	3.24	3.22	3.36		24	5.10	3.75	3.59	3.52	3.50	4.22
10		4.42	3.16	3.35	3.22	4.70	25	4.94	3.69	3.61	3.49	3.68	
11		4.42	3.02	3.52	3.26		26	4.78	3.76	3.55	3.55	3.69	
12		4.46	3.08	3.70	3.37		27	4.68	3.65	3.51	3.56	3.60	
13		4.55	3.14	3.52	3.42		28	4.52	3.59	3.49	3.55	3.33	4.02
14		4.65	3.14	3.39	3.56	4.60	29	4.46	3.58	3.32	3.29	3.89	
15		4.56	3.08	3.50	3.40		30	4.39	3.44	3.26	3.29	3.81	4.27
							31	4.26	3.39		3.42		

NOTE.—Ice during December. The following comparative readings were made:

Date.	Gage height to water surface.	Gage height, top of ice.	Thickness of ice. At gage.	Thickness of ice. Average.	Remarks.
	Feet.	*Feet.*	*Feet.*	*Feet.*	
December 7	4.30	3.37	0.4		Narrow open channel in center.
December 10	4.70	4.00	.7	0.7	River entirely frozen over.
December 14	4.60	3.70	.8	.9	
December 17	4.17	3.43	.8	.8	
December 21	4.22	3.47	1.0	1.0	Three inches of snow on ice.
December 24	4.22	3.50	1.0	1.0	Do.
December 28	4.02	3.33	1.0	.9	Do.
December 30	4.27	3.50	1.0	.95	Do.

Daily discharge, in second-feet, of Minnesota River near Montevideo, Minn., for 1909.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Day.	July.	Aug.	Sept.	Oct.	Nov.
1		446	248	236	290	16		548	204	274	288
2		433	248	230	299	17		523	208	283	382
3		426	252	224	281	18		506	187	288	389
4		420	238	217	277	19		467	183	296	374
5		400	230	212	270	20		441	197	281	321
6		374	230	202	270	21		413	272	292	500
7		410	224	193	266	22	805	400	314	303	467
8		467	226	187	285	23	761	374	318	305	402
9		492	236	232	261	24	713	348	312	296	292
10		523	221	259	232	25	668	334	316	290	332
11		523	197	296	240	26	623	350	303	303	334
12		534	207	336	263	27	595	325	294	305	314
13		559	217	296	274	28	551	312	290	303	255
14		587	217	268	305	29	534	310	252	246	382
15		562	207	292	270	30	514	279	240	246	362
						31	478	268		274	

NOTE.—These discharges are based on a rating curve that is well defined.

Monthly discharge of Minnesota River near Montevideo, Minn., for 1909.

[Drainage area, 6,300 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
July 22-31	805	478	624	0.099	0.04	12,400	A.
August	587	268	431	.068	.08	26,500	A.
September	318	197	243	.039	.04	14,500	A.
October	336	187	267	.042	.05	16,400	A.
November	500	232	316	.050	.06	18,800	A.
December			a 230	.037	.04	14,100	D.

a Estimated, because of ice conditions.

CHIPPEWA RIVER NEAR WATSON, MINN.

This station, which is located at the highway bridge about 2½ miles northeast of Watson, was established July 6, 1909. The records of flow will be of value in devising means for flood prevention.

No important tributary enters between the station and the mouth of the river, about 10 miles distant. Dry Weather Creek enters the Chippewa about 2 miles above the station. The drainage area above the station is 1,940 square miles.

A water-power plant at Montevideo utilizes a head of 7 feet, but the backwater from the dam does not extend to the gaging station. The only dam above the station is at Benson, but here the power is only used during high-water stages, and at other times the flow is not controlled.

The gage is located at the bridge section at which measurements are made. From December to March observations are suspended because of ice.

Since the installation of the gage its datum has remained unchanged.

Owing to the impossibility of obtaining a reliable observer during 1909, no data are available except the discharge measurements. By comparing these records with the complete records of flow of other stations in the same basin, the daily flow can be roughly estimated.

Discharge measurements of Chippewa River near Watson, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
July 6	C. B. Gibson	110	272	7.28	474
July 24	G. A. Gray	85	151	6.17	267
August 15	C. J. Emerson	74	98	5.66	162
September 17	G. A. Gray	50	42	4.87	48.7

REDWOOD RIVER NEAR REDWOOD FALLS, MINN.

This station, which is located about 3 miles above Redwood Falls at the first highway bridge, was established July 2, 1909, as part of the general plan for investigating the water resources of the Minnesota. The records furnish information not only in regard to available water power but also concerning the run-off tributary to Minnesota River.

The nearest dam, that at Redwood Falls, creates a pond that extends upstream for a considerable distance; but rapids just below the gaging station prevent backwater effects at the gage. This dam, by utilizing the natural fall of the river, creates a head of 85 feet.

During all stages except low, discharge measurements are made from the bridge; low-water measurements are made by wading at different sections.

Observations are discontinued from December to March because of ice.

A staff gage was used prior to July 22, 1909, on which data a chain gage was attached to the bridge. The gage datum has remained unchanged.

Conditions at this station are favorable for excellent results and the records should therefore be reliable.

Discharge measurements of Redwood River near Redwood Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
July 2	Follansbee and Gibson	88	370	4.20	781
July 22	G. A. Gray	77	256	2.85	222
August 13	C. J. Emerson [a]	34	576	2.18	50.0

[a] Made by wading.

Daily gage height, in feet, of Redwood River near Redwood Falls, Minn., for 1909.

[C. J. Farlee and Mrs. S. C. Haskins, observers.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.24	2.10	1.92	2.01	2.20	16	3.00	2.65	1.95	1.92	2.00	
2	4.19	2.21	2.10	1.90	1.98	2.20	17	2.96	2.71	1.95	1.95	2.00	
3	4.08	2.22	2.11	1.90	1.95	2.15	18	3.02	2.74	1.95	1.92	2.00	
4	3.91	2.20	2.09	1.90	1.95	2.00	19	2.99	2.79	1.96	1.92	2.00	
5	3.81	2.20	2.05	1.90	1.95		20	2.91	2.81	1.95	1.92	2.15	
6	3.68	2.15	2.05	1.90	1.98		21	2.86	2.79	1.95	1.92	2.20	
7	3.60	2.15	2.05	1.89	1.98		22	2.75	2.74	1.96	1.92	2.20	
8	3.59	2.14	2.04	1.89	1.98		23	2.64	2.66	1.95	1.95	2.20	
9	3.48	2.14	2.04	1.94	1.98		24	2.56	2.55	1.95	1.95	2.10	
10	3.42	2.14	2.02	1.92	1.98		25	2.51	2.46	1.95	1.92	2.15	
11	3.16	2.14	2.01	1.92	1.98		26	2.46	2.40	1.95	1.92	2.20	
12	3.18	2.19	2.04	1.92	1.98		27	2.40	2.34	1.95	1.92	2.20	
13	3.35	2.18	2.02	1.92	2.00		28	2.35	2.28	1.95	1.90	2.20	
14	3.28	2.28	2.00	1.92	2.00		29	2.28	2.22	1.92	1.90	2.20	
15	3.10	2.55	1.99	1.92	2.00		30	2.28	2.19	1.92	1.91	2.20	
							31	2.29	2.14		1.92		

NOTE.—Ice conditions during the latter part of November and all of December.

COTTONWOOD RIVER NEAR NEW ULM, MINN.

This station, which is located at the Alwin highway bridge, about 2 miles southwest of New Ulm, and about 3½ miles above the mouth of the river, was established July 2, 1909, in accordance with the general plan of studying the water resources of the Minnesota River basin.

The dam of the Cottonwood Roller Mill, 2 miles below the station, prevents any possible effect of backwater from the Minnesota reaching the gage. Though the dam itself may be the control for the station, the low-water records show no systematic variation which would indicate such control.

Observations of flow are suspended from December to March because of ice.

Discharge measurements are made from the bridge to which the chain gage is attached.

A staff gage was used until July 21, on which date a chain gage was installed. On August 12, 1909, the datum of the chain gage was lowered 2.28 feet. All readings prior to that date have been corrected and all gage heights apply to the new datum.

As conditions at this station are favorable for excellent results the records should be reliable.

Discharge measurements of Cottonwood River near New Ulm, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
July 1	Follansbee and Gibson	127	575	6.64	2,000
July 21	G. A. Gray	122	225	3.88	593
August 12	C. J. Emerson [a]	61	77.6	2.60	191
September 15	G. A. Gray [a]	63	63.9	2.08	79.8

[a] Made by wading.

Daily gage height, in feet, of Cottonwood River near New Ulm, Minn., for 1909.

[Miss Esther Alwin, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.60	2.34	2.32	1.94	2.00	2.87	16	3.76	5.65	2.01	2.00	1.80	
2	6.30	2.46	2.29	1.90	2.02	2.97	17	3.60	5.22	2.00	1.99	2.36	
3	5.88	2.38	2.32	1.88	2.04	2.99	18	3.73	4.62	1.98	1.98	2.95	
4	5.36	2.37	2.22	1.88	2.04	3.02	19	3.88	4.16	1.98	1.95	3.05	
5	4.83	2.37	2.24	1.87	2.04		20	4.00	3.78	1.98	1.95	2.79	
6	4.53	2.33	2.15	1.85	2.02		21	3.83	3.46	2.06	1.98	2.69	
7	4.48	2.28	2.14	1.82	1.98		22	3.60	3.22	2.04	2.08	2.69	
8	4.38	2.30	2.14	1.82	1.95		23	3.36	3.07	1.98	2.07	2.68	
9	4.28	2.28	2.08	1.88	1.94		24	3.14	3.06	2.02	1.99	2.67	
10		2.32	2.07	2.05	1.98		25	2.96	2.98	2.10	1.95	2.58	
11	4.16	2.40	2.07	2.04	1.90		26	2.80	2.88	2.08	1.90	2.45	
12	4.00	2.55	2.11	1.97	1.88		27	2.70	2.80	2.04	1.97	2.61	
13	3.96	4.48	2.10	1.92	1.92		28	2.60	2.73	2.00	1.98	2.70	
14	4.00	5.88	2.05	1.92	1.88		29	2.47	2.62	1.98	1.98	2.80	
15	3.98	5.94	2.05	1.97	1.85		30	2.40	2.56	1.96	1.98	2.84	
							31	2.43	2.42		1.98		

NOTE.—The river was frozen over during December.

Daily discharge, in second-feet, of Cottonwood River near New Ulm, Minn., for 1909.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Day.	July.	Aug.	Sept.	Oct.	Nov.
1	1,980	133	129	61	70	16	564	1,460	72	70	40
2	1,820	157	123	55	73	17	500	1,240	70	68	136
3	1,590	141	129	52	76	18	542	939	67	67	285
4	1,300	139	109	52	76	19	612	732	67	62	315
5	1,040	139	113	50	76	20	660	572	67	62	238
6	898	131	95	48	73	21	592	451	79	67	212
7	876	121	93	43	67	22	500	367	76	82	212
8	831	125	93	43	62	23	416	321	67	80	210
9	786	121	82	52	61	24	342	318	73	68	208
10	759	129	80	78	67	25	288	294	85	62	185
11	732	145	80	76	55	26	240	264	82	55	155
12	660	178	87	66	52	27	215	240	76	66	150
13	644	876	85	58	58	28	190	290	70	67	150
14	660	1,590	78	58	52	29	159	195	67	67	145
15	652	1,620	78	66	48	30	145	180	64	67	145
						31	151	149	....	67	....

NOTE.—These discharges are based on a rating curve that is well defined between 70 and 2,200 second-feet, except November 27 to 30, which are estimated because of ice conditions.

Monthly discharge of Cottonwood River near New Ulm, Minn., for 1909.

[Drainage area, 1,190 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
July	1,980	145	689	0.579	0.67	42,400	A.
August	1,620	121	444	.373	.43	27,300	A.
September	129	64	84.5	.071	.08	5,030	A.
October	78	43	62.4	.052	.06	3,840	B.
November	315	40	125	.105	.12	7,440	B.

BLUE EARTH RIVER AT RAPIDAN MILLS, MINN.

This station is located 2 miles west of Rapidan, a station on the Chicago, Milwaukee & St. Paul Railway, about 9 miles above the mouth of the river. On June 1, 1909, a station was established at the highway bridge 4 miles above Mankato, but, owing to unsatisfactory conditions, was discontinued and the present station established July 20, 1909, at the highway bridge at Rapidan Mills. The records will be of value not only because of the power available on Blue Earth River, but also for use in connection with the records of the Minnesota near Mankato, to estimate the discharge of Minnesota River above the Blue Earth available for navigation or power. The drainage area of this river above its mouth is 3,430 square miles; above the gaging station it is 2,260 square miles. This large difference is due to the area drained by Lesueur River, which enters Blue Earth River below the gaging station.

The nearest important tributary is Watonwan River, which enters Blue Earth about 4 miles above the gaging station. The heavy fall of the river at this point is utilized immediately above the station by a power plant which develops 23 feet head and generates 100 horsepower.

It was intended to maintain this station during the winter, but ice gorges below the gage cause so much backwater and such unstable ice conditions that the winter records have been abandoned.

The chain gage is attached to the bridge from which discharge measurements are made. The datum of the gage was lowered 1.90 feet on August 11, and all gage heights prior to that time have been increased by that amount, so that all records refer to the same datum.

Conditions at this station are good for reliable results, when the section is completely rated.

Discharge measurements of Blue Earth River near Rapidan Mills, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
July 20	Gray and Gibson	128	450	4.28	1,590
August 11	C. J. Emerson	106	234	a 2.60	243
September 12	G. A. Gray	95	193	2.05	143

a Gage height rose 0.36 foot during the measurement.

Daily gage height, in feet, of Blue Earth River near Rapidan Mills, Minn., for 1909.

[T. L. Rodgers, observer.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Day.	July.	Aug.	Sept.	Oct.	Nov.
1		2.70	2.19	2.19	2.18	16		3.22	2.14	2.25	4.95
2		2.65	2.20	2.14	2.26	17		3.28	2.16	2.30	4.96
3		2.61	2.20		3.16	18		3.26	2.16	2.30	4.88
4		2.56	2.06		4.04	19		3.18	2.19	2.20	4.81
5		2.48	2.11		4.10	20	4.28	3.07	2.14	2.20	4.88
6		2.42	2.12		3.98	21	3.82	2.98	2.15	2.16	4.82
7		2.39	2.10		3.78	22	3.58	2.88	2.25	2.08	4.92
8		2.34	2.08		3.56	23	3.40	2.80	2.28	2.05	4.88
9		2.31	2.05		3.40	24	3.28	2.70	2.58	2.05	4.78
10		2.41	2.04		3.26	25	3.12	2.63	2.70	2.06	4.68
11		2.26	2.00		3.15	26	3.02	2.54	2.60	2.00	4.85
12		2.19	2.09	1.98	3.11	27	2.88	2.49	2.50	2.02	
13		2.21	2.08	2.12	3.22	28	2.79	2.43	2.42	2.02	
14		2.28	2.10	2.28	3.56	29	2.80	2.37	2.35	2.04	
15		2.35	2.14	2.31	4.25	30	2.80	2.32	2.29	2.02	
						31	2.76	2.26		2.15	

NOTE.—Gage not read October 3 to 11. It is probable that the rise in gage heights during the latter part of November was due partly to ice gorging. The river was badly gorged during December.

ST. CROIX RIVER DRAINAGE BASIN.

DESCRIPTION.

St. Croix River, which forms throughout the greater part of its length the boundary between Minnesota and Wisconsin, drains an area of 7,580 square miles lying in eastern Minnesota and northwestern Wisconsin. The river rises at an elevation of 1,010 feet above sea level, in Lake St. Croix, on the Lake Superior divide, only 20 miles from Lake Superior, and flows southwest and then south till it joins the Mississippi opposite Hastings, Minn. In its total length of 160 miles it descends 338 feet, all but 20 feet of which is in the upper 116 miles.

Its principal tributaries are Namakagon, Yellow, Apple, and Willow rivers from the Wisconsin side, and Tamarack, Kettle, Snake, and Sunrise rivers from the Minnesota side.

Almost the entire basin is so thickly covered with glacial drift that rock outcrops, except near the rivers, are very rare. Probably the greater part of the area is underlain by the pre-Cambrian crystalline rocks whose intersection with the St. Croix near Taylors Falls, Minn., causes the falls and rapids that extend for 6 or 7 miles above that point.

The country is for the most part gently undulating and is deeply trenched by the larger rivers which have cut through the drift and into the underlying rock. Kettle River, especially, flows at a level of 75 to 100 feet below the top of the bluffs in a valley cut in the underlying sandstone. In many places the sandstone forms the river bed and produces rapids. Throughout the greater part of its course the river flows alternately in rapids and pools and its aggregate fall is great.

The upper part of the drainage basin is timbered, being at the present time cut-over land.

The annual rainfall is about 30 inches. From December to March the rivers are frozen over, except at the rapids, with ice 1.5 feet thick, and snow remains upon the ground for considerable periods.

In the Wisconsin portion of the basin lakes are much more numerous than elsewhere. Many of the lakes are without surface outlet; and many others have been dammed to control the outflowing stream for logging.

The lakes afford excellent reservoir sites which could be utilized at a comparatively low cost.

The following table [a] shows the elevation at different points of the St. Croix River and thus indicates the possibility of power development.

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[a] From Water-Supply Paper, U. S. Geol. Survey, No. 156, p. 119.

Elevations and distances along St. Croix River.

	Distance above mouth.	Elevation.
	Miles.	*Feet.*
Mouth	0	667
Mouth of Kinnikinnic River	5	668
Mouth of Apple River	28	672
Osceola	42	683
St. Croix Falls (head of navigation)	48	687
Mouth of Trade River	60	753
Mouth of Sunrise River	65	758
Rush City Ferry	75	773
Sec. 35, T. 38 N., R. 20 W	79	782
Mouth of Snake River	86	790
Foot of Kettle River Rapids	89	801
Mouth of Kettle River	90	816
Head of Kettle River Rapids	93	850
Mouth of Clam River	101	868
Sec. 1, T. 40 N., R. 18 W	104	874
Mouth of Yellow River	115	888
Mouth of Namekagon River	127	908
Mouth of Moose River	139	1,001
St. Croix Lake	160	1,010

At Taylors Falls a 50-foot dam has been constructed with hydro-electric development of about 26,000 horsepower. On Kettle River near Sandstone there are two power plants which develop an aggregate of 800 horsepower.

During the glacial epoch, when the volumes of the rivers were much greater than now, Lake Superior stood at an elevation 500 feet above its present level and there was a continuous water channel through Moose and Kettle rivers to the St. Croix and finally to the Mississippi.

KETTLE RIVER NEAR SANDSTONE, MINN.

This station, which is located at the quarries of the Barber Asphalt Company at Banning, 3 miles above Sandstone, was established October 18, 1908, by the Kettle River Quarries Company to obtain data concerning the power available on the river. The gage heights prior to October 1, 1909, have been furnished through the courtesy of the quarries company; but since that date the station has been maintained in cooperation with the United States Geological Survey, although no discharge measurements have been made. The company has also furnished a rating for the section made by current meter, and as the stream flows at the gaging section through solid rock this rating should hold permanently.

No important tributaries enter within several miles of the station. The nearest dam is at Sandstone; but as there is a heavy fall in the 3 miles between the two points the station is above its influence.

The gage is 50 feet above decided rapids, which remain open except for very short periods of extremely cold weather, when they may freeze, and thus cause backwater. As the channel very seldom freezes entirely over at the gage, it is probable that the open-channel rating is applicable, except for the few days when the rapids freeze, and it has been used in computing the winter flow.

Since the installation of the staff gage, its datum has remained unchanged. Conditions are exceptionally favorable for excellent results at this station.

Discharge measurements of Kettle River near Sandstone, Minn., in 1909.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
March 23	W. R Hoag	1.27	105
March 31	do	1.64	200
		2.0	330
		2.3	460
		2.5	560
June 19	W. R. Hoag	2.5	575
		2.8	740
July 23	W. R. Hoag	3.04	835
		3.0	910
		4.3	1,840

NOTE.—The above measurements were scaled from a rating curve furnished by the Kettle River Quarries Company, and are the only data available. See description.

Daily gage height, in feet, and discharge, in second-feet, of Kettle River near Sandstone, Minn., for 1908.

[E. H. Thompson, observer.]

Day.	October.		November.		December.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			3.2	1,000	1.85	186
2			3.1	930	1.8	186
3			2.5	565	1.8	186
4			2.7	675	1.7	186
5			1.7	216	1.6	186
6			1.7	216		186
7			1.7	216	1.6	186
8			1.7	216		180
9			1.7	216	1.55	173
10			1.7	216		166
11			1.65	201	1.5	160
12			1.6	186		154
13			1.65	201	1.45	148
14			1.5	160		148
15			1.5	160		148
16			1.5	160	1.45	148
17			1.5	160		148
18			1.65	201	1.45	148
19			1.6	186		148
20			1.6	186		148
21	0.9	38	1.6	186	1.45	148
22	.95	45	1.6	186		142
23	1.35	124	1.6	186	1.4	136
24	2.3	465	1.6	186		142
25	2.7	675	1.8	186	1.45	148
26	2.05	352	2.0	186		154
27	2.15	398	2.2	186	1.5	160
28	3.2	1,000	2.0	186		160
29	3.8	1,440	2.2	186	1.6	160
30	3.7	1,370	2.0	186		160
31	3.3	1,070			3.0	160

NOTE.—The daily discharges were obtained from a rating curve that is well defined between 90 and 2,000 second-feet, except as noted below. Below 90 second-feet the rating is an extension and is only approximate. Backwater conditions prevailed November 25 to December 4; discharges estimated. Ice conditions December 28 to 31, discharges estimated. Discharges interpolated for days on which gage was not read.

Daily gage height, in feet, of Kettle River near Sandstone, Minn., for 1909.

[E. H. Thompson, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	1.40	1.25	1.90	2.40	3.20	1.65	2.50	1.90	2.10	1.90	2.95
2	......	......	1.25	2.00	2.55	4.00	1.55	2.50	1.80	2.05	1.85	2.90
3	......	1.35	1.25	2.20	2.75	3.80	1.50	2.45	1.70	2.00	1.85	3.00
4	1.40	......	1.25	2.45	2.95	3.75	1.50	2.35	1.60	1.95	1.80	3.00
5	......	1.25	1.25	2.70	3.10	3.90	1.50	2.20	1.60	1.95	1.80	3.00
6	1.80	......	1.30	2.80	4.30	4.00	1.45	2.10	1.65	1.95	1.80	3.20
7	......	......	1.30	2.80	5.30	3.80	1.40	1.95	1.70	1.90	1.80	3.50
8	1.45	1.30	1.30	2.85	5.00	3.50	1.40	1.90	1.70	1.80	1.80	3.50
9	......	......	1.30	2.90	5.10	3.10	1.35	1.80	1.70	1.80	1.80	3.20
10	......	......	1.30	2.80	4.90	2.90	1.35	2.00	1.65	1.85	1.85	2.90
11	1.45	......	1.30	2.75	4.70	2.70	1.30	5.40	1.65	1.90	1.85	2.70
12	......	......	1.30	2.70	4.40	2.60	1.30	6.60	1.60	1.95	1.85	2.70
13	1.40	......	1.30	2.60	4.20	2.45	1.30	6.40	1.65	2.00	1.90	2.65
14	......	......	1.30	2.60	4.40	2.50	1.30	5.80	1.70	2.00	2.05	2.60
15	1.40	......	1.30	2.50	4.55	2.60	1.25	5.20	1.60	1.95	3.00	2.70
16	......	......	1.30	2.60	4.50	2.55	1.20	4.80	1.60	1.95	2.90	2.75
17	......	......	1.35	2.60	4.40	2.50	1.20	4.20	1.60	1.95	2.80	2.90
18	1.30	......	1.35	2.55	4.40	2.50	1.15	3.50	1.60	1.95	2.70	2.95
19	......	1.30	1.35	2.70	4.30	2.50	1.10	3.30	1.70	1.90	2.65	2.95
20	1.25	......	1.35	2.90	4.20	2.40	1.30	3.00	1.70	1.90	2.60	2.80
21	......	......	1.35	3.10	3.80	2.30	1.50	2.85	2.20	1.90	2.55	2.60
22	1.35	1.30	1.40	3.00	3.05	2.20	2.30	2.70	2.70	1.90	2.50	2.30
23	......	......	1.40	2.90	3.70	2.10	3.10	2.55	2.80	1.95	2.50	2.10
24	......	1.25	1.45	2.80	3.60	2.10	2.90	2.50	2.70	1.95	2.45	2.00
25	1.40	......	1.45	3.00	3.40	2.00	2.80	2.40	2.65	1.95	2.45	2.10
26	......	1.25	1.50	2.85	3.35	2.00	2.75	2.35	2.55	1.90	2.60	2.40
27	1.40	......	1.50	2.80	3.20	1.90	2.60	2.30	2.40	1.90	2.90	2.40
28	......	1.25	1.50	2.80	3.15	1.85	2.50	2.20	2.30	1.85	2.90	2.50
29	1.40	......	1.50	2.85	2.95	1.80	2.45	2.15	2.30	1.80	2.95	2.70
30	......	......	1.55	2.65	3.00	1.80	2.30	2.10	2.15	1.80	3.00	2.85
31	......	......	1.65	......	2.95	......	2.50	2.00	......	1.80	......	3.00

Note.—There was little ice during January, February, and the greater part of November. Effective ice conditions from about November 26 to December 31.

Daily discharge, in second-feet, of Kettle River near Sandstone, Minn., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	154	136	101	288	515	1,000	201	565	288	375	288
2	148	130	101	330	592	1,600	173	565	250	352	269
3	142	124	101	420	705	1,440	160	540	216	330	269
4	136	124	101	540	828	1,410	160	490	186	309	250
5	139	124	101	675	930	1,520	160	420	186	309	250
6	142	120	112	735	1,840	1,600	148	375	201	309	250
7	145	116	112	735	2,660	1,440	136	309	216	288	250
8	148	112	112	765	2,410	1,220	136	288	216	250	250
9	148	112	112	795	2,500	930	124	250	216	250	250
10	148	112	112	735	2,320	795	124	330	201	269	269
11	148	112	112	705	2,160	675	112	2,750	201	288	269
12	142	112	112	675	1,920	620	112	3,810	186	309	269
13	136	112	112	620	1,760	540	112	3,630	201	330	288
14	136	112	112	620	1,920	565	112	3,090	216	330	352
15	136	112	112	565	2,040	620	101	2,580	186	309	860
16	128	112	112	620	2,000	592	90	2,240	186	309	795
17	120	112	124	620	1,920	565	90	1,760	186	309	735
18	112	112	124	592	1,920	565	80	1,220	186	309	675
19	106	112	124	675	1,840	565	70	1,070	216	288	648
20	101	112	124	795	1,760	515	112	860	216	288	620
21	112	112	124	930	1,440	465	160	765	420	288	592
22	124	112	136	860	895	420	465	675	675	288	565
23	128	106	136	795	1,370	375	930	592	735	309	565
24	132	101	148	735	1,300	375	795	565	675	309	540
25	136	101	148	860	1,140	330	735	515	648	309	540
26	136	101	160	765	1,110	330	705	490	592	288	a 520
27	136	101	160	735	1,000	288	620	465	515	288	a 500
28	136	101	160	735	965	269	565	420	465	269	a 490
29	136	....	160	765	828	250	540	398	465	250	a 480
30	136	....	173	648	860	250	465	375	398	250	a 470
31	136	....	201	....	828	....	565	330	....	250	....

a Estimated.

NOTE.—These discharges are based on a rating curve that is well defined between 90 and 2,000 second-feet, except as follows: Discharges interpolated January 5 to 7 and February 9 to 18 because of probable backwater due to temporary ice jams, and for other days not having gage heights.

Monthly discharge of Kettle River near Sandstone, Minn., for 1908-9.

[Drainage area, 825 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
1908.							
October 18-31	1,440	38	634	0.768	0.31	13,800	A.
November	1,000	160	271	.328	.37	16,100	B.
December	186	136	161	.195	.22	9,900	B.
1909.							
January	154	101	134	.162	.19	8,240	B.
February	136	101	113	.137	.14	6,280	B.
March	201	101	127	.154	.18	7,810	B.
April	930	288	678	.822	.92	40,300	A.
May	2,660	515	1,490	1.81	2.09	91,600	A.
June	1,600	250	738	.895	1.00	43,900	A.
July	930	70	292	.354	.41	18,000	A.
August	3,810	250	1,060	1.28	1.48	65,200	A.
September	735	186	325	.394	.44	19,300	A.
October	375	250	297	.360	.42	18,300	A.
November	860	250	446	.541	.60	26,500	B.
December	....	....	a 200	.242	.28	12,300	C.
The year	3,810	70	492	.596	8.15	358,000	

a Estimated on the basis of the flow in January, 1910, when the river was open.

SNAKE RIVER AT MORA, MINN.

This station, which is located at the highway bridge three-fourths of a mile south of Mora, was established June 11, 1909, in connection with the general plan for investigating the water resources of Minnesota.

The nearest tributary, Ann River, enters 1 mile below the station. There are two logging dams above Mora, at Knife Lake outlet and at White Pine, but these dams have not seriously affected the gage heights since the station has been established. The only dam below Mora is at the outlet of Cross Lake at Pine City and is too far distant to affect the river at Mora.

About 40 miles above Mora and just below the Aitkin-Kanabec county line Snake River makes a considerable descent known as the upper and lower falls. The upper falls are two-thirds of a mile below the mouth of Cowans Brook and are caused by granite outcrops on both banks of the river, which here flows between vertical walls for a distance of 10 rods, with a fall of about 3 feet. At the lower falls, which are located a short distance farther downstream, the river descends 20 feet in a distance of three-fourths of a mile.

From December to March, when ice conditions prevail at the station, discharge measurements are made through the ice to determine the approximate winter rating.

The low-water section of the staff gage is placed at the right abutment of the old bridge location, 2 rods upstream from the present bridge, which carries the high-water portion of the gage. Discharge measurements are made from the highway bridge and by wading.

Conditions at this station are excellent, and the records should therefore be reliable.

Discharge measurements of Snake River at Mora, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 11	G. A. Gray	104	129	6.65	169
July 9	Gray and Gibson	91	55.4	5.89	59.2
August 3	G. A. Gray	107	270	7.58	417
August 31	Robert Follansbee	103	137	6.23	97.7
October 20	G. A. Gray	92	111	5.90	59.5

Daily gage height, in feet, of Snake River at Mora, Minn., for 1909.

[Edith Lasher, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.55	6.50	6.20	5.95	6.00	7.15	16	6.30	5.70	9.55	5.90	5.90	7.70	
2		6.50	6.50	6.12	5.90	6.00	7.40	17	6.40	5.80	9.15	5.90	5.90	7.70	
3		6.20	7.55	6.10	5.90	6.00	7.40	18	6.40	5.80	8.85	5.90	5.90	8.45	
4		6.20	7.30	6.08	5.90	6.00	7.40	19	6.42	5.80	8.20	5.90	5.90	8.20	
5		6.20	7.00	6.00	5.90	6.00		20	6.32	6.00	7.65	5.90	5.90	8.00	
6		6.20	6.55	6.00	5.90	6.00		21	6.25	6.52	7.25	6.00	5.90	7.45	7.60
7		6.20	6.50	6.00	5.90	6.00		22	6.35	7.00	7.10	6.18	5.90	7.30	
8		5.90	6.50	6.00	5.90	6.00		23	6.62	7.50	7.00	6.25	5.95	7.20	
9		5.80	6.45	5.90	5.90	6.00		24	6.62	8.15	6.90	6.32	6.00	7.00	7.10
10		5.80	6.50	5.85	5.90	6.00		25	6.58	7.90	6.55	6.30	6.00	7.00	
11	6.60	5.82	7.80	5.80	5.95	6.00	7.90	26	6.50	7.50	6.50	6.20	6.00	6.90	
12	6.55	5.85	9.50	5.70	5.95	6.00		27	6.60	7.10	6.50	6.20	6.00	6.80	
13	6.50	5.82	9.90	5.90	5.90	6.00		28	6.85	6.90	6.50	6.10	6.00	7.00	7.90
14	6.40	5.78	10.00	5.90	5.90	6.20	7.40	29	6.78	6.80	6.45	6.10	6.00	7.15	
15	6.30	5.70	9.60	5.90	5.90	6.40		30	6.70	6.70	6.35	6.05	6.00		
								31		6.50	6.28		5.95		6.90

NOTE.—The river more than half frozen over during first half of December; entirely frozen over during the last half of December. It is probable that the gage heights were affected by ice conditions November 16 to December 31.

Daily discharge, in second-feet, of Snake River at Mora, Minn., for 1909.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		148	140	97	66	71	16	111	43	1,370	61	61	300
2		140	140	86	61	71	17	125	51	1,150	61	61	300
3		97	407	83	61	71	18	125	51	990	61	61	250
4		97	326	81	61	71	19	128	51	675	61	61	225
5		97	242	71	61	71	20	114	71	442	61	61	200
6		97	148	71	61	71	21	104	143	311	71	61	150
7		97	140	71	61	71	22	118	242	268	94	61	150
8		61	140	71	61	71	23	160	390	242	104	66	125
9		51	132	61	61	71	24	160	652	217	114	71	125
10		51	140	56	61	71	25	153	541	148	111	71	125
11	156	53	500	51	66	71	26	140	390	140	97	71	125
12	148	56	1,340	43	66	71	27	156	268	140	97	71	100
13	140	53	1,560	61	61	71	28	206	217	140	83	71	100
14	125	49	1,620	61	61	97	29	190	194	132	83	71	100
15	111	43	1,400	61	61	125	30	174	174	118	77	71	100
							31		140	108		66	

NOTE.—These discharges are based on a rating curve that is well defined below 390 second-feet, except those for November 16 to 30, which are estimated, because of probable ice conditions at the gage.

Monthly discharge of Snake River at Mora, Minn., for 1909.

[Drainage area, 422 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
June 11–30	206	104	142	0.336	0.25	5,630	A.
July	652	43	155	.367	.42	9,530	A.
August	1,620	108	483	1.14	1.31	29,700	A.
September	114	43	75.4	.179	.20	4,490	A.
October	71	61	64.1	.152	.18	3,940	A.
November		71	[a] 121	.287	.32	7,200	D.
December			[b] 80	.190	.22	4,920	D.

[a] Partly estimated because of ice conditions. [b] Estimated because of ice conditions.

CANNON RIVER DRAINAGE BASIN.

DESCRIPTION.

Cannon River drains an area comprising 1,490 square miles, located chiefly in Goodhue, Rice, Lesueur, and Steele counties, Minn. The river rises in Shields Lake, in the western part of Rice County, flows westward into Lesueur County, then southward and eastward into Rice County again, passing through several lakes, the largest being 4 miles long and from one-half to three-fourths of a mile wide, and finally taking a general northeasterly course to its junction with the Mississippi a short distance above Red Wing. The last lake on the river is Cannon Lake, which has an area of several square miles. The valley is deeper in the lower part than in the upper, and its limits are marked by steep bluffs. At the lower end the width of the valley is one-half mile.

Except in the valleys, the region is covered with glacial drift and presents a generally undulating surface, which is, in the lower part of the basin, deeply cut by the river valleys. These valleys are marked by gravel terraces.

During the glacial epoch the Cannon Valley carried the waters of Minnesota River, as the lower Minnesota Valley was blocked by ice. Its discharge during this period was apparently not directly into the Mississippi, but in part by way of Hay Creek to Wells Creek, reaching the Mississippi at Florence.

The principal tributaries are Devil, Wolf, Heath, and Chub creeks from the north, and Straight and Little Cannon rivers, and Belle, Hay, and Wells creeks from the south.

Straight River, the most important of the tributaries, rises in lakes and springs scattered among the morainic hills in the southern part of the basin, flows northward over the drift until it reaches a point about 2 miles north of Owatonna, where it first encounters bed rock, and joins the Cannon just below Cannon Lake.

The annual rainfall in the basin, as determined from a number of records exceeding fifteen years in length, is about 29 inches.

As Cannon River lies in one of the most thickly settled farming sections of the State by far the greater part of its drainage area is cultivated land.

From December to March the streams are frozen over except at rapids, and snow lies on the ground for considerable periods.

The many lakes drained by the river and its tributaries afford possible reservoir sites for the regulation of flow of the main stream.

In order to determine the availability of Cannon River for power development, a survey was made during 1909 from the mouth to Cannon Lake, a short distance above Faribault. From the data collected on this survey, sheets have been prepared showing a profile of the water surface, a plan of the river, and the contours along the river bank. These sheets have been published separately, and may be had on application to the Director of the Geological Survey. From this survey the following table of elevations and distances has been compiled:

Elevation and distances along Cannon River.

	Distance above mouth.	Elevation.
	Miles.	*Feet.*
Mississippi River	0	666
Chicago, Milwaukee & St. Paul Ry	4	673
Highway bridge	7	679
Range line, 15-16 W	9	683
Belle Creek	11	690
Welch, tail water	14	706
Welch, head water	14	712
Range line, 16-17 W	18	730
Sec. 10, T. 112 N., R. 17 W	21	750
Pine Creek	23	758
Cannon Falls, tail water	25	773
Cannon Falls, head water	25	782
Goodhue Mill, tail water	26	782
Goodhue Mill, head water	26	797
Sec. 14, T. 112 N., R. 18 W	28	808
Prairie Creek	30	830
Chicago Great Western R. R	33	850
Wallace, tail water	34	856
Wallace, head water	34	866
Highway bridge	37	871
Highway bridge	38	876
Highway bridge	39	879
Waterford, tail water	40	881
Waterford, head water	40	888
Northfield, tail water	42	888
Northfield, head water	42	899
Dundas, tail water	45	908
Dundas, head water	45	917
Highway bridge	53	938
Highway bridge	54	941
Chicago, Rock Island & Pacific R. R	57	950
Faribault, tail water	59	955
Faribault, head water	59	963
Sheffield, tail water	61	964
Sheffield, head water	61	978

Of the 312 feet fall between Cannon Lake and the mouth of the river approximately 75 feet have been utilized by power plants developing about 1,500 horsepower at Faribault, Bridgewater, Northfield, Waterford, Cannon Falls, and Welch. Just above Cannon Falls a high dam is being built to develop about 60 feet additional head.

CANNON RIVER AT WELCH, MINN.

This station, which is located at the highway bridge at Welch, was established June 7, 1909, to determine the amount of water power available on the river.

The nearest important tributary, Belle Creek, enters 3 miles below Welch. A very small tributary enters the river just above the station.

About 800 feet above the bridge is a dam at which approximately 40 horsepower are developed. The operation of this water-power plant, together with other plants farther upstream, causes considerable variation in the flow. The gage is read twice daily.

During the period from December to March ice is frequently gorged at the bridge, and reliable winter records are thereby made impossible.

The chain gage is attached to the bridge from which discharge measurements are made. The current makes an angle of less than 90 degrees with the bridge, and a correction for the angle must therefore be made at each measurement. This correction involves some uncertainty, and therefore the records can not be considered excellent, especially as the flow is controlled.

Prior to September 10 a staff gage was used, after which date readings were from a chain gage installed at the same datum. Since the installation of the gage its datum has remained unchanged.

Discharge measurements of Cannon River at Welch, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 7	G. A. Gray	97	448	6.70	637
July 16	Gray and Gibson	87	270	5.55	224
August 18	G. A. Gray	102	478	7.21	1,010
August 27	C. J. Emerson	91	355	6.06	385
September 10	Follansbee and Smith	93	382	6.32	426
October 29	G. A. Gray	96	293	6.20	394

Daily gage height, in feet, of Cannon River at Welch, Minn., for 1909.

[William Veith, observer.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		6.30	5.58	5.85	6.21	6.65	8.21	16	6.60	5.65	10.55	6.78	6.45	9.01	
2		6.20	5.58	5.86	6.15	9.10	8.08	17	6.65	5.78	8.70	6.84	6.35	8.86	
3		6.20	5.80	5.78	6.46	8.90	8.29	18	6.80	5.80	7.18	6.32	6.32	9.15	
4		6.05	5.68	6.45	5.85	8.28	8.22	19	6.65	5.38	7.30	6.34	6.38	9.16	
5		5.80	5.32	6.40	6.20	7.44	8.12	20	6.40	5.35	7.28	6.30	6.10	9.00	
6		5.80	5.32	6.20	6.28	6.85	8.25	21	6.30	5.72	7.40	6.30	6.08	8.68	
7	6.70	5.70	5.58	6.30	6.12	6.78	7.10	22	6.30	5.75	6.41	6.78	6.31	8.20	
8	6.65	5.65	5.40	6.38	6.19	6.78	7.20	23	6.30	5.70	6.38	7.40	6.30	8.22	
9	6.55	5.40	5.40	6.48	6.22	6.72		24	6.20	5.25	6.20	7.22	6.31	8.08	
10	6.45	5.60	5.55	6.36	6.46	6.40		25	6.20	5.40	6.11	7.00	6.32	7.81	
11	6.40	5.80	5.50	6.28	6.55	6.35		26	6.20	5.15	6.04	6.82	6.20	7.92	
12	6.40	5.85	6.78	7.72	6.68	6.68		27	6.00	5.70	6.00	6.60	6.28	8.22	
13	6.50	5.95	6.80	8.84	6.71	8.18		28	6.00	5.52	5.86	6.20	6.22	8.25	
14	6.55	5.90	9.50	7.44	6.71	9.35		29	6.10	6.05	5.81	6.22	6.21	8.22	
15	6.60	5.90	10.95	7.10	6.54	9.18		30	6.20	6.12	5.85	6.05	6.18	8.18	
								31		6.05	5.80		6.20		

NOTE.—The high water in November and December was chiefly due to rain and melting snow. During December there were ice conditions.

CHIPPEWA RIVER DRAINAGE BASIN.

DESCRIPTION.

Chippewa River drainage system has its source in more than a hundred lakes, large and small, with many connecting swamps, lying in the northwestern part of Wisconsin, near the Michigan boundary and only 20 miles from Lake Superior. The main line of drainage runs very nearly along the central line of the basin, but the name Chippewa River is not applied to the continuation of the main stream. The river divides 112 miles from the mouth; one branch, the prolongation of the line of drainage, called the Flambeau, rises in the lakes near the Michigan line, at an elevation approximately 1,600 feet above sea level; the other branch, the Chippewa, is formed in the central part of Sawyer County by the union of East and West branches, both of which rise in the southwestern part of Ashland County. The course of the river is general southwestward to its junction with the Mississippi at the foot of Lake Pepin. The Flambeau drains about 1,983 square miles; the Chippewa above its junction with the Flambeau drains only about 1,777 square miles. The total length of the Chippewa is 267 miles. The drainage basin, which is regular in shape, is about 180 miles long and about 60 miles in average width, and comprises about 9,573 square miles, of which over 6,000 square miles include the most unsettled region of northern Wisconsin.

The important tributaries of the Chippewa are as follows: From the west (beginning at the sources), West Branch and Red Cedar rivers; from the east, East Branch, Thornapple, Flambeau, Jump, Yellow, and Eau Claire rivers.

The entire area above Chippewa Falls is covered with glacial drift, the underlying crystalline rocks appearing only in the river bed. In the southern part of the basin the rivers have cut deeply into the drift and rock, but in the northern districts they have not cut much below the surface. The country is level or rolling.

With few exceptions all the many and important water powers on Chippewa River are found in the region of crystalline rocks, but on account of the deep glacial drift the power sites on the upper streams occur at bowlder rapids.

The lakes in this drainage basin are situated in two widely separated groups; one in the extreme northeastern part at the headwaters of the Flambeau, the other in the northwestern part at the headwaters of Chippewa and Red Cedar rivers. The remainder of the area is almost devoid of lakes. The wooded regions, however, include very large areas of cedar and tamarack swamps. The sources of Chippewa River have an elevation of about 1,500 feet above sea level; at Chippewa Falls the elevation is 806 feet; at the mouth of the river it is about 665 feet. The elevation of the sources of Flambeau River is about 1,650 feet; at Ladysmith the elevation is 1,115 feet.

This drainage basin contains the richest forests of both hard and soft woods still standing in Wisconsin. Although lumbering has been carried on actively for many years, considerable pine timber still remains, chiefly at the upper headwaters, but it is fast disappearing. The upper half of the drainage basin may be considered forested.

The mean annual rainfall is about 30 inches. The winters are severe. The snowfall is heavy and lasts for long periods; ice forms on the streams about 2 feet in thickness and remains for three to four months.

This drainage area affords an unusually large number of excellent sites for reservoirs. According to surveys made by the United States Engineer Corps in 1880, 12 reservoir sites were located and surveyed, whose total capacity was approximately 25,000,000,000 cubic feet. The highest dam necessary was about 26 feet. The operation of these reservoirs, it was estimated, would increase the ordinary low-water flow of the river by 3,245 second-feet for ninety days, thus about doubling the present available water power of the river. The main obstacle to building such reservoirs at the present time by the Government is the fact that, owing to the settling of this region, the land that would be flooded has become very valuable. Private enterprise has developed some of the smaller sites.

Several valuable developed water powers and many undeveloped power sites are located on this river and its tributaries. The Dells Paper & Pulp Co.'s plant, near Eau Claire, has a turbine installation of over 8,000 horsepower, and plans have been made to increase the head from 26 to 32 feet by increasing the height of the dam. On the Flambeau and Red Cedar exceptionally good power sites exist. Near Ladysmith, on the Flambeau, are two plants, one of which has a rated turbine installation of 3,000 horsepower. In a 30-mile stretch of Red Cedar River there are six sites for water power capable of developing about 13,000 horsepower. The utilization of many of the power sites is retarded by the fact that the area is not now thickly settled and many sections lack railroad facilities.

The river and its tributaries are used extensively for running logs, but where railroads are accessible the logs are moved by rail. The extension of railroad facilities in this section will tend to relieve the river of its burden of logs and correspondingly add to the value of the streams for water power development.

The use of the river for flooding logs modifies the normal flow of the river very materially.

FLAMBEAU RIVER SURVEY.

In order to determine the amount of power available along Flambeau River, a survey was made during 1906 from Flambeau to a point near the western border of Lac du Flambeau Indian Reservation; the section from the mouth to Flambeau had been surveyed by the Geological Survey in 1902. From the data collected sheets have been prepared showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets, and may be had on application to E. A. Birge, director, Wisconsin Geological and Natural History Survey, Madison, Wis.

CHIPPEWA RIVER AT CHIPPEWA FALLS, WIS.

This station is located at the highway bridge at Chippewa Falls, Wis. The gage was originally established by the Chippewa Lumber & Boom Co. in April, 1899, and records of gage heights since that time have been obtained by that company. The gage heights as originally recorded are in feet and inches, but have been reduced to feet and hundredths. On June 1, 1906, the United States Geological Survey began taking discharge measurements at this place to determine the amount of water available for water power and storage and to obtain data of value in general statistical and comparative studies of run-off. The United States Weather Bureau has obtained gage-height records for this station beginning with 1904, and the gage heights furnished by them have been used for March to September, 1905, 1907, 1908, and April to July, 1909.

The dam of the Chippewa Lumber & Boom Co. is about 2,500 feet above the station.

The winters are severe in this vicinity, and ice forms on the river about 2 feet in thickness; but, owing to the swift water and the proximity of the dam, considerable open water is found at the measuring section. The river fluctuates very rapidly at times during the "sawing season" on account of the storage and release of water at a reservoir at Holcombe, some 30 miles above. The stored water is used to flood logs to the sawmill.

The normal flow of the stream is much modified by logging and by the power plants at Chippewa Falls, which cause great and rapid fluctuations in stage from day to day. The datum of the staff gage, which is located on one of the bridge piers, has remained unchanged.

Conditions of flow appear to be permanent, and an excellent rating curve has been developed. Discharge measurements are made from the bridge only.

The following discharge measurement was made under ice conditions by W. M. O'Neill:

February 15, 1909: Width, 339 feet; area, 1,090 square feet; gage height, 0.85; foot discharge, 1,240 second-feet.

Daily gage height, in feet, of Chippewa River at Chippewa Falls, Wis., for 1909.

[N. O. Swift, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.2	0.9	0.6	1.2	4.2	2.5	1.5	2.5	1.2	1.0	1.8	4.25
2	1.2	.9	.6	1.3	3.9	3.3	1.4	2.8	1.1	1.0	2.05	3.9
3	1.2	.9	.6	1.4	3.4	4.8	1.3	1.8	1.1	.9	3.4	3.55
4	1.2	.9	.6	1.6	3.9	7.4	1.2	1.8	1.0	.85	4.0	3.75
5	1.1	.9	.6	1.7	4.4	2.0	1.0	2.0	......	1.05	3.9	3.45
6	1.1	.9	.6	1.8	6.7	4.5	1.3	1.8	1.0	1.05	3.7	3.25
7	1.1	.9	.7	1.9	6.8	4.9	1.1	1.8	1.0	1.1	3.4	3.0
8	1.0	.8	.7	2.0	8.0	5.3	1.0	......	1.1	1.05	3.0	2.85
9	1.0	.8	.7	2.0	6.9	6.0	1.1	1.8	.8	1.05	2.8	2.8
10	.9	.8	.7	1.9	7.1	5.7	1.0	1.5	.8	.95	2.35	2.75
11	.8	.8	.7	2.0	6.5	4.7	.9	1.5	1.0	1.2	1.95	2.7
12	.8	.8	.7	2.1	6.8	3.7	1.3	1.7	......	1.5	2.1	2.6
13	.8	.8	.7	2.5	5.4	2.3	1.4	1.8	1.3	1.5	2.75	2.6
14	.8	.7	.6	2.6	2.2	2.5	1.5	1.5	1.3	1.6	5.25	2.55
15	.8	.6	.6	3.3	3.9	2.1	1.6	......	1.4	1.55	7.45	2.5
16	.8	.6	.6	3.5	7.3	3.0	1.7	2.8	1.3	1.55	7.25	2.65
17	.7	.6	.6	3.6	8.0	2.5	1.8	2.1	1.3	1.45	6.6	2.7
18	.6	.5	.6	3.7	8.5	3.1	1.6	1.8	1.3	1.5	5.4	2.5
19	.6	.5	.6	3.8	8.1	3.0	1.5	1.8	......	1.55	4.5	2.65
20	.6	.5	.6	5.0	7.2	3.7	1.7	1.7	1.3	1.45	4.6	3.0
21	.6	.5	.7	5.5	7.0	2.9	1.5	1.8	1.5	1.4	4.55	2.9
22	.6	.5	.7	6.0	6.0	2.5	1.6	1.0	1.2	1.65	3.9	2.8
23	.7	.5	.7	5.8	5.9	2.2	1.7	1.3	1.2	1.6	3.1	3.0
24	.8	.5	.7	3.6	5.1	2.3	2.1	1.3	1.2	1.7	3.15	2.95
25	.8	.5	.8	4.3	4.5	2.1	3.6	1.3	1.2	1.7	3.1	2.8
26	.8	.5	.9	3.3	4.0	2.2	4.0	1.5	......	1.8	3.2	2.95
27	.8	.5	1.0	4.7	3.5	2.1	3.9	1.3	1.2	1.9	3.45	3.0
28	.8	.5	1.0	4.9	3.6	2.0	3.5	1.2	1.0	1.8	3.9	2.95
29	.8	......	1.0	5.0	3.1	1.9	3.0	......	1.0	1.8	4.6	2.85
30	.8	......	1.0	4.9	3.0	1.8	3.4	1.2	1.0	1.8	4.8	2.95
31	.8	......	......	......	6.3	......	2.2	1.2	......	1.6	......	3.0

NOTE.—Ice conditions existed from January 1 to about March 25. Maximum thickness of ice was 1.3 feet. Gage heights are to water surface during period of ice conditions.

Daily discharge, in second-feet, of Chippewa River at Chippewa Falls, Wis., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,700	1,400	1,100	2,000	10,400	5,510	3,110	5,510	2,450	2,030	3,800	10,600
2	1,700	1,400	1,100	2,400	9,500	7,710	2,890	6,300	2,240	2,030	4,400	9,500
3	1,700	1,400	1,100	2,700	8,000	12,300	2,670	3,800	2,240	1,830	8,000	8,450
4	1,700	1,400	1,100	3,340	9,500	21,900	2,450	3,800	2,030	1,740	9,800	9,050
5	1,600	1,400	1,100	3,570	11,000	4,280	2,030	4,280	2,030	2,140	9,500	8,150
6	1,600	1,400	1,100	3,800	19,200	11,400	2,670	3,800	2,030	2,140	8,900	7,560
7	1,600	1,400	1,200	4,040	19,600	12,700	2,240	3,800	2,030	2,240	8,000	6,850
8	1,500	1,300	1,200	4,280	24,200	14,000	2,030	3,800	2,240	2,140	6,850	6,440
9	1,500	1,300	1,200	4,280	20,000	16,600	2,240	3,800	1,640	2,140	6,300	6,300
10	1,400	1,300	1,200	4,040	20,700	15,400	2,030	3,110	1,640	1,930	5,140	6,160
11	1,300	1,300	1,200	4,280	18,400	12,000	1,830	3,110	2,030	2,450	4,160	6,030
12	1,300	1,300	1,200	4,520	19,600	8,900	2,670	3,570	2,350	3,110	4,520	5,770
13	1,300	1,300	1,200	5,510	14,400	5,010	2,890	3,800	2,670	3,110	6,160	5,770
14	1,300	1,200	1,100	5,770	4,760	5,510	3,110	3,110	2,670	3,340	13,900	5,640
15	1,300	1,100	1,100	7,710	9,500	4,520	3,340	4,700	2,890	3,220	22,100	5,510
16	1,300	1,100	1,100	8,300	21,500	6,850	3,570	6,300	2,670	3,220	21,300	5,900
17	1,200	1,100	1,100	8,600	24,200	5,510	3,800	4,520	2,670	3,000	18,800	6,030
18	1,100	1,000	1,100	8,900	26,200	7,130	3,340	3,800	2,670	3,110	14,400	5,510
19	1,100	1,000	1,100	9,200	24,600	6,850	3,110	3,800	2,670	3,220	11,400	5,900
20	1,100	1,000	1,100	13,000	21,100	8,900	3,570	3,570	2,670	3,000	11,700	6,850
21	1,100	1,000	1,200	14,700	20,400	6,570	3,110	3,800	3,110	2,890	11,500	6,570
22	1,100	1,000	1,200	16,600	16,600	5,510	3,340	2,030	2,450	3,460	9,500	6,300
23	1,200	1,000	1,200	15,800	16,200	4,760	3,570	2,670	2,450	3,340	7,130	6,850
24	1,300	1,000	1,200	8,600	13,300	5,010	4,520	2,670	2,450	3,570	7,280	6,710
25	1,300	1,000	1,300	10,700	11,400	4,520	8,600	2,670	2,450	3,570	7,130	6,300
26	1,300	1,000	1,500	7,710	9,800	4,760	9,800	3,110	2,450	3,800	7,420	6,710
27	1,300	1,000	1,600	12,000	8,300	4,520	9,500	2,670	2,450	4,040	8,150	6,850
28	1,300	1,000	1,600	12,700	8,600	4,280	8,300	2,450	2,030	3,800	9,500	6,710
29	1,300	....	1,600	13,000	7,130	4,040	6,850	2,450	2,030	3,800	11,700	6,440
30	1,300	....	1,700	12,700	6,850	3,800	8,000	2,450	2,030	3,800	12,300	6,710
31	1,300	....	1,800	....	17,700	....	4,760	2,450	....	3,340	....	6,850

NOTE.—Daily discharges for January 1 to March 25 were obtained from the 1908 ice curve and are only approximate. Discharges estimated for period March 26 to April 3, and interpolated for days of no gage height during August and September. Discharges after April 3 were obtained from a rating well defined between 2,030 and 36,400 second-feet.

Monthly discharge of Chippewa River at Chippewa Falls, Wis., for 1909.

[Drainage area, 5,300 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	1,700	1,100	1,360	0.257	0.30	C.
February	1,400	1,000	1,180	.223	.23	C.
March	....	1,100	1,250	.236	.27	C.
April	16,600	....	7,820	1.48	1.65	B.
May	26,200	4,760	15,200	2.87	3.31	A.
June	21,900	3,800	8,020	1.51	1.68	A.
July	9,800	1,830	4,060	.766	.88	A.
August	6,300	2,030	3,600	.679	.78	A.
September	3,110	1,640	2,350	.443	.49	A.
October	4,040	1,740	2,920	.551	.64	A.
November	22,100	3,800	9,690	1.83	2.04	A.
December	10,600	5,510	6,810	1.29	1.49	A.
The year	26,200	1,000	5,350	1.01	13.76	

CHIPPEWA RIVER NEAR EAU CLAIRE, WIS.

This station, which is located at the highway bridge at Shawtown, about 2 miles below Eau Claire, Wis., was established November 13, 1902, to obtain data for water-power and storage problems, and was discontinued March 31, 1909.

Eau Claire River enters from the east about 3 miles above the station. Winters are severe in this vicinity. Ice forms to a thickness of 1 to 2 feet and greatly modifies the relations between discharge and gage heights. The normal flow of the stream is very materially affected by the power plants at Eau Claire and Chippewa Falls and by the holding and releasing of storage water for logging.

Discharge measurements are all made from the bridge. The datum of the chain gage, which is located on the bridge, has remained unchanged. Except as noted, the records are reliable and accurate, and the estimates of the flow should be good.

Daily gage height, in feet, of Chippewa River near Eau Claire, Wis., for 1909.

[J. E. Kimpton, observer.]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1				11			4.35	21		3.50	3.72
2				12			4.34	22			3.98
3				13			3.92	23			4.05
4				14		4.50	3.74	24			4.24
5			3.90	15			3.84	25			3.83
6			3.88	16			3.90	26			3.98
7		3.80	3.92	17	4.80		4.04	27			4.25
8			4.70	18			3.90	28		3.40	4.16
9			4.75	19			3.88	29			4.16
10	3.15		4.75	20			3.80	30			4.26
								31	4.1		4.36

NOTE.—Ice conditions existed from January 1 to about March 4. Thickness of ice varied from 0.7 to 1.6 feet. Gage heights during January and February are to water surface.

Daily discharge, in second-feet, of Chippewa River near Eau Claire, Wis., for 1909.

Day.	Mar.	Day.	Mar.	Day.	Mar.
1	1,000	11	2,640	21	1,430
2	1,200	12	2,620	22	1,910
3	1,400	13	1,800	23	2,040
4	1,600	14	1,460	24	2,420
5	1,760	15	1,650	25	1,630
6	1,720	16	1,760	26	1,910
7	1,800	17	2,030	27	2,440
8	3,380	18	1,760	28	2,260
9	3,490	19	1,720	29	2,260
10	3,490	20	1,570	30	2,460
				31	2,660

NOTE.—Daily discharges estimated for March 1 to 5, and obtained from a rating well defined above 1,950 second-feet for the rest of the month.

Monthly discharge of Chippewa River near Eau Claire, Wis., for 1909.

[Drainage area, 6,740 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January			1,730	0.257	0.30	D.
February			1,500	.223	.23	D.
March	3,490		2,360	.350	.40	B.

NOTE.—Monthly means for January and February obtained from the records at Chippewa Falls by use of the drainage area ratio.

RED CEDAR RIVER AT CEDAR FALLS, WIS.

This station, which is located at the highway bridge on the outskirts of Cedar Falls, Wis., was established in 1908 to replace the station at Menomonie, but gage heights were not obtained until April 1, 1909. The data collected at this station are used in studying water-power, water-supply, pollution, and storage problems.

No important tributaries enter Red Cedar River in the immediate vicinity of the gage.

Winters are severe in this locality. Anchor ice forms at the rapids a short distance below the bridge and at times produces backwater at the gage.

The datum of the staff gage, which is fastened to a pier of the bridge, has remained unchanged.

The records are reliable and accurate, except as conditions above noted may affect the gage heights. No measurements of discharge have been obtained. The observer at this station is paid by the Chippewa Valley Light & Power Co.

Daily gage height, in feet, of Red Cedar River at Cedar Falls, Wis., for 1909.

[Olaf Oas, observer.]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.45	3.35	2.9	2.5	2.3	2.3	2.3	2.65	3.25
2	3.85	3.3	3.45	2.5	2.2	.3	2.3	2.75	3.05
3	3.9	3.25	3.55	2.5	2.25	2.3	2.3	2.95	3.2
4	3.75	3.2	3.6	2.5	2.2	2.3	2.3	3.3	3.25
5	3.55	3.35	3.25	2.5	2.2	2.3	2.3	2.85	3.15
6	3.5	3.8	3.35	2.45	2.2	2.3	2.3	2.75	3.05
7	3.4	4.5	3.9	2.4	2.2	2.3	2.3	2.65	3.0
8	3.35	4.4	4.0	2.3	2.2	2.3	2.3	2.6	3.0
9	3.4	3.65	3.8	2.3	2.2	2.45	2.3	2.8	3.0
10	3.45	3.35	3.15	2.3	2.2	2.5	2.45	2.6	3.0
11	3.3	3.15	3.0	2.3	2.25	2.5	2.55	2.7	3.0
12	3.25	3.1	2.8	2.6	2.6	2.5	2.7	2.7	3.0
13	3.4	2.8	2.8	2.7	2.65	2.6	2.65	2.7	3.1
14	3.35	2.85	2.85	2.55	2.5	2.55	2.55	2.9	3.15
15	3.1	2.95	2.9	2.45	2.35	2.5	2.5	3.6	3.25
16	3.0	3.5	2.7	2.35	2.3	2.5	2.4	3.45	3.3
17	3.0	3.9	2.7	2.3	2.3	2.5	2.4	3.3	3.4
18	3.0	3.9	2.7	2.3	2.3	2.5	2.4	3.2	3.5
19	3.05	3.75	2.65	2.3	2.3	2.5	2.4	3.1	3.55
20	3.05	3.5	2.6	2.3	2.3	2.5	2.4	3.05	3.6
21	3.05	3.45	2.55	2.3	2.3	2.5	2.4	3.0	3.6
22	3.05	3.3	2.5	2.3	2.3	2.5	2.5	3.15	3.7
23	3.05	3.0	2.6	2.3	2.3	2.5	2.5	3.0	3.7
24	3.05	2.85	2.7	2.3	2.3	2.5	2.5	3.0	3.7
25	3.0	2.9	2.55	2.3	2.3	2.5	2.5	2.9	3.7
26	3.45	2.8	2.5	2.3	2.3	2.5	2.5	2.9	....
27	3.35	2.8	2.5	2.3	2.3	2.4	2.4	3.0	....
28	3.2	2.8	2.5	2.3	2.4	2.4	2.4	3.05	....
29	3.15	2.8	2.5	2.3	2.3	2.3	2.4	3.25	....
30	3.3	2.7	2.5	2.3	2.3	2.3	2.4	3.4	4.0
31	....	2.7	....	2.3	2.3	....	2.45	....	....

NOTE.—Ice conditions existed from December 5 to 31, the stream being frozen over after December 25. Gage height of December 30 was read to water surface. Thickness of ice on that day was 0.5 foot.

ZUMBRO RIVER DRAINAGE BASIN.

DESCRIPTION.

Zumbro River drains an area comprising 1,390 square miles bounded by the Cannon River basin on the north and the basin of Root River on the south and located chiefly in Wabasha, Goodhue, Dodge, and Olmsted counties in southeastern Minnesota. The North Branch of Zumbro River rises in the southeastern part of Rice County and flows eastward; the South Branch is formed by a number of small tributaries in the southwestern part of Olmsted County and flows northward, receiving throughout its course many tributaries, the largest being the Middle Branch. In the western part of Wabasha County the two streams unite to form the Zumbro, which takes a general easterly course until it reaches the flood plain of the Mississippi, where it empties into one of the sloughs of the region.

The valleys of the North and South branches are cut 100 to 200 feet below the general level of the country and are bounded by bluffs. The valley of lower Zumbro River becomes deeper, and at the mouth is 400 feet deep and is bounded by rock cliffs, chiefly sandstone.

The general width of the valley is from 1 to 2 miles. The streams discharging into the Zumbro Valley at the present time deposit on the flood plain more material than the Zumbro itself can carry away, and the valley is being gradually filled up. A great many large springs issue from the bluffs along the various streams, and there are many springs and marshes that form the sources of the headwater streams.

The region is in general a gently undulating prairie that is deeply cut by the streams, all of which lie in well-defined valleys—in the upper part cut into the glacial drift and the lower part sunk deep into the underlying rock.

Very little forest remains in the basin of the Zumbro at the present time, as most of the land is under cultivation.

The rivers of the basin are frozen over generally during the period from December to March, except at rapids, and snow lies on the ground for considerable periods.

Because of the complete absence of lakes and the general flatness of the uplands, reservoir sites can be obtained only within the valleys of the streams by building dams from bluff to bluff.

The river has a good fall throughout its course, and there are many places where water power in moderate amounts can be developed. At the present time there are power plants at Zumbrota, Forest Mills, Mazeppa, and Jarretts on the main river.

Owing to the flatness of the uplands drainage work has been carried on to a considerable extent, about 34,000 acres, chiefly in Wabasha and Dodge counties, having been ditched.

ZUMBRO RIVER AT ZUMBRO FALLS, MINN.

This station, which is located at the highway bridge at Zumbro Falls, was established June 8, 1909, on account of the power available on the Zumbro.

The nearest tributary is the South Branch, which enters the river about 8 miles above this point. The nearest dam is at Jarretts, but its influence does not extend to the station, owing to the fall of the river between the two points.

Owing to the rapids a short distance above the station and also to springs, open water continues practically throughout the year from the rapids for a distance of several miles downstream.

Prior to October 22, 1909, a staff gage was used, after which date a chain gage installed at the same datum was read. Since the installation of the chain gage, which is attached to the bridge from which discharge measurements are made, its datum has remained unchanged.

Conditions at this station are good and the records of flow should be reliable.

Discharge measurements of Zumbro River at Zumbro Falls, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 8	G. A. Gray	129	279	6.30	618
July 15	Gray and Gibson	129	185	5.52	270
August 26	C. J. Emerson	129	228	5.69	319
October 22	G A. Gray	129	197	5.50	281

Daily gage height, in feet, of Zumbro River at Zumbro Falls, Minn., for 1909.

[F. J. Sugg and A. H. Sugg, observers.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	6.05	5.24	5.42	5.52	5.52	7.38	16	5.90	5.45	9.05	6.32	5.59	9.89	6.42
2	......	5.90	5.24	5.42	5.51	6.70	7.22	17	6.00	5.44	7.40	6.28	5.54	8.55	6.38
3	......	5.95	5.24	5.42	5.50	6.69	7.30	18	6.35	5.44	6.95	6.18	5.50	7.70	6.20
4	......	5.95	5.21	5.42	5.46	6.48	7.55	19	6.20	5.46	6.72	6.10	5.50	7.51	6.26
5	......	5.75	5.21	5.42	5.46	6.22	7.20	20	6.15	5.44	6.35	5.85	5.50	7.38	6.30
6	......	5.75	5.19	5.39	5.46	6.02	6.55	21	5.85	5.41	5.82	5.82	5.50	7.38	6.36
7	......	5.65	5.16	5.39	5.45	5.90	6.26	22	5.90	5.32	5.82	5.82	5.52	7.64	6.32
8	6.30	5.60	5.31	5.39	5.42	5.84	......	23	7.35	5.31	5.95	5.88	5.50	7.30	6.30
9	6.20	5.55	5.35	5.39	5.44	5.78	......	24	6.65	5.34	5.68	5.92	5.48	7.02	6.21
10	6.10	5.50	5.42	5.41	5.48	5.70	......	25	6.60	5.31	5.62	5.95	5.45	6.96	6.14
11	6.15	5.50	6.85	5.41	5.62	5.82	......	26	6.35	5.26	5.72	5.92	5.46	6.98	6.06
12	6.20	5.55	8.00	6.70	5.88	6.59	6.88	27	6.45	5.29	5.68	5.82	5.45	8.05	6.10
13	6.15	5.50	7.40	7.10	5.70	7.65	6.70	28	6.45	5.26	5.68	5.68	5.41	8.79	6.09
14	6.00	5.55	8.00	6.60	5.67	9.75	6.66	29	6.35	5.26	5.69	5.40	5.40	8.10	6.00
15	6.00	5.49	8.45	6.60	5.64	11.85	6.56	30	6.30	5.26	5.58	5.15	5.41	7.60	6.02
								31	......	5.24	5.52	......	5.40	......	6.05

NOTE.—During December the river was open more than half way across at the gage and this open space extended from a point ¼ mile above to ¾ mile below the gage.
Backwater caused by temporary ice gorging December 8 to 11.

BLACK RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of the Black River lies west of the central part of the State of Wisconsin. The river rises in the northeastern part of Taylor County, flows in a generally southwesterly direction, and joins the Mississippi at La Crosse. The drainage basin is long and narrow and the tributaries are small. The more important are Poplar River and East Fork of Black River, both of which enter from the east. The total length of the river is about 145 miles; the total drainage area is about 2,272 square miles.

The basin is about 120 miles long and has an average width of 20 miles. All that portion of the river north of Black River Falls is in the crystalline rock. Through a large portion of this stretch the river has worn deeply into the rock, and the banks rise 40 to 60 feet above the river. In places the rock is covered with glacial drift. Below Black River Falls the river flows into a sandstone region, its valley is wide and the banks are usually low. The surface of the basin is level or rolling. The soil in the upper part of the basin is sandy, but a heavier clay soil is found in some places. This section was at one time covered with pine. In the lower part of the basin the soil is less sandy, as it contains more clay.

The elevation of the sources of the river is about 1,400 feet; at Neillsville the elevation is 990 feet; at the mouth of the river the elevation is 628 feet.

The timber on this drainage basin has been about all cut off. The river is no longer used for running logs. The country is well settled.

The mean annual rainfall is about 32 inches. The winter conditions are severe. The snowfall is heavy, and ice forms from 1 to 2 feet in thickness and lasts about three months.

There are but few lakes in the drainage basin, and some of these may afford suitable reservoirs, but the basin is so well settled that the building of storage reservoirs would be prohibited by the cost of the land that would be flooded.

Conditions are not favorable for the development of water power, for the size of the drainage area decreases rapidly toward the head of the river. The porous nature of the soil, however, compensates in a measure for the smallness of the drainage area, and power sites of considerable head, favorably located for the building of dams, are numerous. Most of the valuable sites are above Black River Falls.

BLACK RIVER SURVEY.

In order to determine the availability of Black River for power development, a survey was made during 1906 from Black River Falls to Wisconsin Central Railway crossing. From the data collected on this survey sheets have been prepared showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets and may be had on application to E. A. Birge, director, Wisconsin Geological and Natural History Survey, Madison, Wis.

BLACK RIVER AT NEILLSVILLE, WIS.

This station, which is located at the lower highway bridge across Black River, about 700 feet below the Chicago, St. Paul, Minneapolis & Omaha Railroad bridge at Neillsville, Wis., was established April 7, 1905, to obtain data for use in studying water power, water supply, and pollution problems. This station was discontinued March 31, 1909.

The winters are severe in this vicinity; ice forms to a thickness of 1 to 2 feet and modifies the relation between discharge and gage heights.

The datum of the chain gage, which is located on the bridge, has remained unchanged. The records are reliable and accurate. In extreme low water measurements are made by wading; at other times measurements are made from the bridge.

The following discharge measurement was made under ice conditions by W. M. O'Neill:

February 17, 1909; width, 130 feet; area, 100 square feet; gage height, 3.38 feet; discharge, 51 second-feet.

Daily gage height, in feet, of Black River at Neillsville, Wis., for 1909.

[A. Bissell, observer.]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1				11				21		3.5	4.3
2				12				22			
3	3.2			13				23			
4				14		3.9	4.4	24	4.5		
5				15				25			
6				16				26			
7		3.3	3.8	17	3.4			27			
8				18				28		3.4	4.8
9				19				29			
10	3.5			20				30			
								31	4.0		

NOTE.—Ice conditions from January 1 to March 28, an ice cover ranging in thickness from 0.6 foot to 2.1 feet existing during the period. Water was reported on top of the ice on January 24 and March 28.

Monthly discharge of Black River at Neillsville, Wis., for 1909.

[Drainage area, 675 square miles.]

Month.	Discharge in second-feet.		Run-off (depth in inches on drainage area).	Accuracy.
	Mean.	Per square mile.		
January	98	0.144	0.17	D.
February	54	.080	.08	D.
March	139	.206	.24	D.

NOTE.—These monthly mean discharges are based on one discharge measurement during the period, a study of climatologic data, and observer's notes on ice conditions.

ROOT RIVER DRAINAGE BASIN.

DESCRIPTION.

Root River, which joins the Mississippi about 3 miles below La Crosse, drains an area comprising 1,660 square miles, including the extreme southeastern portion of Minnesota and a very small area, not exceeding a few square miles, in northeastern Iowa. The North Fork, which is the principal branch, rises in the southeastern part of Dodge County and flows in a general easterly course, being joined by the Middle Fork a few miles below Chatfield and by the South Fork near Lanesboro. Rush Creek enters the main stream near Rushford, and Money Creek and South Root River near Houston.

The region drained is an undulating plateau whose uplands range in altitude from 1,100 to 1,300 feet above sea level. In the upper portion of the basin the Root and its fanlike tributaries flow over glacial drift, but farther down they occupy rock-cut valleys which become deeper as the streams are descended. In general the main valley is about 500 feet deep and 2 miles in average width. Main and tributary valleys cut through sandstone.

By far the greater part of the region drained by the Root is under cultivation, the forested areas being chiefly on the sides of the bluffs. The annual rainfall for the basin, as shown by a number of records exceeding ten years in length, is about 32 inches. From December to March the streams of the basin are frozen over for the most part and snow remains on the ground for considerable periods.

As the basin contains no lakes, reservoirs can be formed only by building dams from bluff to bluff across the gorgelike valleys. One good site of this type exists on the North Fork, a few miles above Chatfield.

In order to determine the availability of Root River for power development, a survey was made during 1910 from the mouth to Orion Mill, a point on the North Branch several miles above Chatfield. From the data collected on this survey, sheets have been prepared showing a profile of the water surface, a plan of the river, and the contours along the river bank. These sheets have been published separately, and may be had upon application to Robert Follansbee, district engineer, United States Geological Survey, Old Capitol Building, St. Paul, Minn. From this survey the following table of elevations and distances has been compiled:

Elevations and distances along Root River.

	Distance above mouth.	Elevation.
	Miles.	*Feet.*
Mississippi River	0	633
Chicago, Milwaukee & St. Paul Ry	4	635
Do	6	636
Thompson Creek	8	640
Hokah	11	645
Mound Prairie	18	655
Crystal Creek	21	659
Silver Creek	23	662
South Root River	27	669
Money Creek	31	680
Chicago, Milwaukee & St. Paul Ry	34	686
Rushford, tail water	44	710
Rushford, head water	47	725
Peterson	52	734
Whalen	62	768
South Branch of Root River	66	784
Money Creek	77	850
Trout Creek	81	873
Highway Bridge	91	913
Middle Branch of Root River	94	927
Chatfield dam, tail water	94	925
Chatfield dam, head water	95	939
Chatfield	98	951
Highway bridge	103	990
Orion Mill, tail water	107	1,018

The streams are fed by many springs, which are found in the bluffs, and the flow is therefore comparatively uniform, although the streams are subject to sudden freshets from heavy rains. When the river is in flood it inundates large areas of the valley lands. In the lower part of the valley the floods are so frequent that much of the bottom land is not under cultivation.

ROOT RIVER NEAR HOUSTON, MINN.

This station, which is located at the first highway bridge 1 mile below Houston, was established May 28, 1909, to obtain data for use in connection with water-power development and studies of flood prevention.

The nearest tributary, South Root River, enters 1 mile below the bridge. Although this is ordinarily an insignificant stream, during heavy rains it overflows its banks badly and floods a considerable area. The drainage area above this station is 1,560 square miles.

There is no dam below, and the nearest one above it is at Rushford. As the flow of the river is at all times ample for the power generated at that point, it is not held back during certain portions of the day and thus has no influence on the gage heights at Houston.

The river is ice bound from December to March, and during that period discharge measurements are made through the ice to obtain an approximate winter rating curve.

Discharge measurements are made from the bridge at which the staff gage is located. Since the establishment of the gage its datum has remained unchanged.

The channel scours out during floods and gradually fills in afterwards, and for this reason it is necessary to make more frequent measurements than at other sections, and the estimates based on the measurement can probably not be considered as better than fair, or possibly good, except during low stages when no change occurs.

Discharge measurements of Root River near Houston, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 28	Hoyt and Gibson	105	302	1.50	615
June 18	G. A. Gray	103	273	1.30	540
Do	C. B. Gibson	103	279	1.30	530
July 14	Gray and Gibson	102	240	.92	424
August 26	Follansbee and Emerson	105	424	1.76	605
September 11	Follansbee and Smith	104	290	1.11	426
November 11	G. A. Gray	105	288	1.45	596

Daily gage height, in feet, of Root River near Houston, Minn., for 1909.

[Olof Larson, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1.40	1.75	0.68	1.25	1.05	1.34	3.32
2		1.40	1.50	.75	1.22	1.05	1.42	3.10
3		1.35	1.32	.65	1.35	1.00	1.40	2.96
4		1.65	1.20	.70	1.32	1.06	1.42	2.90
5		1.80	1.15	.65	1.22	.98	1.58	2.95
6		2.20	1.10	.65	1.21	.96	1.44	2.82
7		1.98	1.10	.65	1.18	.96	1.30	2.48
8		1.75	1.02	.60	1.14	.95	1.26	
9		1.65	1.05	.65	1.14	.96	1.20	
10		1.60	1.32	.65	1.12	1.02	1.14	
11		1.58	1.10	4.65	1.11	1.02	1.50	
12		1.50	1.05	4.00	1.50	1.05	1.55	
13		1.42	.98	3.72	1.36	1.05	2.50	
14		1.38	.90		1.75	1.02	4.84	
15		1.30	.90		2.15	1.02	7.50	
16		1.28	.90	4.85	2.04	.98	7.72	2.80
17		1.35	.82	3.80	1.98	1.04	4.92	
18		1.32	.82	3.08	1.86	.96	3.96	
19		1.25	.80	2.70	1.66	.95	3.46	2.90
20		1.15	.75	2.40	1.60	.96	3.20	
21		1.15	.75	2.15	1.48	.99	3.09	
22		1.15	.80	2.00	1.38	.98	3.35	2.80
23		1.10	.75	1.92	1.32	.90	3.60	
24		1.20	.72	1.88	1.28	.95	3.20	
25		1.32	.70	1.75	1.22	.95	2.99	
26		1.22	.70	1.64	1.16	.95	2.88	
27		1.82	.72	1.55	1.15	.92	2.98	
28	1.50	1.78	.75	1.48	1.12	.92	4.58	
29	1.50	1.70	.72	1.39	1.12	.90	4.74	
30	1.48	2.15	.72	1.34	1.08	.92	3.78	
31	1.42		.70	1.32		.94		2.80

NOTE.—Water over gage August 14 and 15. Maximum gage height August 14, 9.40 feet, determined from high-water mark.

It is probable that the rise in gage heights during the latter part of November was due partly to backwater. The river was frozen over during the greater part of December. The following comparative readings were made:

Date.	Gage height to water surface.	Gage height, top of ice.	Thickness of ice at gage.	Remarks.
		Feet.	*Feet.*	
December 15		3.7	0.3	
December 18		3.7	.7	River half open near gage.
December 21	2.8	2.85	.8	River frozen nearly across.
December 24	2.9	2.9	.5	More open water.
December 27	2.8	2.9	.5	
December 31	2.8	2.9	.6	River frozen nearly across.

WISCONSIN RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Wisconsin River, except for a few square miles, lies wholly within the State of Wisconsin. The river rises in Lake Vieux Desert, lying directly on the boundary line between upper Michigan and Wisconsin, whence it flows in a southwesterly direction for about 300 miles to the city of Portage, near the center of Portage County. At this point it turns westward and empties into Mississippi River at Prairie du Chien, Wis., about 40 miles from the southern boundary of the State. The important tributaries beginning at the sources are as follows: On the west or right bank of the river, Tomahawk, Rib, Big Eau Pleine, Eau Pleine, Yellow, Lemonweir, Baraboo, Pine, and Kickapoo rivers; on the left bank, Pelican, Prairie, Eau Claire, and Plover rivers.

The total length of the river is about 429 miles. The total drainage area is about 12,280 square miles.

The drainage area is comparatively long and narrow, being about 225 miles long and about 50 miles average width. The river flows, for the most part, in the eastern half of its basin. Below Portage it flows within 10 miles of its southern edge. At Portage the divide between Wisconsin River and Fox River is so low that during high water the current in one of the tributaries of the Wisconsin is reversed and flows into the Fox.

Like all the large rivers of the State, the Wisconsin heads in the high drift-covered region. That part of the basin which lies above Nekoosa, including more than half of the drainage area, is underlain by crystalline rocks, which, by presenting a barrier to erosion, cause numerous rapids that afford excellent sites for water power. Below Nekoosa the crystalline rocks give way to the softer sandstone, the disintegration of which has made the bed of the river a succession of shifting sand bars almost without interruption to its mouth. Where this formation is near the surface in the surrounding country the soil is very light and in places even sterile. North of Nekoosa this sandy belt rapidly narrows, and at Merrill, Wis., about 90 miles above, almost entirely disappears, and is replaced by the clayey loams and loamy clays. North of Tomahawk the clays are again replaced by sandy soils containing gravel and by bowlders and glacial drift.

In general the country is level or undulating. In places decided ridges break the surface, as, for example, the Baraboo ranges of quartzite and the bluffs along the lower river. The northern part of the drainage area is covered with innumerable lakes and swamps which tend to make the flow of the stream uniform and steady.

According to the United States Engineer Corps, the elevation of Lake Vieux Desert, the source of the river, is about 1,650 feet; the elevation at the mouth is about 604 feet; the total fall is therefore about 1,050 feet. About 634 feet of this fall occur in the 150 miles between Rhinelander and Nekoosa, an average of over 4 feet to the mile. This descent is concentrated at many places, producing a large number of valuable water powers, many of which are still undeveloped.

The dense growth of pine which covered the upper part of the drainage basin of Wisconsin River has nearly all been cut off, and a thick growth of brush and second-growth timber has taken its place; large areas have been brought under cultivation. In some places this second growth has been burned over, leaving almost impenetrable thickets of brush and dead timber. The effect of this new growth of brush and timber on the run-off is probably about the same as that of the pine forests which it has replaced.

The mean annual rainfall on the headwaters of the river is about 31 inches; at the lower part of the basin the rainfall is about 34 inches.

The winters, except in the very lowest part of the basin, are severe. The snowfall is comparatively heavy and stays on the ground for long periods, and the streams are covered with ice from 1 to 2 feet in thickness for three to four months. These conditions tend to make the winter season the period of minimum flow, and discharge measurements taken during the ice period are very valuable.

The basin affords many sites for storage. The United States Engineer Corps located and surveyed eight reservoir sites at the headwaters of Wisconsin River to aid navigation of Mississippi River. The capacity of these reservoirs is about 20,000,000,000 cubic feet, and it was estimated that a flow of 3,000 cubic feet per second could be maintained for three months. Such a flow would nearly double the low-water flow of the river and its resulting water power. Several of these reservoirs have been constructed by private parties for water-power development. The Wisconsin Valley Improvement Co. has been authorized by law to construct, acquire, and maintain a system of reservoirs located on the tributaries of the Wisconsin River north of the south line of township 34, about 6 miles below Tomahawk, for the purpose of producing a uniform flow of water, etc. The law provides that when this company shall have completed reservoirs of a capacity of 2,000,000,000 cubic feet it may collect and receive reasonable tolls from the owner of every improved and operated water power located on the river below such reservoirs. The tolls are to yield not to exceed 6 per cent on the actual investment.

The stream is used quite extensively for logging, but the greater part of the large timber has been cut off and lumbering is decreasing, although considerable pulp wood is being run on the river. Dams at the water-power sites would not interfere seriously with the small run of logs at the present time.

WISCONSIN RIVER SURVEY.

In order to determine the amount of power available along Wisconsin River a survey was made during 1906 between Sauk City and Dekorra and between Lewiston station and Jersey City. From the data collected sheets have been prepared, showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets and may be obtained by applying to E. A. Birge, director, Wisconsin Geological and Natural History Survey, Madison, Wis.

EAU CLAIRE RIVER SURVEY.

A survey was also made along Eau Claire River during 1906, from the mouth of the river to Johnson. From the data collected sheets have been prepared, showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets and may be obtained by applying to E. A. Birge, director, Wisconsin Geological and Natural History Survey, Madison, Wis.

WISCONSIN RIVER NEAR RHINELANDER, WIS.

This station, which is located at a highway bridge about 8 miles southwest of Rhinelander, Wis., at Forbes & Wixson's power station, was established December 1, 1905, to obtain data for water power, water supply, pollution, and storage problems.

Pelican River enters about 8 miles above the station.

The winters in this vicinity are severe, but the operation of the power plant about 400 feet above the bridge prevents the river from freezing at the gaging section, and ice forms only in narrow strips along the shores. The pond above the dam modifies the normal flow, and the total range in gage height is small. The fluctuations of the load on the turbines may also affect discharge measurements. Discharge measurements are made from the bridge.

The datum of the chain gage, which is located on the bridge, has remained unchanged, and aside from the above conditions the records are reliable and accurate.

The gage reader at the station has been paid by the Wisconsin Valley Improvement Co., Madison, Wis., since April, 1909.

Daily gage height, in feet, of Wisconsin River near Rhinelander, Wis., for 1909.

[Charles Hagen, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.3	2.4	2.4	....	3.6	3.1	2.8	3.6	3.3	2.1	3.2	3.0
2	2.4	2.8	2.3	....	3.5	3.3	2.8	3.7	2.6	2.7	3.1	3.0
3	2.4	2.3	2.5	....	3.4	2.7	2.7	3.7	2.3	1.5	3.2	3.2
4	2.4	2.8	2.3	....	3.2	3.3	1.6	3.3	3.6	2.1	3.2	3.2
5	2.9	2.4	2.3	....	3.1	3.3	1.6	3.6	2.6	2.1	3.4	2.9
6	2.5	2.3	2.3	....	3.4	2.4	1.6	3.4	1.0	1.7	3.2	2.6
7	2.5	2.5	2.3	....	3.4	3.4	2.2	3.3	3.3	2.6	3.0	2.3
8	3.1	2.4	2.4	2.3	3.4	3.6	2.8	2.3	3.2	2.6	3.0	2.3
9	2.6	2.5	2.4	2.7	2.5	3.3	2.3	3.3	2.9	2.7	3.0	2.3
10	2.8	2.5	2.3	2.3	3.8	3.5	2.3	3.6	2.6	1.6	2.8	2.6
11	2.5	2.5	2.4	1.8	3.9	3.6	1.8	3.6	2.8	2.7	3.0	2.7
12	3.0	2.5	2.3	2.8	4.0	3.5	3.1	3.6	1.6	2.7	3.0	2.8
13	2.5	2.9	2.9	2.7	4.0	2.4	2.9	3.6	2.7	2.4	3.2	2.7
14	2.3	2.5	2.4	2.2	4.0	3.3	2.5	3.6	2.7	2.6	3.1	2.7
15	2.6	2.5	2.9	2.8	4.1	3.2	2.6	1.8	2.7	2.4	3.8	2.6
16	2.5	3.1	2.3	2.8	3.0	3.2	2.4	3.6	3.1	2.5	3.5	2.7
17	2.7	2.5	2.3	2.4	4.1	3.0	3.1	3.5	3.2	1.4	3.2	2.6
18	2.8	2.4	2.4	2.7	4.0	3.2	1.6	3.6	3.2	2.7	3.4	2.8
19	2.6	2.4	2.3	2.8	4.0	3.2	3.3	3.5	1.6	2.6	3.4	2.5
20	2.4	2.5	2.3	2.9	3.9	1.9	3.1	3.5	3.2	3.0	3.5	2.7
21	2.7	2.5	1.9	3.4	3.8	2.8	3.3	3.5	3.1	2.7	3.3	2.7
22	3.1	2.5	2.4	3.0	3.7	2.7	3.8	1.8	3.2	2.9	3.4	2.9
23	2.6	2.5	2.3	2.9	2.4	2.7	3.6	3.6	3.1	2.7	3.3	2.7
24	2.6	2.5	2.3	3.2	3.5	2.7	3.6	3.0	3.1	2.7	2.8	2.9
25	2.4	2.2	2.2	2.1	3.4	2.8	2.8	3.2	2.7	2.5	3.1	2.7
26	2.4	2.3	2.3	3.2	3.5	2.7	3.8	3.2	1.7	2.5	2.6	2.7
27	2.4	2.4	2.4	3.2	3.1	1.5	3.8	3.4	2.7	2.7	3.6	2.9
28	2.4	2.4	1.5	3.2	3.3	2.5	3.9	4.0	2.7	2.7	3.2	3.0
29	2.5	....	2.3	4.1	3.2	2.0	3.7	1.0	2.7	2.7	3.3	2.8
30	2.5	....	2.3	3.5	1.9	2.1	3.7	2.6	2.7	2.6	3.1	2.7
31	2.8	....	2.3	....	3.1	....	3.6	3.2	....	1.7	....	2.9

Daily discharge, in second-feet, of Wisconsin River near Rhinelander, Wis., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	606	690	690	....	2,010	1,440	1,090	2,010	1,660	452	1,550	1,320
2	690	1,090	606	....	1,900	1,660	1,090	2,120	870	980	1,440	1,320
3	690	606	775	....	1,780	980	980	2,120	606	140	1,550	1,550
4	690	1,090	606	....	1,550	1,660	179	1,660	2,010	452	1,550	1,550
5	1,200	690	606	....	1,440	1,660	179	2,010	870	452	1,780	1,200
6	775	606	606	....	1,780	690	179	1,780	15	223	1,550	870
7	775	775	606	....	1,780	1,780	526	1,660	1,660	870	1,320	606
8	1,440	690	690	606	1,780	2,010	1,090	606	1,550	870	1,320	606
9	870	775	690	980	775	1,660	606	1,660	1,200	980	1,320	606
10	1,090	775	606	606	2,240	1,900	606	2,010	870	179	1,090	870
11	775	775	690	270	2,360	2,010	270	2,010	1,090	980	1,320	980
12	1,320	775	606	1,090	2,470	1,900	1,440	2,010	179	980	1,320	1,090
13	775	1,200	1,200	980	2,470	690	1,200	2,010	980	690	1,550	980
14	606	775	690	526	2,470	1,660	775	2,010	980	870	1,440	980
15	870	775	1,200	1,090	2,580	1,550	870	270	980	690	2,240	870
16	775	1,440	606	1,090	1,320	1,550	690	2,010	1,440	775	1,900	980
17	980	775	606	690	2,580	1,320	1,440	1,900	1,550	106	1,550	870
18	1,090	690	690	980	2,470	1,550	179	2,010	1,550	980	1,780	1,090
19	870	690	606	1,090	2,470	1,550	1,660	1,900	179	870	1,780	775
20	690	775	606	1,200	2,360	324	1,440	1,900	1,550	1,320	1,900	980
21	980	775	324	1,780	2,240	1,090	1,660	1,900	1,440	980	1,660	980
22	1,440	775	690	1.320	2,120	980	2,240	270	1,550	1,200	1,780	1,200
23	870	775	606	1,200	690	980	2,010	2,010	1,440	980	1,660	980
24	870	775	606	1,550	1,900	980	2,010	1,320	1,440	980	1,090	1,200
25	690	526	526	452	1,780	1,090	1,090	1,550	980	775	1,440	980
26	690	606	606	1,550	1,900	980	2,240	1,550	223	775	870	980
27	690	690	690	1,550	1,440	140	2,240	1,780	980	980	2,010	1,200
28	690	690	140	1,550	1,660	775	2,360	2,470	980	980	1,550	1,320
29	775	....	606	2,580	1,550	384	2,120	15	980	980	1,660	1,090
30	775	....	606	1,900	324	452	2,120	870	980	870	1,440	980
31	1,090	....	606	....	1,440	....	2,010	1,550	....	223	....	1,200

NOTE.—These daily discharges are based on a rating that is well defined between 775 and 3,070 second-feet.

Monthly discharge of Wisconsin River near Rhinelander, Wis., for 1909.

Month.	Discharge in second-feet.			Accuracy.
	Maximum.	Minimum.	Mean.	
January	1,440	606	875	B.
February	1,440	526	788	B.
March	1,200	140	645	C.
April	2,580	270	1,030	B.
May	2,580	324	1,860	B.
June	2,010	140	1,250	B.
July	2,360	179	1,240	B.
August	2,470	15	1,640	B.
September	2,010	15	1,090	B.
October	1,320	106	761	C.
November	2,240	870	1,550	B.
December	1,550	606	1,040	B.
The year	2,580	15	1,150	

WISCONSIN RIVER AT MERRILL, WIS.

This station, which is located at a highway bridge at the east end of Merrill, Wis., was established November 17, 1902, to obtain data for water power, water supply, pollution, and storage problems.

The bridge is about 1,000 feet below the dam. Prairie River enters from the east about half a mile above the station. The flow is somewhat modified by the dam and power plants above the station.

The current is so swift that ice does not form across the section, and there is open water at the gage the year round, but winters are severe, and during the ice period the relation between gage height and discharge is affected by backwater. The stream is used considerably for log running, and jams below the measuring section may affect the gage heights for short periods. Discharge measurements are all made from the bridge.

The datum of the chain gage, which is located on the bridge, has remained unchanged; the records are reliable and accurate except as conditions above may affect the readings.

The gage reader at this station has been paid by the Wisconsin Valley Improvement Co., Madison, Wis., since April, 1909.

The following discharge measurement, with 4 per cent of the discharge under ice cover, was made by W. M. O'Neill:

February 19, 1909; width, 251 feet; area, 744 square feet; gage height, 4.79 feet; discharge, 1,610 second-feet.

Daily gage height, in feet, of Wisconsin River at Merrill, Wis., for 1909.

[A. F. Lueck, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.7	4.7	4.5	4.55	7.0	5.8	3.55	5.6	4.95	4.6	4.25	6.25
2	4.8	4.75	4.55	4.35	6.25	6.35	4.6	5.1	4.3	4.45	5.15	6.1
3	4.7	4.8	4.65	4.45	6.6	6.15	4.35	4.75	4.9	4.25	5.75	6.0
4	5.1	4.75	4.5	....	6.65	6.2	4.45	5.55	4.3	4.15	5.95	6.0
5	4.35	4.3	4.55	....	7.2	6.2	4.1	5.2	4.4	4.0	5.75	5.7
6	4.7	4.6	4.5	....	8.0	6.5	4.2	5.05	4.25	4.7	5.85	5.95
7	4.8	4.6	4.35	....	8.65	7.1	3.35	5.05	4.15	4.65	5.9	5.25
8	4.35	4.4	4.4	5.25	8.5	7.55	3.35	4.95	4.15	4.25	5.7	5.0
9	4.1	4.65	4.3	5.25	8.0	8.05	3.95	5.05	4.65	4.45	5.4	5.15
10	4.25	4.7	4.4	5.15	8.15	7.1	4.8	4.7	4.75	4.4	5.35	5.15
11	4.15	4.45	4.4	5.25	8.4	6.4	4.35	4.6	4.75	4.55	5.55	5.1
12	4.75	4.6	4.55	5.1	7.75	6.4	4.25	4.95	5.05	4.4	6.4	5.0
13	4.85	4.55	4.5	5.55	7.65	5.7	4.4	5.05	4.65	4.6	6.55	4.95
14	4.65	4.7	4.4	5.65	8.1	5.4	4.9	4.9	4.65	4.55	6.65	5.2
15	4.45	4.6	4.4	5.75	7.7	5.45	4.9	4.85	5.05	4.55	6.65	4.95
16	4.55	4.25	4.35	5.7	7.9	5.65	5.2	4.75	4.9	4.65	7.85	4.95
17	4.5	4.6	4.8	6.05	8.05	5.9	6.1	4.9	5.5	4.6	7.4	5.05
18	4.65	4.75	4.55	6.4	8.05	5.85	5.95	5.05	5.25	4.55	6.7	4.95
19	4.6	4.5	4.5	7.05	8.25	5.5	5.7	5.05	4.95	3.95	6.45	4.9
20	4.6	4.4	4.4	7.75	8.0	5.3	6.15	4.95	4.5	4.55	6.6	4.95
21	4.75	4.25	4.35	8.25	7.2	4.95	5.9	4.75	4.95	4.85	6.4	4.75
22	4.7	4.55	4.1	8.35	7.3	4.5	5.95	4.85	5.15	5.0	6.15	5.05
23	4.55	4.45	3.85	7.75	6.4	4.9	6.35	4.55	5.0	4.9	6.1	4.8
24	4.6	4.45	4.55	7.55	6.2	5.0	6.9	4.1	4.8	4.6	6.05	4.7
25	4.65	4.6	4.45	7.2	6.7	4.8	6.35	4.5	4.9	4.55	5.95	4.85
26	4.75	4.4	4.65	6.8	6.55	4.65	5.8	4.7	4.85	4.6	5.7	5.05
27	4.7	4.65	4.6	7.35	6.5	4.55	5.0	4.65	4.55	4.6	5.9	5.2
28	4.65	4.45	4.55	7.25	5.4	4.4	5.55	4.65	4.0	4.9	6.2	5.1
29	4.45	....	4.4	7.25	6.05	4.35	5.45	4.65	4.7	4.7	6.65	5.1
30	4.65	....	4.45	7.25	6.1	4.55	5.5	4.65	4.7	4.65	6.5	4.95
31	4.75	....	4.45	....	6.15	....	5.75	4.7	....	4.3	....	4.75

Daily discharge, in second-feet, of Wisconsin River at Merrill, Wis., for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,600	1,600	1,350	1,410	6,300	3,420	530	3,010	1,940	1,470	1,080	4,460
2	1,730	1,660	1,410	1,180	4,460	4,700	1,470	2,160	1,130	1,300	2,240	4,100
3	1,600	1,730	1,540	1,300	5,300	4,220	1,180	1,660	1,870	1,080	3,320	3,870
4	2,160	1,660	1,350	1,520	5,430	4,340	1,300	2,920	1,130	985	3,760	3,870
5	1,180	1,130	1,410	1,740	6,820	4,340	940	2,310	1,240	850	3,320	3,210
6	1,600	1,470	1,350	1,950	9,070	5,060	1,030	2,080	1,080	1,600	3,530	3,760
7	1,730	1,470	1,180	2,170	11,100	6,560	415	2,080	985	1,540	3,640	2,390
8	1,180	1,240	1,240	2,390	10,600	7,770	415	1,940	985	1,080	3,210	2,010
9	940	1,540	1,130	2,390	9,070	9,220	810	2,080	1,540	1,300	2,640	2,240
10	1,080	1,600	1,240	2,240	9,520	6,560	1,730	1,600	1,660	1,240	2,560	2,240
11	985	1,300	1,240	2,390	10,300	4,820	1,180	1,470	1,660	1,410	2,920	2,160
12	1,660	1,470	1,410	2,160	8,340	4,820	1,080	1,940	2,080	1,240	4,820	2,010
13	1,800	1,410	1,350	2,920	8,050	3,210	1,240	2,080	1,540	1,470	5,180	1,940
14	1,540	1,600	1,240	3,110	9,370	2,640	1,870	1,870	1,540	1,410	5,430	2,310
15	1,300	1,470	1,240	3,320	8,190	2,730	1,870	1,800	2,080	1,410	5,430	1,940
16	1,410	1,080	1,180	3,210	8,770	3,110	2,310	1,660	1,870	1,540	8,620	1,940
17	1,350	1,470	1,730	3,980	9,220	3,640	4,100	1,870	2,820	1,470	7,360	2,080
18	1,640	1,660	1,410	4,820	9,220	3,530	3,760	2,080	2,390	1,410	5,550	1,940
19	1,470	1,350	1,350	6,430	9,840	2,820	3,210	2,080	1,940	810	4,940	1,870
20	1,470	1,240	1,240	8,340	9,070	2,470	4,220	1,940	1,350	1,410	5,300	1,940
21	1,660	1,080	1,180	9,840	6,820	1,940	3,640	1,660	1,940	1,800	4,820	1,660
22	1,600	1,410	940	10,200	7,090	1,350	3,760	1,800	2,240	2,010	4,220	2,080
23	1,410	1,300	735	8,340	4,820	1,870	4,700	1,410	2,010	1,870	4,100	1,730
24	1,470	1,300	1,410	7,770	4,340	2,010	6,040	940	1,730	1,470	3,980	1,600
25	1,540	1,470	1,300	6,820	5,550	1,730	4,700	1,350	1,870	1,410	3,760	1,800
26	1,660	1,240	1,540	5,800	5,180	1,540	3,420	1,600	1,800	1,470	3,210	2,080
27	1,600	1,540	1,470	7,220	5,060	1,410	2,010	1,540	1,410	1,470	3,640	2,310
28	1,540	1,300	1,410	6,960	2,640	1,240	2,920	1,540	850	1,870	4,340	2,160
29	1,300	....	1,240	6,960	3,980	1,180	2,730	1,540	1,600	1,600	5,430	2,160
30	1,540	....	1,300	6,960	4,100	1,410	2,820	1,540	1,600	1,540	5,060	1,940
31	1,660	....	1,300	....	4,220	....	3,320	1,600	....	1,130	....	1,660

NOTE.—These daily discharges were obtained from a rating fairly well defined from 1,350 to 10,600 second-feet.

Monthly discharge of Wisconsin River at Merrill, Wis., for 1909.

[Drainage area, 2,630 square miles.]

Month.	Discharge in second-feet.				Run-off depth in inches on drainage area.	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	2,160	940	1,490	0.567	0.65	B.
February	1,730	1,080	1,420	.540	.56	B.
March	1,730	735	1,300	.495	.57	B.
April	10,200	1,180	4,530	1.72	1.92	B.
May	11,100	2,640	7,160	2.72	3.14	B.
June	9,220	1,180	3,520	1.34	1.50	B.
July	6,040	415	2,410	.916	1.06	B.
August	3,010	940	1,840	.700	.81	B.
September	2,820	850	1,660	.631	.70	B.
October	2,010	810	1,410	.536	.62	B.
November	8,620	1,080	4,250	1.62	1.81	B.
December	4,460	1,600	2,370	.901	1.04	B.
The year	11,100	415	2,780	1.06	14.38	

WISCONSIN RIVER NEAR NECEDAH, WIS.

This station, which is located at the highway bridge about 3 miles east of Necedah, Wis., was established December 2, 1902, to obtain data for studying water power, water supply, and pollution problems.

Big Roche a Cri Creek is tributary from the west about 5 miles below the station. The drainage area above the section is about 5,800 square miles.

The winters in this region are severe. Ice forms from 1 to 2 feet in thickness and lasts for about three months. Part of the river bottom is liable to shift in floods. But few discharge measurements have been made since 1906. The 1906 discharge table should not be used for later years. Discharge measurements are all made from the bridge.

The datum of the chain gage, which is located at the bridge, has remained unchanged. The gage heights are reliable and accurate.

The gage reader at this station has been paid since April, 1909, by the Wisconsin Valley Improvement Co., Madison, Wis.

The following discharge measurement was made under ice conditions by W. M. O'Neill:

February 11, 1909: Width, 328 feet; area, 1,600 square feet; gage height, 6.01 feet; discharge, 2,190 second-feet.

Daily gage height, in feet, of Wisconsin River near Necedah, Wis., for 1909.

[W. F. Huber and Michael Coughlin, observers.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	......	......	......	9.05	6.85	5.45	5.5	4.8	5.85	5.0	7.45
2	......	......	......	......	8.8	6.8	5.4	5.2	5.0	4.85	5.15	7.55
3	......	5.95	6.2	......	8.45	6.8	5.35	5.4	5.0	4.8	4.8	7.25
4	......	......	......	......	8.3	7.2	5.3	5.25	4.9	4.8	5.0	7.0
5	......	......	......	......	8.75	7.6	5.1	5.3	4.9	4.8	4.8	7.0
6	5.65	......	......	......	8.8	7.7	4.9	5.35	4.9	4.7	4.6	6.9
7	......	......	......	......	9.5	8.0	5.65	5.4	4.95	5.1	4.8	6.8
8	......	......	......	......	10.45	8.2	4.8	5.35	4.85	4.7	5.5	6.45
9	......	......	......	7.55	10.8	9.2	4.9	5.2	4.75	4.6	6.0	7.85
10	......	6.0	6.3	8.45	11.2	9.6	5.2	5.7	4.95	4.8	5.75	......
11	......	......	......	8.8	10.8	9.45	5.15	5.45	5.0	4.65	5.9	......
12	......	......	......	8.5	10.3	9.0	5.0	4.75	5.0	4.8	5.75	......
13	5.8	......	......	8.1	9.8	8.3	4.7	5.15	4.95	4.4	5.75	......
14	......	......	......	8.95	9.3	7.8	5.0	5.0	4.8	4.85	5.75	......
15	......	......	......	9.3	9.1	7.45	5.0	5.15	4.85	4.7	6.55	......
16	......	......	......	9.4	8.7	7.2	5.15	5.15	5.1	4.7	8.2	......
17	......	6.05	6.2	9.2	9.2	7.1	5.2	5.4	5.1	4.7	9.25	8.15
18	......	......	......	9.1	9.9	6.9	5.2	5.35	5.45	4.6	9.35	......
19	......	......	......	9.4	10.5	6.95	5.3	5.2	5.45	4.85	9.0	......
20	5.8	......	......	9.75	10.2	7.1	5.45	5.2	5.3	4.6	8.1	......
21	......	......	......	10.5	9.9	6.95	5.2	5.1	5.65	5.1	7.75	......
22	......	......	......	10.9	9.2	6.8	5.2	5.2	5.4	4.95	7.75	......
23	......	......	......	11.3	8.6	6.6	5.15	5.25	5.1	4.85	7.3	......
24	......	......	5.8	11.4	8.3	6.3	5.0	5.25	5.2	4.85	7.25	7.55
25	......	6.0	5.7	10.95	8.2	5.95	5.1	5.15	5.0	4.75	6.85	......
26	......	......	5.95	10.15	7.7	5.8	5.3	4.95	5.3	5.2	6.35	......
27	5.9	......	5.8	9.6	7.3	5.9	5.45	4.95	5.1	4.9	6.85	......
28	......	......	5.8	9.3	7.4	5.8	5.6	4.9	5.1	5.1	6.75	......
29	......	......	5.7	9.3	7.2	5.9	5.3	5.2	4.7	4.65	6.55	......
30	......	......	5.7	9.2	7.0	5.65	5.5	5.2	5.0	4.9	6.85	......
31	......	......	4.95	......	6.9	......	5.5	5.1	......	4.95	......	6.95

NOTE.—Stream covered with ice from January 1 to after March 17; thickness of ice varying from 0.7 to 2.45 feet. River clear of ice on March 24. Ice formed December 10 and averaged 1 foot in thickness from December 17 to 31. Readings during frozen periods are to water surface.

WAPSIPINICON RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Wapsipinicon River lies almost entirely in the northeastern part of Iowa. The river rises a few miles north of the Minnesota State line in Mower County, flows southeastward, and joins the Mississippi along the southern boundary of Clinton County, Iowa, about 10 miles below the city of Clinton, Iowa. The length of the river, not following the numerous bends, is about 220 miles, and the total length by stream course is not far from 300 miles. The drainage basin is long and narrow, being approximately 185 miles in length and 14 miles in average width.

The tributaries are all small. The more important are the West, Middle, and East branches, which unite above Tripoli in Bremer County, and Little Wapsipinicon River and Buffalo Creek, which enter from the east.

The basin is underlain by limestones which have been thinly covered with glacial drift. The surface of the country is a gently undulating prairie, and the valley of the river is narrow with gently sloping sides.

Near Anamosa the valley is narrow and picturesque; the bed and banks are rocky, the banks rising to a good height and in places running abruptly up into bluffs.

The elevation of the sources of the river is about 1,250 feet; at Independence the elevation is about 900 feet; at Stone City, about 780 feet; at the mouth the elevation is 560 feet.

The drainage basin contains no forested areas. The mean annual rainfall is about 32 inches. The winters are severe, snowfall is heavy, and ice forms from 1 to 2 feet in thickness and lasts about three months.

Storage sites have not been investigated, but the topography of the basin is not favorable and the high value of the land for farming would undoubtedly prohibit the construction of reservoirs.

A number of fair power sites are found along the river, some of which have been developed. Conditions are favorable for building dams, as the banks are as a rule firm, and rock forms the river bed in many places. The geological formation tends to keep the flow of the river fairly uniform and steady, as the glacial drift is thin, and the rainfall reaches the river through springs at the rock outcrops.

One gaging station has been maintained in this drainage basin: Wapsipinicon River at Stone City, Iowa, 1903 to 1909.

WAPSIPINICON RIVER AT STONE CITY, IOWA.

This station is located at Stone City, Iowa, at the highway bridge, a short distance above the Chicago, Milwaukee & St. Paul Railway bridge. It was established August 19, 1903, to obtain data for use in studying water power, water supply, and pollution problems. The records at this station are furnished by Frank Dearborn.

Buffalo Creek enters from the east about 4 miles below the station.

The winters are severe; ice forms from 1 to 2 feet in thickness and lasts about three months.

The datum of the chain gage is 776.69 feet above sea level. On December 4, 1906, repairs to the bridge resulted in raising the gage box. The necessary corrections have been applied to the gage readings between that date and January 23, 1910. The gage is located on the bridge from which all discharge measurements have been made. No measurements have been made since 1906. The accuracy of the daily and monthly estimates published below depends, therefore, on the conditions of flow, which are believed to be permanent.

Daily gage height, in feet, of Wapsipinicon River at Stone City, Iowa, for 1907–1909.

[Frank Dearborn, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.[a]												
1	......	......	7.86	5.26	3.33	3.43	3.87	4.04	6.10	4.55	3.05	2.99
2	......	......	8.91	5.03	3.26	3.36	3.75	3.90	4.38	4.78	3.11	2.97
3	4.83	......	9.26	4.77	3.26	3.33	3.72	3.80	4.18	5.40	3.09	2.95
4	......	3.23	9.41	4.99	3.21	3.11	3.65	3.74	4.00	5.80	3.07	2.92
5	......	......	9.21	5.06	3.23	3.34	3.10	3.62	3.86	6.28	3.05	2.92
6	......	......	8.96	4.96	3.16	3.48	3.06	3.50	3.98	5.90	3.03	2.95
7	......	......	9.06	4.76	3.09	3.61	3.50	3.82	4.13	5.13	3.03	2.99
8	......	3.27	9.01	4.43	3.12	3.96	3.77	4.55	4.38	4.26	3.03	2.97
9	4.23	......	8.51	4.27	3.13	4.13	4.02	4.58	4.65	4.06	3.07	2.95
10	......	......	7.76	4.06	3.11	4.33	4.34	4.70	4.40	3.88	3.17	2.95
11	......	......	6.56	4.01	3.07	4.73	4.77	4.33	4.25	3.78	3.15	3.27
12	......	3.09	6.11	3.93	3.06	5.89	5.14	3.72	4.18	3.73	3.20	3.12
13	......	......	5.46	3.88	3.06	6.29	5.10	3.52	3.98	3.60	3.25	3.39
14	......	......	5.01	3.77	3.11	6.23	5.60	3.40	3.90	3.48	3.25	3.42
15	3.86	......	4.66	3.71	3.13	5.99	5.75	3.35	3.85	3.45	3.25	3.17
16	......	4.51	4.61	3.66	3.06	5.61	6.20	7.86	3.78	......	3.25	3.09
17	......	5.46	4.61	3.58	3.07	4.93	6.65	9.92	3.70	3.43	3.22	3.05
18	......	6.26	4.53	3.56	3.06	4.66	7.37	7.67	3.63	3.40	3.22	3.08
19	6.43	6.76	4.33	3.47	3.05	4.39	7.50	4.77	4.08	3.40	3.13	3.09
20	......	7.71	4.21	3.39	3.03	4.17	9.65	4.18	4.30	3.38	3.15	3.09
21	......	8.61	4.16	3.39	3.01	4.01	9.65	4.02	4.10	3.38	3.17	3.11
22	......	8.81	4.01	3.36	3.01	3.89	9.15	3.77	3.98	3.36	3.27	3.09
23	5.13	8.04	4.06	3.33	3.03	3.81	8.42	3.65	3.92	3.36	3.52	3.07
24	......	7.26	4.16	3.33	3.11	3.91	6.72	3.55	3.84	3.33	3.37	......
25	......	7.19	4.05	3.25	3.31	4.06	6.60	3.50	3.78	3.33	3.22	......
26	......	7.21	4.01	3.25	3.41	4.33	6.20	3.50	3.90	3.30	3.09	3.09
27	......	7.23	4.06	3.21	3.57	4.51	6.02	4.05	4.07	3.08	3.02	3.09
28	4.26	7.34	4.09	3.29	3.66	4.63	5.47	4.25	4.80	3.06	3.02	3.05
29	......	......	4.13	3.25	3.63	4.24	4.83	5.02	4.68	3.06	2.99	3.05
30	......	......	4.76	3.31	3.66	4.03	4.48	6.85	4.66	3.06	2.97	3.01
31	......	......	5.09	......	3.53	......	4.12	7.92	......	3.06	......	2.95
1908.[b]												
1	2.92	......	6.91	4.48	3.56	9.46	6.70	3.88	3.13	2.98	2.97	2.94
2	2.92	......	6.83	4.26	3.53	8.69	6.50	3.78	3.13	2.93	3.02	2.87
3	2.89	3.31	6.52	4.11	3.51	8.14	6.90	3.63	3.13	2.91	2.99	2.77
4	2.87	......	6.46	3.86	3.46	7.46	6.78	3.45	3.13	2.88	2.97	2.77
5	2.87	......	6.33	3.78	3.46	6.84	5.81	3.48	3.10	2.83	2.92	2.77
6	2.87	......	5.71	3.78	3.43	6.19	5.45	3.48	3.08	2.83	2.82	......
7	2.87	......	8.01	3.91	3.43	5.71	5.78	3.45	3.08	2.95	2.82	......
8	2.87	......	6.91	3.93	3.41	4.89	5.45	3.38	3.06	2.98	2.80	......
9	2.87	......	6.60	4.01	3.36	4.81	4.90	3.33	3.05	2.93	2.82	2.72
10	2.87	3.12	5.81	4.08	3.33	4.64	4.48	3.30	3.00	2.90	2.92	......
11	......	......	5.84	3.93	3.43	4.49	4.23	3.23	2.98	2.90	2.97	......
12	......	3.37	5.61	3.76	3.73	4.21	4.08	3.23	2.98	2.93	3.02	......
13	......	5.47	5.98	3.81	4.01	4.24	4.20	3.58	2.95	2.98	2.97	......
14	2.84	5.59	5.86	3.83	4.38	4.21	4.40	3.53	2.93	2.93	2.97	......
15	......	5.42	5.86	3.81	4.73	4.11	4.38	3.45	2.85	2.93	2.94	......
16	......	5.29	5.81	3.78	4.51	4.04	......	3.33	2.81	2.90	2.87	2.84
17	......	5.09	5.34	3.71	4.48	3.91	4.23	3.31	2.78	2.91	2.82	......
18	2.75	4.47	5.04	3.64	4.46	3.91	4.18	3.25	2.73	2.85	2.77	......
19	......	3.97	4.96	3.56	4.63	3.89	4.33	3.23	2.78	2.78	2.70	......
20	......	4.02	4.91	3.53	4.98	3.86	6.20	3.23	2.73	2.78	2.70	......
21	......	4.64	4.51	3.46	4.88	4.49	7.65	3.23	2.70	2.83	2.74	......
22	......	4.89	4.33	3.48	5.11	5.64	7.90	3.23	2.70	2.85	2.77	......
23	......	5.12	4.13	3.46	5.28	5.32	7.43	3.28	2.70	2.93	2.82	......
24	......	6.12	3.86	3.51	5.51	5.41	7.25	3.25	2.70	3.08	2.82	2.89
25	2.89	7.37	3.88	3.66	5.96	4.99	7.30	3.23	2.70	3.00	2.79	......
26	......	8.17	3.81	3.58	5.33	4.96	7.10	3.21	2.70	2.93	2.82	......
27	......	7.82	2.71	3.53	7.70	4.84	6.55	3.21	2.90	2.91	2.96	......
28	......	7.37	2.68	3.51	8.23	5.39	5.70	3.18	2.90	2.88	3.07	......
29	......	6.97	3.63	3.61	8.86	6.51	4.93	3.43	2.88	2.88	3.00	......
30	......	......	3.61	3.56	9.61	6.71	4.40	3.30	3.01	2.85	2.97	......
31	2.99	......	4.03	......	9.63	......	4.13	3.18	......	2.83	......	2.77

[a] Ice conditions existed from January 1 to March 8, and December 18 to 27. Readings are to top of ice on January 3 and December 18, and to water over ice for February 17 to 24.

[b] Ice conditions existed from January 6 to March 8, and December 5 to 31. Readings are to top of ice for January 6 to 10, and February 12 to 25.

Daily gage height, in feet, of Wapsipinicon River at Stone City, Iowa, for 1907–1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.[a]												
1	......	......	6.10	6.87	9.12	3.70	4.97	3.02	3.23	2.90	2.64	5.33
2	......	......	6.02	6.82	9.05	3.77	4.90	2.97	3.22	2.89	2.62	5.66
3	......	......	6.20	6.80	9.00	3.75	4.82	2.95	3.17	2.88	2.74	5.99
4	......	5.62	6.47	6.42	9.40	3.67	4.70	2.92	3.10	2.75	2.76	6.43
5	......	3.72	6.30	6.00	9.10	3.65	4.95	2.90	3.02	2.72	2.76	6.66
6	......	5.54	6.72	5.72	8.25	3.62	4.90	2.85	3.05	2.68	2.73	6.86
7	2.47	5.97	8.35	5.47	7.50	3.70	4.82	2.82	3.02	2.60	2.68	7.01
8	......	6.32	7.02	5.40	6.25	6.10	4.88	2.80	3.00	2.60	2.79	6.83
9	......	6.29	6.52	5.40	5.70	6.95	4.40	2.80	3.00	2.57	2.83	5.73
10	......	5.94	6.40	5.40	5.35	6.38	4.00	2.80	3.00	2.55	2.86	5.41
11	......	5.47	6.05	5.27	5.05	6.35	3.85	2.80	2.97	2.55	2.86	5.23
12	......	5.32	5.78	5.18	4.62	6.28	3.80	2.85	2.97	2.58	2.99	5.09
13	......	5.17	5.57	5.10	4.40	5.92	3.74	3.00	3.07	2.55	3.01	......
14	2.50	5.12	5.00	4.97	4.35	5.48	3.70	3.27	3.52	2.55	3.06	......
15	......	5.12	4.87	5.57	5.20	5.12	3.65	3.95	3.45	2.55	3.16	......
16	......	5.02	4.85	5.79	8.02	4.95	3.60	4.17	3.38	2.52	3.62	4.63
17	......	5.02	4.55	5.92	9.75	4.91	3.52	4.60	3.25	2.52	4.16	......
18	......	4.97	4.40	6.45	7.50	4.70	3.48	5.22	3.17	2.52	4.66	......
19	......	4.75	5.40	7.17	5.70	4.62	3.42	5.46	3.22	2.50	5.26	......
20	2.57	4.95	6.08	7.82	5.45	4.47	3.35	5.03	3.30	2.47	5.63	......
21	......	5.30	6.72	9.30	5.45	4.35	3.30	4.95	3.30	2.62	5.86	......
22	......	5.90	6.97	12.67	5.40	4.60	3.30	4.90	3.27	2.68	6.11	4.23
23	......	6.67	7.22	13.30	5.20	4.75	3.28	4.65	3.22	2.72	5.81	......
24	......	6.72	7.22	11.35	5.02	5.10	3.27	4.38	3.18	2.62	5.53	......
25	......	7.00	7.65	9.67	4.67	5.12	3.25	4.10	3.15	2.65	5.16	......
26	......	6.65	8.20	8.77	4.45	4.60	3.20	3.92	3.10	2.65	4.86	......
27	2.69	6.50	9.02	8.30	4.15	4.85	3.20	3.80	3.02	2.62	4.73	......
28	......	6.15	7.92	6.95	4.00	4.97	3.15	3.68	3.00	2.62	4.69	......
29	......	......	7.05	7.72	3.87	4.97	3.12	3.50	2.97	2.65	4.81	3.86
30	......	......	7.02	8.30	3.67	5.05	3.07	3.35	2.95	2.67	5.06	......
31	......	......	6.95	......	3.72	......	3.05	3.27	......	2.64	......	......

[a] Ice conditions existed January 1 to March 7, and December 8 to 31. Readings are to top of ice for February 4 to March 7, December 9 to 12, and December 16.

Daily discharge, in second-feet, of Wapsipinicon River at Stone City, Iowa, for 1907–1909.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.[a]										
1	....	1,380	385	435	655	740	1,880	995	268	247
2	....	1,260	352	400	595	670	910	1,120	290	240
3	....	1,110	352	385	580	620	810	1,460	282	234
4	....	1,230	330	290	545	590	720	1,700	275	224
5	....	1,270	339	390	286	530	650	1,990	268	224
6	....	1,220	310	460	272	470	710	1,760	261	234
7	....	1,110	282	525	470	630	785	1,310	261	247
8	3,860	935	294	700	605	995	910	850	261	240
9	3,480	855	298	785	730	1,010	1,050	750	275	234
10	2,950	750	290	885	890	1,080	920	660	314	234
11	2,160	725	275	1,090	1,110	885	845	610	306	357
12	1,890	685	272	1,750	1,320	580	810	585	326	294
13	1,500	660	272	1,990	1,300	480	710	520	348	415
14	1,250	605	290	1,960	1,580	420	670	460	348	430
15	1,050	575	298	1,810	1,670	395	645	445	348	314
16	1,030	550	272	1,590	1,940	3,020	610	440	348	282
17	1,030	510	275	1,200	2,220	4,580	570	435	335	268
18	985	500	272	1,050	2,690	2,890	535	420	335	....
19	885	455	268	915	2,780	1,110	760	420	298	....
20	825	415	261	805	4,360	810	870	410	306	....
21	800	415	254	725	4,360	730	770	410	314	....
22	725	400	254	665	3,960	605	710	400	357	....
23	750	385	261	625	3,420	545	680	400	480	....
24	800	385	290	675	2,270	495	640	385	405	....
25	745	348	375	750	2,190	470	610	385	335	....
26	725	348	425	885	1,940	470	670	370	282	....
27	750	330	505	975	1,830	745	755	279	257	....
28	765	366	550	1,040	1,500	845	1,130	272	257	....
29	785	348	535	840	1,150	1,250	1,060	272	247	....
30	1,110	375	550	735	960	2,350	1,050	272	240	....
31	1,290	....	485	....	780	3,060	....	272	....	....

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1908.[a]									
1	....	960	500	4,210	2,260	660	298	244	240
2	....	850	485	3,620	2,120	610	298	228	257
3	....	775	475	3,220	2,380	535	298	221	247
4	....	650	450	2,750	2,310	445	298	212	240
5	....	610	450	2,350	1,710	460	286	198	224
6	....	610	435	1,930	1,490	460	279	198	195
7	....	675	435	1,650	1,690	445	279	234	195
8	2,390	685	425	1,180	1,490	410	272	244	189
9	2,190	725	400	1,140	1,180	385	268	228	195
10	1,710	760	385	1,040	960	370	250	218	224
11	1,720	685	435	965	835	339	244	218	240
12	1,590	600	585	825	760	339	244	228	257
13	1,810	625	725	840	820	510	234	244	240
14	1,740	635	910	825	920	485	228	228	240
15	1,740	625	1,090	775	910	445	204	228	231
16	1,710	610	975	740	872	385	192	218	209
17	1,430	575	960	675	835	375	184	221	195
18	1,260	540	950	675	810	348	170	204	181
19	1,220	500	1,040	665	885	339	184	184	162
20	1,190	485	1,230	650	1,940	339	170	184	162
21	975	450	1,170	965	2,880	339	162	198	173
22	885	460	1,300	1,600	3,050	339	162	204	181
23	785	450	1,390	1,420	2,730	361	162	228	195
24	650	475	1,530	1,470	2,610	348	162	279	195
25	660	550	1,800	1,230	2,640	339	162	250	186
26	625	510	1,420	1,220	2,520	330	162	228	195
27	165	485	2,910	1,150	2,160	330	218	221	237
28	157	475	3,280	1,450	1,640	318	218	212	275
29	535	525	3,740	2,130	1,200	435	212	212	250
30	525	500	4,330	2,260	920	370	254	204	240
31	735	....	4,340	....	785	318	....	198	....

[a] See note on page 164.

Daily discharge, in second-feet, of Wapsipinicon River at Stone City, Iowa, for 1907–1909—Continued.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.										
1	....	2,370	3,940	570	1,220	257	339	218	147	1,420
2	....	2,330	3,890	605	1,180	240	335	215	142	1,620
3	....	2,320	3,850	595	1,140	234	314	213	173	1,810
4	....	2,070	4,160	555	1,080	224	286	175	178	2.080
5	....	1,820	3,920	545	1,210	218	257	167	178	2,130
6	....	1,650	3,300	530	1,180	203	268	157	170	2,360
7	....	1,500	2,780	570	1,140	195	257	137	157	2,460
8	2,460	1,460	1,970	1,880	1,170	189	250	137	186	....
9	2,140	1,460	1,640	2,420	920	189	250	130	198	....
10	2,060	1,460	1,430	2,050	720	189	250	126	206	....
11	1,850	1,390	1,270	2,030	645	189	240	126	206	....
12	1.690	1,340	1,030	1,990	620	203	240	133	247	....
13	1,560	1,300	920	1,770	590	250	275	126	254	....
14	1,240	1,220	895	1,510	570	357	480	126	272	....
15	1,170	1,560	1,350	1,210	545	695	445	126	310	....
16	1,160	1,690	3,130	1,310	520	805	410	119	530	....
17	995	1,770	4,440	1,190	480	1,020	348	119	800	....
18	920	2,090	2,780	1,080	460	1,360	314	119	1,050	....
19	1,460	2,560	1,640	1,030	430	1,500	335	115	1,380	....
20	1,870	3,000	1,490	955	395	1,260	370	109	1,600	....
21	2,270	4,080	1,490	895	370	1,210	370	142	1,740	....
22	2,430	7,370	1,460	1,020	370	1,180	357	157	1,890	....
23	2,590	8,190	1,350	1,100	361	1,050	335	167	1,710	....
24	2,590	5,880	1,250	1,300	357	910	318	142	1,540	....
25	2,880	4,380	1,060	1,310	338	770	306	150	1,330	....
26	3,260	3,680	945	1,020	326	680	286	150	1,160	....
27	3,860	3,330	795	1,160	326	620	257	142	1,090	....
28	3,060	2,420	720	1,220	306	560	250	142	1.070	....
29	2,480	2,920	655	1,220	294	470	239	150	1,140	....
30	2,460	3,330	555	1,270	275	395	234	155	1,270	....
31	2,420	....	580	....	268	357	....	147	....	....

NOTE.—The daily discharges for 1907 to 1909 were obtained from a rating based on measurements made during 1904 to 1906 which is well defined above 162 second-feet.

Monthly discharge of Wapsipinicon River at Stone City, Iowa, for 1907–1909.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1907.						
March 8–31	3,860	725	1,340	1.02	0.91	B.
April	1,380	330	683	.521	.58	B.
May	550	254	338	.258	.30	B.
June	1,990	290	911	.695	.78	B.
July	4,360	272	1,640	1.25	1.44	B.
August	4,580	395	1,100	.841	.97	B.
September	1,880	535	815	.622	.69	B.
October	1,990	272	679	.518	.60	B.
November	480	240	308	.235	.26	B.
December 1–17	430	224	278	.212	.13	B.
1908.						
March 8–31	2,390	157	1,180	.901	.80	B.
April	960	450	599	.457	.51	B.
May	4,340	385	1,310	1.00	1.15	B.
June	4,210	650	1,520	1.16	1.29	B.
July	3,050	760	1,620	1.24	1.43	B.
August	660	318	404	.308	.36	B.
September	298	162	225	.172	.19	B.
October	279	184	220	.168	.19	B.
November	275	162	215	.164	.18	B.
1909.						
March 8–31	3,860	920	2,120	1.62	1.45	B.
April	8,190	1,220	2,730	2.08	2.32	B.
May	4,440	555	1,960	1.50	1.73	B.
June	2,420	530	1,200	.916	1.02	B.
July	1,220	268	639	.488	.56	B.
August	1,500	189	580	.443	.51	B.
September	480	234	307	.234	.26	B.
October	218	109	146	.111	.13	B.
November	1.890	142	744	.568	.63	B.
December 1–7	2,460	1,420	1,980	1.51	.39	

ROCK RIVER DRAINAGE BASIN.

DESCRIPTION.

Rock River drains the southeastern part of Wisconsin and the northwestern part of Illinois. The river rises in the southeastern part of Fond du Lac County, in Wisconsin, flows in a slight southwesterly direction across the Illinois State line, and at Rockford, Ill., turns more to the southwest and joins Mississippi River about 6 miles below the city of Rock Island, Ill. The total length of the river is about 286 miles. The total drainage area is about 11,000 square miles, of which 5,650 square miles are in Wisconsin, and about 5,350 square miles in Illinois.

The more important tributaries beginning at the sources are on the left or east bank: East Branch of Rock River, Oconomowoc, Bark, Turtle Creek, Kiskaukee, Kyte, and Green rivers; on the right or west bank, West Branch of Rock River, Crawfish, Catfish, and Pecatonica rivers, and Rock Creek.

The drainage basin is irregular in shape, being about 175 miles in length and about 85 miles in greatest width. In the upper part of its course the river flows rather toward the eastern side of the basin, at the Illinois State line it approaches the center, and in its lower course it flows decidedly near the western boundary. The rocks underlying this basin are limestones and shales which have been in large part covered by the drift and morainic débris of glacial times, and the soils vary with the geologic formations on which they rest.

The Illinois portion of the drainage area is an undulating, semi-prairie region; in Wisconsin the surface is moderately hilly, elevations ranging from 750 feet where the river enters the State of Illinois to 1,100 feet on the crests of the Kettle Range. The rise from the interior of the valley is gradual, and few of the hilltops are more than 100 feet above the intervening valleys. The low uneven topography has led to the formation of an intricate tributary system with numerous spring-fed lakes. These lakes occur chiefly in two groups, an eastern, comprising about 20 lakes with an aggregate area of 11 square miles, and a western, including five lakes, with a total area of 13 square miles. The elevation of the sources of the river is approximately 1,000 feet above sea level; at Horicon the elevation is 858 feet; at the State line it is 731 feet, and at the mouth of the river 540 feet. The average slope is a little over 1 foot per mile.

According to L. S. Smith, of Madison, Wis., about 30 per cent of the Wisconsin part of the drainage area is forested. The forested area in Illinois is probably less than in Wisconsin, as the State has been longer settled.

The mean annual rainfall is about 35 inches. The winters in the northern part of this drainage area are comparatively severe, snowfall is heavy, and ice forms a foot or more in thickness on the streams. In the lower part of the drainage basin the winters are somewhat milder.

The basin contains many sites at which storage might be developed, but the value of the land that would be flooded by reservoirs prohibits their construction. Lake Koshkoning, an expansion of Rock River, 23 square miles in extent, is the only body of water now controlled in the interests of manufacturing.

Although the average slope of Rock River is small, sites for water power are numerous, as in general, good foundations for dams may be found. A great many of the power sites are fully or partly developed, but there are still undeveloped power sites on the main stream and its tributaries. The power sites on the tributaries, with few exceptions, have small fall, and many developed sites have been abandoned because of the greater value of the submerged land for farms.

ROCK RIVER AT ROCKTON, ILL.

This station, which is located at the highway bridge at Rockton, Ill., was established May 13, 1903, to obtain data for studying water power, water supply, and pollution problems, and was discontinued March 31, 1909.

Pecatonica River enters from the west about three-fourths of a mile above the station. A dam and power plant above the station may modify the flow somewhat during periods of low water.

The winters in this vicinity are comparatively mild; ice forms on the river, but open places generally exist at the section. Ice jams are frequent below the station and cause backwater at the gage.

Discharge measurements are all made from the bridge at which the gage is located.

The monthly discharge for October, November, and December, 1906, was determined from a rating curve applicable to gage heights based on the original datum, and hence are considerably in error. When a new rating curve is developed these will be revised.

Daily gage height, in feet, of Rock River at Rockton, Ill., for 1909.

[O. F. Bartholomew, observer.]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	1.75	....	6.05	11	2.52	3.72	6.28	21	2.1	2.7	3.8
2	1.78	3.8	5.8	12	2.48	4.1	6.28	22	2.1	4.68	4.4
3	1.35	3.15	5.4	13	2.55	3.85	5.98	23	6.12	5.75	4.7
4	1.2	3.2	4.88	14	2.45	3.4	5.2	24	5.55	6.88	4.9
5	1.35	4.05	4.82	15	2.22	4.05	4.15	25	5.55	6.1	5.1
6	2.35	5.35	4.92	16	2.38	6.2	3.82	26	5.15	6.45	4.9
7	2.88	4.9	5.0	17	2.1	5.42	3.45	27	5.55	6.6	4.8
8	2.85	5.05	5.15	18	2.25	4.7	3.48	28	5.85	6.45	4.55
9	2.52	4.85	5.45	19	2.32	3.88	3.5	29	5.95	....	4.3
10	2.45	3.78	6.18	20	2.15	3.15	3.55	30	4.25	....	4.12
								31	....	....	4.05

NOTE.—Gage heights were probably affected by ice conditions from January 1 to March 1. Stream frozen across February 17.

IOWA RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Iowa River and its tributary, Cedar River, occupies the north-central and southeast-central part of the State of Iowa, and parts of Freeborn, Dodge, Steele, and Mower counties in southern Minnesota. The river rises in the northern part of Hancock County, Iowa, flows southeastward, and joins Mississippi River in the southeastern part of Louisa County. The length of Iowa River is about 270 miles, not following the bends. The total drainage area is about 12,400 square miles.

Cedar River, which is called a tributary of the Iowa, although its drainage area above their junction is much the larger, rises in the southern part of Dodge County, in southern Minnesota, flows southeastward into Iowa, and continues in that direction until it reaches Moscow, in the northern part of Muscatine County, where it makes an abrupt turn to the southwest and joins the Iowa in Louisa County. The river is about 260 miles long, not following the bends. In its upper course it is called Red Cedar River. The drainage area above its mouth is about 7,600 square miles. It is the only important tributary of the Iowa. The principal tributaries of Cedar River are Little Cedar, Shell Rock, and West Fork of Red Cedar rivers, all of which are tributary above Waterloo.

The drainage basin of Iowa River proper is long and narrow. The river rises in a broad, flat, or slightly undulating drift region, and the first rock exposed in its valley is the limestone that forms the rocky banks of the stream in the southwestern corner of Franklin County; from this point to its confluence with the Cedar, the river crosses a succession of sedimentary rocks. The drift which covers this region is well supplied with springs which help to maintain the flow of the stream. The surface of the surrounding country is a gently undulating prairie.

The drainage basin of Cedar River is underlain throughout its entire course by limestones which are thinly covered with glacial drift. Rock is exposed at many places along the main stream and its tributaries. The valleys of the upper tributaries are narrow, with gently sloping sides; below the mouth of the Shell Rock the valley is broad and shallow and is separated from the uplands by distinctly defined borders. The surface of the country is a gently undulating prairie, apparently level in some sections. The upper basin is about 50 miles wide, but the lower is much narrower, and at one point below Cedar Rapids it measures only 8 or 9 miles across.

At the headwaters of both Iowa and Cedar rivers are a few lakes, ranging in area from 2 to 10 square miles.

The elevation of the sources of Iowa River is about 1,250 feet above sea level; at Iowa City the elevation is 670 feet; at the mouth of the Cedar it is 565 feet, and at the junction with the Mississippi the elevation is about 522 feet. The elevation of the sources of Cedar River is about 1,300 feet; at Waterloo about 820 feet; at Cedar Rapids about 725 feet, and at the mouth about 565 feet.

The basin contains no large forested areas. The mean annual rainfall is about 32 inches. The winters are severe, especially in the upper part of the basin. The fall of snow is comparatively heavy, and ice forms to considerable thickness on the streams and lasts for three to four months.

It may be possible to make storage reservoirs at the lakes at the headwaters of both Cedar and Iowa rivers, but the overflow damages would undoubtedly prohibit their construction.

Iowa and Cedar rivers are by far the most important streams in Iowa for water power. Power sites of small head are numerous, and a number of them have been developed. Those on Cedar River are more important than those on the Iowa. The numerous rock outcrops furnish good foundations for dams. The flow of the streams sustained is kept up by numerous springs, but during long-continued droughts the flow becomes very low.

CEDAR RIVER NEAR AUSTIN, MINN.

This station, which is located just below the Red Cedar mill dam 2 miles below Austin, was established May 29, 1909, for the purpose of determining the amount of water power available on Cedar River.

The nearest tributary is Turtle Creek, which enters the Cedar 1 mile above the station. The drainage area above this point is 425 square miles.

Immediately above the station is the power plant known as Red Cedar mill. During the low-water season the water is drawn down below the crest of the dam by the end of the ten or twelve hour run, and after the turbine is closed the water is held back for several hours before it has risen sufficiently to flow over the crest. Consequently the stage of the river changes considerably during each twenty-four hours. In order to get a mean gage height the gage is read five times daily, as follows: Before the turbine is started in the morning, one hour after starting, at noon, just before shutting down the turbine at night, and half an hour later.

Observations are little affected by ice during the winter months as the gage is placed near the tailrace of the mill where the river remains open for the most part.

Since the establishment of the station the datum of the staff gage has remained unchanged.

The natural conditions of flow at this point are excellent and as there is a favorable measuring section at the highway bridge 100 yards below the gage, excellent results would be obtained were it not for the uncertainty in mean daily gage height resulting from the controlled flow. The system of five daily readings should, however, give the mean with a good degree of accuracy.

Discharge measurements of Cedar River near Austin, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 29	J. C. Hoyt	107	136	4.48	128
June 18	G. A. Gray	111	172	4.85	218
Do	C. B. Gibson	111	147	4.85	231
July 14	Gray and Gibson	108	94.5	3.90	48.6
August 24	Follansbee and Emerson	113	164	4.67	189

Daily gage height, in feet, of Cedar River near Austin, Minn., for 1909.

[J. M. King, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.63	4.70	3.78	4.20	4.15	4.45	5.95
2		4.56	4.60	4.18	4.15	4.15	5.66	5.95
3		4.56	4.40	4.09	4.20	3.85	5.50	6.40
4		5.06	4.25	3.92	4.15	3.95	5.10	6.55
5		5.12	4.30	3.94	3.95	4.00	4.80	5.45
6		5.12	4.40	3.41	4.20	4.05	4.55	5.25
7		5.16	4.32	3.80	4.15	4.10	4.50	5.15
8		5.10	4.30	3.30	4.10	4.10	4.20	4.95
9		5.28	4.05	3.75	4.15	4.10	4.30	4.50
10		5.10	4.40	3.85	4.00	4.10	4.20	4.65
11		4.94	4.05	3.96	4.05	4.30	4.90	4.60
12		4.71	4.15	4.15	3.95	4.25	6.25	4.50
13		4.50	3.82	4.60	4.25	4.45	7.70	4.60
14		5.10	4.19	8.30	4.55	4.25	14.4	4.60
15		5.54	3.94	10.04	4.60	4.20	11.7	4.55
16		4.93	3.84	8.40	4.60	4.20	8.95	4.50
17		4.93	3.88	7.40	4.45	4.10	7.30	4.50
18		4.75	3.85	6.82	4.40	4.25	6.50	4.45
19		4.55	3.95	6.10	3.95	4.10	5.95	4.40
20		4.25	4.05	5.58	4.10	4.30	5.80	4.65
21		4.50	3.82	5.20	4.15	4.30	6.05	4.40
22		4.25	3.92	4.79	4.10	4.35	6.05	4.50
23		4.30	3.88	4.75	4.30	4.35	5.70	4.70
24		4.25	3.89	4.55	4.30	3.95	5.70	4.40
25		4.55	3.92	4.36	4.25	4.15	5.50	4.20
26		4.65	3.88	4.45	4.05	4.40	6.20	4.20
27		5.88	3.90	4.35	4.20	4.20	10.15	4.40
28		6.05	3.86	4.34	4.15	3.90	8.75	4.70
29	4.32	5.55	3.84	3.99	4.15	3.95	7.20	4.70
30	4.36	5.12	3.80	4.19	4.15	3.95	6.25	4.45
31	4.92		3.88	4.22		3.75		4.45

NOTE.—There was very little ice effect at this station, owing to the nearness to the mill dam above.

CEDAR RIVER AT CEDAR RAPIDS, IOWA.

The station on Cedar River at Cedar Rapids, Iowa, was established October 26, 1902, to obtain data for studying water power, water supply, and pollution problems, and was discontinued March 31, 1909.

The gage is an inclined timber, set on posts in the bank of the river, and is located about half a mile below the First Avenue Bridge. Discharge measurements previous to August 18, 1903, were made from a cable immediately above the gage. Since that date they have been made from the bridge. There is a large island in the river about 500 feet below the section.

The gage is located where the current is swift and the river rarely freezes clear across, ice forming only along the shores. The relation between gage height and discharge is probably therefore very little affected by ice. A dam and power plant above the station may modify the flow to some extent in low water.

The elevation of the gage zero has not been checked for a number of years, but it is thought that the datum has remained unchanged. The records and estimates of the discharge at this station are considered excellent.

Daily gage height, in feet, of Cedar River at Cedar Rapids, Iowa, for 1909.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	2.9	4.3	4.55	11	3.2	4.7	6.25	21	3.2	3.7	5.0
2	2.95	4.0	4.45	12	3.2	4.55	5.65	22	3.25	4.25	5.05
3	2.9	3.8	4.55	13	3.15	4.6	5.3	23	3.2	5.05	5.05
4	2.95	4.0	4.7	14	3.15	4.6	5.0	24	3.15	5.1	5.15
5	2.95	4.5	5.1	15	3.1	4.8	4.65	25	3.15	4.9	5.55
6	3.0	4.6	5.45	16	3.15	4.8	4.5	26	3.1	5.15	5.8
7	3.05	4.7	5.15	17	3.15	4.4	4.35	27	3.1	5.05	6.4
8	3.05	4.6	6.5	18	3.2	3.95	4.35	28	3.2	4.9	7.65
9	3.1	4.9	6.45	19	3.2	3.9	4.4	29	4.3	....	8.75
10	3.15	4.7	6.2	20	3.2	3.75	5.05	30	5.8	....	8.8
								31	4.9	....	7.85

NOTE.—Slight ice conditions existed January 1 to 28. Gage heights were probably slightly affected by backwater from January 29 to March 8.

Daily discharge, in second-feet, of Cedar River at Cedar Rapids, Iowa, for 1909.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	840	4,120	4,940	11	1,270	5,450	10,900	21	1,270	2,300	6,500
2	905	3,180	4,610	12	1,270	4,940	8,780	22	1,360	3,960	6,680
3	840	2,580	4,940	13	1,190	5,100	7,550	23	1,270	6,680	6,680
4	905	3,180	5,450	14	1,190	5,100	6,500	24	1,190	6,850	7,020
5	905	4,780	6,850	15	1,110	5,800	5,280	25	1,190	6,150	8,420
6	970	5,100	8,080	16	1,190	5,800	4,780	26	1,110	7,020	9,300
7	1,040	5,450	7,020	17	1,190	4,450	4,290	27	1,110	6,680	11,500
8	1,040	5,100	11,900	18	1,270	3,020	4,290	28	1,270	6,150	16,800
9	1,110	6,150	11,700	19	1,270	2,880	4,450	29	4,120	....	20,800
10	1,190	5,450	10,800	20	1,270	2,440	6,680	30	9,300	....	21,000
								31	6,150	....	17,600

NOTE.—These daily discharges are based on a rating well defined between 840 and 33,600 second-feet.

Monthly discharge of Cedar River at Cedar Rapids, Iowa, for 1909.

[Drainage area, 6,320 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
January	9,300	840	1,660	0.263	0.30	B.
February	7,020	2,300	4,850	.767	.80	B.
March	21,000	4,290	8,780	1.39	1.60	B.

NOTE.—The open channel rating was applied during the period; accuracy only slightly affected by the slight ice conditions. The above values of accuracy are dependent on the constancy of conditions of flow since the last measurements were made in 1906.

DES MOINES RIVER DRAINAGE BASIN.

DESCRIPTION.

Des Moines River rises in the southern part of Minnesota, flows to the south and southeast diagonally across the State of Iowa and enters the Mississippi near Keokuk, Iowa. Its principal tributaries are East Fork of the Des Moines, which enters near Dakotah, in Humboldt County, and Raccoon River, which joins the main stream at Des Moines.

The total drainage area is 14,700 square miles. The area in Minnesota is 1,220 square miles; above the mouth of the Raccoon, 6,460 square miles. The drainage area of the Raccoon is 3,680 square miles.

The Des Moines throughout its course flows in a well-defined valley eroded for the most part in the glacial drift which covers the entire drainage basin. The depth of the valley increases from 50 to 150 feet, with a width of one-third to two-thirds of a mile between the top of the bluffs along the river. The entire area is within the prairie region and the only timber is found on the borders of the numerous lakes in the upper part of the basin or along the larger streams.

The annual rainfall is about 30 inches. During the period from December to March the streams are frozen over entirely with ice 1 foot or more in thickness.

The Des Moines affords many sites for the development of water power. The lakes in the upper part of the basin aid in regulating the stream flow.

DES MOINES RIVER AT JACKSON, MINN.

This station, which is located at the highway bridge half a mile below the dam at Jackson, was established May 31, 1909, because of the power available on Des Moines River and also as part of the general plan for investigating the water resources of Minnesota.

The nearest tributary is a small stream that enters from the west at a point 300 feet below the station.

At the dam half a mile above the station is a power plant which develops 35 horsepower under a head of 6½ feet. The plant operates only six hours per day on the average, but thus far the morning and evening gage heights do not show any appreciable change in the stage of the river owing to water being held back in low-water season after the turbines have been shut down.

From December to March observations are discontinued because of ice.

The datum of the gage has remained unchanged since the station was established. The staff gage is located at the bridge from which discharge measurements are made. Conditions are favorable for good results and the records of flow should be reliable.

Discharge measurements of Des Moines River at Jackson, Minn., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 31	Hoyt and Gibson	87	450	7.55	1,010
Do	C. B. Gibson	87	460	7.55	1,040
June 17	G. A. Gray	87	442	7.52	923
Do	C. B. Gibson	87	439	7.50	1,010
July 14	G. A. Gray	88	605	9.46	1,540
August 23	Follansbee and Emerson	81	163	4.13	197
October 27	G. A. Gray	78	103	3.39	80.0
Do	do	78	92.2	3.28	66.7

Daily gage height, in feet, of Des Moines River at Jackson, Minn., for 1909.

[Albert Strobel, observer.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		7.78	9.32	6.06	3.50	3.10	3.16	4.10
2		7.65	9.30	5.82	3.48	3.08	3.26	4.24
3		7.70	9.35	5.55	3.58	3.06	3.31	4.30
4		7.85	9.52	5.45	3.56	3.01	3.24	4.15
5		8.00	9.68	5.30	3.52	3.00	3.28	
6		8.12	9.75	5.14	3.50	3.02	3.15	
7		8.05	9.80	5.19	3.45	3.04	3.20	4.18
8		7.95	9.72	5.00	3.45	3.05	3.05	4.10
9		7.82	9.50	5.00	3.40	3.05	3.04	4.04
10		7.85	9.65	4.90	3.36	3.06	3.10	4.10
11		7.75	9.55	4.90	3.28	3.15	3.16	4.14
12		7.72	9.58	4.95	3.40	3.30	3.22	4.20
13		7.82	9.45	4.88	3.39	3.11	3.28	4.20
14		8.20	9.35	4.80	3.44	3.11	3.72	4.30
15		8.02	9.22	4.72	3.42	3.12	3.68	4.32
16		7.70	9.14	4.70	3.41	3.08	3.45	
17		7.55	9.05	4.58	3.35	3.05	3.45	
18		7.25	9.05	4.54	3.30	3.06	3.45	
19		6.95	9.00	4.35	3.28	3.06	3.60	
20		6.75	8.82	4.30	3.24	3.05	3.32	
21		6.80	8.56	4.22	3.30	3.05	3.72	
22		6.80	8.35	4.18	3.30	3.06	3.85	
23		7.30	8.05	4.15	3.28	3.09	3.85	
24		8.00	7.88	4.08	3.25	3.10	3.60	
25		7.82	7.58	4.06	3.20	3.06	3.55	
26		7.78	7.38	3.92	3.16	3.24	3.75	
27		8.32	7.20	3.90	3.16	3.25	4.14	
28		9.25	6.88	3.91	3.15	3.18	4.24	
29		10.00	6.72	3.80	3.12	3.06	3.72	
30		9.78	6.40	3.66	3.12	3.18	4.05	
31	7.60		6.30	3.58		3.15		

NOTE.—Backwater conditions probably prevailed during December, due to freezing.

Daily discharge, in second-feet, of Des Moines River at Jackson, Minn., for 1909.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	......	1,070	1,500	616	95	48	55	16	......	1,050	1,450	307	83	46	88
2	......	1,040	1,490	556	92	46	66	17	......	1,010	1,420	282	76	43	88
3	......	1,050	1,510	492	106	44	71	18	......	928	1,420	273	70	44	88
4	......	1,090	1,560	468	103	39	63	19	......	847	1,410	236	68	44	109
5	......	1,130	1,600	435	98	38	68	20	......	795	1,360	226	63	43	72
6	......	1,160	1,620	400	95	40	54	21	......	808	1,290	211	70	43	127
7	......	1,140	1,630	411	88	42	59	22	......	808	1,230	203	70	44	147
8	......	1,120	1,610	370	88	43	43	23	......	941	1,140	198	68	47	147
9	......	1,080	1,550	370	82	43	42	24	......	1,130	1,100	186	64	48	109
10	......	1,090	1,590	349	77	44	48	25	......	1,080	1,020	182	59	44	102
11	......	1,060	1,560	349	68	54	55	26	......	1,070	963	158	55	63	132
12	......	1,050	1,570	360	82	70	61	27	......	1,220	914	155	55	64	196
13	......	1,080	1,540	345	81	49	68	28	......	1,480	829	157	54	57	215
14	......	1,190	1,510	328	87	49	127	29	......	1,690	787	139	50	44	127
15	......	1,140	1,470	311	85	50	121	30	......	1,630	704	118	50	57	180
								31	1,020	......	678	106	......	54	......

NOTE.—These discharges are based on a rating curve that is fairly well defined.

Monthly discharge of Des Moines River at Jackson, Minn., for 1909.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
June	1,690	795	1,100	0.948	1.06	65,500	A.
July	1,630	678	1,320	1.14	1.31	81,200	A.
August	616	106	300	.259	.30	18,400	B.
September	106	50	76.1	.066	.07	4,530	B.
October	70	38	47.9	.041	.05	2,950	B.
November	223	42	97.6	.084	.09	5,810	B.
The period						178,000	

ILLINOIS RIVER DRAINAGE BASIN.

DESCRIPTION.

Illinois River enters the Mississippi from the east about 24 miles above the mouth of the Missouri. Its drainage area, comprising 29,000 square miles, is distributed among three States—Illinois, Wisconsin, and Indiana; 24,700 square miles are in Illinios, extending in a broad band 250 miles long and averaging 100 miles in width directly across the center of the State in a northeast-southwest direction; 1,080 square miles are in Wisconsin, extending north from the Illinois area; and 3,220 square miles are in Indiana, projecting east from the same area. The eastern projection is the basin of Kankakee River; the northern one contains the basins of Fox and Des Plaines rivers. The name Illinois is applied to the river from the junction of the Kankakee and Des Plaines.

The region drained by the Illinois is level or undulating, and includes some of the finest agricultural land in the United States. Many large and prosperous cities are situated within it, and it is covered with a network of railroads.

The drainage into the Illinois is rather evenly distributed along its course. The more important tributaries are Fox and Spoon rivers from the west, and the Vermilion and Sangamon from the east.

SANGAMON RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Sangamon River lies wholly within the State of Illinois, very nearly in the center of the State. The river rises in the southwestern part of Ford County, flows southwestward to Decatur, in Macon County, thence westward to a point near Springfield, northwestward to its junction with Salt Creek at the northern boundary line of Menard County, and westward to its junction with Illinois River at the northern boundary of Cass County. Springfield is about 20 miles southwest of the center of the basin, which is roughly a right triangle in shape, with the mouth of the river opposite the vertical. The river is about 180 miles long, not including bends. The total drainage area is 5,410 square miles. The principal tributaries are Salt Creek and South Fork.

The eastern third of the drainage basin is somewhat undulating and elevated, the rest of the basin is a level prairie. The soil is a very fertile, rich, black loam, especially adapted for raising corn. There are coal mines in the vicinity of Springfield. The bed and banks of the river are soft and insecure. The slope of the river is small. The elevation of its source is about 700 feet above sea level, and that of its mouth is about 430 feet. The only timber in this drainage basin is in small groves or along the river banks.

The annual rainfall is about 37 inches. The winters are mild. Ice forms to some extent, and during severe winters attains considerable thickness.

The basin contains many swamp areas and is so level and low that little ground storage is available. High water follows every heavy rain, floods are of frequent occurrence and considerable duration, and as the banks of the river are low large areas are flooded. The drainage of the swamps and the opening up of channels so that flood waters may have an opportunity of returning quickly to the main stream makes the study of flood control and drainage of considerable importance. In some places short sections of the main stream are being straightened in an effort to provide a better channel so that floods will quickly drain off the adjacent land. Such work is of doubtful value, for in a few years at the most the river will return to its former channel or make new channels in order to keep in equilibrium. Any improvement of this kind should take into account the stream as a whole and should be begun at the lower end.

On account of the low slope, floods, low water, and lack of suitable foundations for dams, opportunities for development of water power are lacking.

SANGAMON RIVER AT MONTICELLO, ILL.

This station, which is located at the Illinois Central Railroad bridge about half a mile west of Monticello, Ill., was established February 4, 1908, for the purpose of collecting data to be used in studying drainage, water supply, and flood-control problems.

No important tributaries enter near the station. The drainage area above the section is 550 square miles.

Discharge measurements are made from the railroad bridge and a trestle approach on the left bank.

The datum of the chain gage, which is located on the bridge, has not been changed; the records are reliable and accurate.

Discharge measurements of Sangamon River at Monticello, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 9	R. J. Taylor	154	1,110	9.25	1,410
May 12	do	366	2,860	13.65	6,830
July 26	do	101	130	2.65	61
December 15	do	67	64	2.05	13
1909.					
March 20	W. M. O'Neill	137	417	4.83	281
March 24	do	125	351	4.35	222
May 20	H. J. Jackson	138	463	5.13	352
December 7	do	116	181	3.07	79

Daily gage height, in feet, of Sangamon River at Monticello, Ill., for 1909.

[Martin Doyle, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.4	2.5	8.6	4.25	9.25	6.55	3.85		2.2	2.0	2.35	3.25
2	2.3	2.4	8.1	4.15		6.4	3.6	3.1	2.1	2.0	3.4	3.2
3		2.4	7.7	4.2	8.55	6.85	3.5	3.0	2.2		2.35	3.15
4	2.3	2.4	7.1		7.6	7.4		2.95	2.2	2.0	2.35	3.1
5	2.3	2.6	6.7	4.1	7.0	7.3	3.55	2.95		2.0	2.35	
6	2.0	2.7	6.4	4.3	6.6		3.8	2.9	2.1	2.0	2.3	3.5
7	2.0			8.4	6.05	5.8	7.8	2.8	2.1	2.0		3.5
8	2.0	3.2	5.8	9.8	6.1	5.35	8.5		2.1	1.95	2.35	
9	2.0	3.8	5.9	9.1	7.95	8.55	8.2	2.6	2.1	1.95	2.3	
10		4.8	6.3	7.6	9.15	8.4	7.2	2.55	2.1		2.3	
11	2.0	4.8	6.5		9.35	7.15	9.2	2.5	2.1	2.0	2.3	2.8
12	2.1	4.6	6.2	6.2	8.95	6.9	14.85	2.45		2.0	2.7	
13	2.1	4.9	5.9	9.95	8.10		13.15	2.4	2.05	2.0	2.9	3.7
14	2.1			10.9	7.5	9.7	10.95	2.4	2.0			4.3
15	2.1	7.2	5.4	10.9	6.9	7.9	9.1		2.1	2.1	2.9	4.3
16	2.1	8.5	5.2	10.15		6.3	7.8	2.4	1.95	2.0	4.4	4.35
17		8.0	5.0	9.2	6.1	5.75	6.9	2.3	1.95		5.0	4.4
18	2.1	7.8	4.7		5.7	5.2		2.3	1.95	2.3	4.5	4.25
19	2.0	8.0	4.9	8.55	5.4	4.9	5.7	2.25		2.15	4.7	4.2
20	2.0	9.0	4.9	8.75	5.2		5.2	2.2	2.0	2.2	4.25	3.9
21	2.1			9.8	5.05	4.4	5.0	2.2	2.0	2.25		3.7
22	2.4	9.8	4.6	10.5	4.8	5.3	4.75		2.4	2.3	3.7	3.6
23	2.5	10.1	4.5	10.4		5.3	4.3	2.0	2.4	2.4	3.8	3.5
24		10.85	4.3	10.0	4.45	4.8	4.15	2.1	2.25		3.8	3.4
25	2.3	11.1	4.7		4.9	4.5		2.1	2.2	2.4	3.95	3.5
26	2.35	11.1	5.0	8.65	6.6	4.4	3.8	2.9		2.35	3.85	3.2
27	2.3	10.3	5.2	8.0	8.2		3.8	3.0	2.1	2.3	3.7	3.25
28	2.3			7.4	9.0	4.8	3.7	2.45	2.1	2.3		3.25
29	2.6		4.85	7.05	7.9	4.4	3.6		2.1	2.3	3.4	3.1
30	2.5		4.6	8.7		4.1	3.45	2.2	2.0	2.25	3.3	3.1
31			4.4		6.4		3.35	2.2				3.1

NOTE.—Varying ice conditions existed from January 6 to February 5, and December 7 to 31. Gage heights are to top of ice on January 6, 7, and 30, and on December 8 to 10 and 18 to 31.

Daily discharge, in second-feet, of Sangamon River at Monticello, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1			1,830	619	1,920	756	82	20	11	8	11	20
2			1,920	638	1,280	657	138	20	8	8	11	20
3			2,430	600	1,070	581	99	20	8	8	11	20
4		194	2,650	562	1,580	543	90	15	8	8	11	20
5		524	2,650	543	3,360	505	82	15	8	6	11	20
6		1,100	2,650	543	3,600	429	74	15	6	6	11	18
7		1,240	2,650	524	4,970	392	74	15	6	6	11	15
8		1,010	2,760	657	6,560	338	66	15	6	6	11	15
9		846	2,650	1,280	5,920	320	66	11	6	6	11	15
10		676	2,120	1,450	5,440	302	66	11	6	6	11	11
11		562	1,580	1,170	3,990	268	58	11	6	6	11	11
12		756	1,330	976	6,720	236	58	11	6	6	11	11
13		1,100	1,170	777	8,320	208	50	15	6	6	11	11
14		2,120	1,040	735	9,280	222	66	25	6	6	11	11
15		3,240	920	676	7,360	222	82	20	6	6	11	11
16		3,480	777	676	5,120	194	66	20	6	6	11	11
17		4,250	715	695	3,860	170	58	20	6	6	11	11
18		3,360	715	695	4,250	159	50	15	6	6	11	11
19		2,120	920	657	3,730	148	43	11	6	6	11	11
20		976	1,130	638	3,600	148	43	11	6	6	11	11
21		920	1,200	581	3,600	138	43	11	6	6	11	11
22		846	1,070	505	3,730	118	43	11	6	8	11	11
23		895	895	505	2,760	118	37	8	6	8	15	11
24		777	756	920	2,020	108	37	8	6	8	15	11
25		1,010	676	2,020	1,660	99	43	8	6	8	15	11
26		2,020	619	2,430	1,330	90	43	8	6	8	20	11
27		2,540	562	3,120	1,130	82	37	8	6	8	20	11
28		2,430	562	3,000	976	82	37	8	8	11	15	11
29		2,430	676	2,760	948	90	31	8	8	11	20	11
30			581	2,650	920	90	25	8	8	11	25	25
31			619		870		25	8		11		31
1909.												
1	31	20	1,100	201	1,360	610	154	93	20	11	28	94
2	25	31	948	188	1,220	581	128	82	15	11	108	90
3	25	31	846	194	1,080	666	118	74	20	11	28	86
4	25	31	715	188	822	777	120	70	20	11	28	82
5	25	43	638	182	695	756	123	70	18	11	28	100
6	8	50	581	208	619	612	148	66	15	11	25	118
7	6	70	524	1,040	514	467	870	58	15	11	26	118
8	6	90	467	1,740	524	383	1,070	50	15	10	28	80
9	6	148	486	1,280	907	1,080	976	43	15	10	25	50
10	6	284	562	822	1,300	1,040	735	40	15	10	25	40
11	6	284	600	682	1,420	725	1,330	37	15	11	25	50
12	8	252	543	543	1,220	676	8,720	34	14	11	50	100
13	8	302	486	1,880	948	1,170	6,000	31	13	11	66	138
14	8	518	439	2,880	799	1,660	2,940	31	11	13	66	208
15	8	735	392	2,880	676	895	1,280	31	15	15	66	208
16	10	1,070	356	2,070	600	562	870	31	10	11	222	215
17	10	920	320	1,330	524	458	676	25	10	18	320	222
18	10	870	268	1,200	448	356	562	25	10	25	236	180
19	11	920	302	1,080	392	302	448	22	10	18	268	150
20	11	1,240	302	1,150	356	262	356	20	11	20	201	130
21	15	1,490	277	1,740	329	222	320	20	11	22	170	120
22	31	1,740	252	2,430	284	374	276	16	31	25	138	100
23	37	2,020	236	2,320	256	374	208	11	31	31	148	80
24	30	2,820	208	1,920	229	284	188	15	22	31	148	70
25	23	3,120	268	1,520	302	236	168	15	20	31	164	60
26	28	3,120	320	1,120	619	222	148	66	18	28	153	50
27	25	2,220	356	920	976	253	148	74	15	25	138	50
28	25	1,660	325	777	1,240	284	138	34	15	25	123	40
29	20		293	705	895	222	128	27	15	25	108	40
30	20		252	1,130	738	182	113	20	11	22	99	30
31	15		222		581		104	20		25		30

NOTE.—These daily discharges for 1908 to 1909 are taken from a rating based on 1908 to 1910 measurements, and well defined between 11 and 1,390 second-feet, and fairly well defined to 6,720 second-feet. Discharges for the following periods in 1909 have been estimated because of ice conditions, January 6 to 18; January 29 to February 1; December 8 to 12 and 18 to 31. Discharges were interpolated for days of no gage height.

Monthly discharge of Sangamon River at Monticello, Ill., for 1908-9.

[Drainage area, 550 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
February 4-29	4,250	194	1,890	3.44	3.33	B.
March	2,760	562	1,380	2.51	2.89	B.
April	3,120	505	1,120	2.04	2.28	B.
May	9,280	870	3,610	6.56	7.56	B.
June	756	82	260	.473	.53	A.
July	138	25	58.5	.106	.12	A.
August	25	8	13.2	.024	.03	B.
September	11	6	6.63	.012	.01	C.
October	11	6	7.29	.013	.01	C.
November	25	11	12.9	.024	.03	B.
December	31	11	14.2	.026	.03	B.
1909.						
January	37	....	16.8	.031	.04	C.
February	3,120	....	932	1.69	1.76	B.
March	1,100	208	448	.815	.94	A.
April	2,880	182	1,210	2.20	2.46	B.
May	1,420	229	738	1.34	1.54	A.
June	1,660	182	556	1.01	1.13	A.
July	8,720	104	954	1.73	1.99	B.
August	93	11	40.4	.074	.09	A.
September	31	10	15.9	.029	.03	B.
October	31	10	17.7	.032	.04	B.
November	320	25	109	.198	.22	A.
December	....	....	101	.184	.21	C.
The year	8,720	....	428	.778	10.45	

SANGAMON RIVER AT RIVERTON, ILL.

This station, which is located on the Wabash Railroad bridge about one-fourth mile west of the depot at Riverton, Ill., was established February 13, 1908, to obtain data to be used in the study of drainage and flood control problems.

The South Fork joins the Sangamon 2 or 3 miles above the station. The drainage area above the section is 2,560 square miles.

Discharge measurements are made from the railroad bridge to which the chain gage is attached.

The datum of the gage has not been changed. The records are reliable and accurate.

The high water of 1883 reached a height of approximately 32 feet on the present gage. The high water of 1875 is said to have been about one-half foot lower than this.

Discharge measurements of Sangamon River at Riverton, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 13	R. J. Taylor	218	2,200	16.50	3,760
July 27	do	151	733	8.4	326
1909.					
February 7	R. J. Taylor	157	856	9.39	397
March 18	W. M. O'Neill	181	1,360	12.27	1,480
March 23	do	175	1,170	11.33	1,090
May 18	H. J. Jackson	197	1,760	14.56	2,440
November 26	do	180	1,210	11.97	1.250

Daily gage height, in feet, of Sangamon River at Riverton, Ill., for 1909.

[B. H. Watson, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.1	8.2	....	11.0	16.5	20.0	10.7	10.5	7.8	8.0	8.4	10.9
2	7.1	8.4	....	10.9	16.0	19.0	10.0	10.4	7.8	8.0	8.4	10.6
3	7.1	8.6	17.2	10.9	15.8	19.0	9.8	10.3	7.8	8.0	8.5	10.55
4	7.1	8.6	16.4	10.9	15.6	19.25	9.6	10.2	7.8	8.0	8.5	10.45
5	7.1	8.7	15.7	10.9	15.2	18.0	10.1	10.1	7.8	8.0	8.5	10.2
6	7.1	8.9	15.0	10.8	15.0	16.9	13.7	9.9	7.8	8.0	8.5	10.2
7	7.1	9.0	14.7	10.8	14.8	15.8	20.5	9.8	7.8	8.0	8.5	10.15
8	7.1	9.4	13.9	10.9	14.9	15.4	19.9	9.8	7.8	8.0	8.6	9.7
9	7.1	9.6	12.5	11.4	15.1	15.65	19.9	9.8	7.7	8.0	8.8	9.3
10	7.1	9.9	12.4	12.1	16.5	14.95	19.5	9.7	7.7	8.0	8.9	9.6
11	7.1	10.4	12.0	12.6	16.4	14.5	19.0	9.5	7.7	8.0	9.0	9.8
12	7.1	10.5	11.8	12.9	17.2	14.5	20.5	9.3	7.6	8.0	9.0	10.0
13	7.1	10.8	11.5	13.2	18.5	14.7	22.5	9.2	7.6	8.0	9.05	10.3
14	7.1	10.9	11.9	13.8	18.4	14.9	23.7	8.9	7.6	8.0	9.05	10.9
15	7.1	11.0	12.0	14.0	18.3	13.7	24.3	8.7	7.6	8.0	....	11.8
16	7.1	11.2	12.1	14.4	18.0	13.1	24.0	8.7	7.9	8.0	....	12.4
17	7.1	14.0	12.1	15.9	17.4	12.9	22.0	8.4	8.0	8.0	....	13.0
18	7.1	15.1	11.9	16.9	16.7	12.7	21.0	8.3	8.0	8.0	....	12.9
19	7.1	16.0	11.8	18.4	16.2	12.1	20.5	8.1	8.0	8.4	....	12.4
20	7.2	17.0	11.6	19.5	15.4	11.8	19.4	8.1	8.2	8.5	11.8	12.0
21	7.3	18.0	11.6	20.8	14.4	11.6	18.0	8.0	8.2	8.5	....	11.7
22	7.3	18.6	11.5	21.9	13.4	11.3	17.2	7.9	8.1	8.5	....	11.7
23	7.3	19.4	11.5	22.6	12.6	11.2	16.5	7.8	8.1	8.4	....	11.4
24	7.4	19.6	11.4	22.3	11.7	11.0	15.2	7.8	8.1	8.4	....	11.15
25	7.5	....	11.3	22.0	13.0	10.7	14.0	7.7	8.0	8.4	....	10.9
26	7.5	....	11.3	21.4	14.05	11.0	13.1	7.7	8.0	8.4	12.0	10.7
27	7.5	....	11.2	20.5	15.6	11.6	12.7	7.7	8.0	8.4	11.9	10.5
28	7.5	....	11.25	19.0	16.4	11.8	11.6	7.6	8.0	8.3	11.65	10.4
29	7.6	....	11.1	18.1	17.5	11.6	11.2	7.6	8.0	8.3	11.4	10.2
30	7.6	....	11.0	17.5	17.5	11.4	10.8	7.6	8.0	8.3	11.0	10.0
31	7.9	....	11.0	....	19.0	....	10.6	7.6	....	8.3	....	10.0

NOTE.—Ice conditions existed from December 8 to 31. On December 30 the ice was 1 foot thick about one-fourth mile above the gage.

Daily discharge, in second-feet, of Sangamon River at Riverton, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	......	......	8,010	3,140	6,220	3,320	460	190	148	92	67	101
2	......	......	7,790	3,200	5,660	2,700	435	179	148	92	67	101
3	......	......	7,570	3,260	5,340	2,260	388	179	138	83	67	101
4	......	......	7,350	3,200	7,680	2,000	344	168	138	83	60	101
5	......	......	7,130	3,090	9,180	1,870	344	168	128	83	60	101
6	......	......	7,460	3,040	10,000	1,750	324	158	119	83	60	101
7	......	......	7,350	3,200	11,200	1,620	513	158	119	83	60	101
8	......	......	7,460	3,430	13,000	1,460	792	158	110	83	60	101
9	......	......	8,010	3,610	13,100	1,280	760	158	110	83	60	101
10	......	......	8,230	3,720	12,700	1,240	603	158	110	83	60	101
11	......	......	8,010	3,840	12,400	1,170	460	158	110	83	60	101
12	......	......	7,790	3,840	11,900	1,100	411	158	110	83	60	101
13	......	3,490	7,570	3,780	11,200	1,060	366	158	110	83	60	101
14	......	4,370	7,350	3,720	10,600	920	324	158	110	75	60	101
15	......	5,740	6,820	3,430	9,420	856	287	158	110	75	60	101
16	......	5,830	6,520	3,140	9,300	792	287	158	110	75	60	101
17	......	6,720	5,420	2,700	9,540	728	270	158	101	75	67	101
18	......	6,320	3,840	2,380	9,660	696	270	148	101	75	75	101
19	......	5,830	3,490	2,100	9,180	665	254	148	92	75	75	101
20	......	6,220	3,200	2,050	8,580	572	254	148	83	75	75	101
21	......	6,320	2,920	1,830	8,010	542	254	148	83	67	75	101
22	......	6,320	2,700	1,830	8,580	486	254	138	92	67	75	101
23	......	5,920	2,600	2,050	8,340	460	254	128	92	67	83	101
24	......	5,830	2,480	2,600	8,120	435	270	129	92	67	83	101
25	......	6,420	2,320	3,200	7,900	411	270	119	92	67	92	101
26	......	7,570	2,260	4,760	7,790	388	254	119	92	67	92	101
27	......	8,010	2,430	5,580	7,240	366	254	110	92	67	101	101
28	......	7,900	2,650	6,920	6,320	344	240	110	92	67	101	101
29	......	7,680	2,980	6,720	5,580	344	227	100	92	67	101	101
30	......	......	3,140	6,520	5,040	486	214	101	92	67	101	101
31	......	......	3,260	......	4,310	......	202	128	......	67	......	101
1909.												
1	101	214	4,350	920	3,490	5,830	824	760	168	190	240	888
2	101	240	4,120	888	3,200	5,040	603	728	168	190	240	792
3	101	270	3,900	888	3,090	5,040	542	696	168	190	254	776
4	101	270	3,430	888	2,980	5,230	486	665	168	190	254	744
5	101	287	3,040	888	2,760	4,370	634	634	168	190	254	665
6	101	324	2,650	856	2,650	3,720	1,960	572	168	190	254	665
7	101	344	2,480	856	2,540	3,090	6,320	542	168	190	254	650
8	101	435	2,050	888	2,600	2,870	5,740	542	168	190	270	400
9	101	486	1,460	1,060	2,700	3,010	5,740	542	158	190	305	300
10	101	572	1,420	1,310	3,490	2,620	5,420	513	158	190	324	400
11	101	728	1,280	1,500	3,430	2,380	5,040	460	158	190	344	542
12	101	760	1,200	1,620	3,900	2,380	6,320	411	148	190	344	603
13	101	856	1,100	1,750	4,690	2,480	8,460	388	148	190	355	696
14	101	888	1,240	2,000	4,620	2,600	9,900	324	148	190	355	888
15	101	920	1,280	2,100	4,560	1,960	10,600	287	148	190	400	1,200
16	101	990	1,310	2,320	4,370	1,710	10,300	287	179	190	800	1,420
17	101	2,100	1,310	3,140	4,010	1,620	7,900	240	190	190	1,000	1,660
18	101	2,700	1,240	3,720	3,610	1,540	6,820	227	190	190	1,200	1,620
19	101	3,200	1,200	4,620	3,320	1,310	6,320	202	190	240	1,200	1,420
20	110	3,780	1,130	5,420	2,870	1,200	5,340	202	214	254	1,200	1,280
21	119	4,370	1,130	6,620	2,320	1,130	4,370	190	214	254	1,200	1,170
22	119	4,760	1,100	7,790	1,830	1,020	3,900	179	202	254	1,220	1,000
23	119	5,340	1,100	8,580	1,500	990	3,490	168	202	240	1,240	800
24	128	5,500	1,060	8,230	1,170	920	2,760	168	202	240	1,260	700
25	138	5,270	1,020	7,900	1,660	824	2,100	158	190	240	1,280	600
26	138	5,040	1,020	7,240	2,130	920	1,710	158	190	240	1,280	500
27	138	4,810	990	6,320	2,980	1,130	1,540	158	190	240	1,240	500
28	138	4,580	1,010	5,040	3,430	1,200	1,130	148	190	227	1,150	400
29	148	......	955	4,430	4,070	1,130	990	148	190	227	1,060	400
30	148	......	920	4,070	4,070	1,060	856	148	190	227	920	300
31	179	......	920	......	5,040	......	792	148	......	227	......	300

NOTE.—These daily discharges for 1908 to 1909 are taken from a rating, based on 1908, 1909, and 1910 measurements, and fairly well defined between 254 and 4,370 second-feet. Discharges were estimated because of ice effects for December 8 to 10 and 22 to 31, 1909, and interpolated for days of missing gage heights.

Monthly discharge of Sangamon River at Riverton, Ill., for 1908-9.

[Drainage area, 2,560 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
February 13-29	8,010	3,490	6,260	2.45	1.55	B.
March	8,230	2,260	5,360	2.09	2.41	B.
April	6,920	1,830	3,530	1.38	1.54	B.
May	13,100	4,310	8,810	3.44	3.97	B.
June	3,320	344	1,080	.422	.47	B.
July	792	202	350	.137	.16	B.
August	190	101	147	.057	.07	B.
September	148	83	107	.042	.05	C.
October	92	67	76.1	.030	.03	C.
November	101	60	72.6	.028	.03	C.
December	101	101	101	.039	.05	C.
1909.						
January	179	101	114	.044	.05	C.
February		214	2,140	.836	.87	B.
March		920	1,690	.660	.76	B.
April	8,580	856	3,460	1.35	1.51	B.
May	5,040	1,170	3,200	1.25	1.44	B.
June	5,830	824	2,340	.914	1.02	B.
July	10,600	486	4,160	1.62	1.87	B.
August	760	148	355	.139	.16	B.
September	214	148	178	.070	.08	C.
October	254	190	211	.082	.09	B.
November		240	723	.282	.31	C.
December	1,660		783	.306	.35	C.
The year		101	1,610	.630	8.51	

SANGAMON RIVER NEAR OAKFORD, ILL.

This station, which is located at the highway bridge about 3 miles northeast of Oakford, Ill., and about 2½ miles upstream from the Chicago, Peoria & St. Louis Railroad bridge, was established October 26, 1909, for the purpose of obtaining data for use in studying problems of drainage and flood control.

Crane Creek enters on the right bank about 1¼ miles below, and Salt Creek, also on the right bank, about 6¼ miles above the section. The total drainage area above the gaging station is 5,000 square miles.

This station is on the improved portion of the river, the new channel being straight for about 5 miles above and 1½ miles below the gaging section. When constructed, this artificial channel was 70 feet wide at the top and is now about 140 feet wide. Material changes are therefore liable to occur in the gaging section and cause variations in the relation of discharge to gage height. The bridge of the Chicago, Peoria & St. Louis Railroad, 2½ miles below the station, is a wooden trestle with numerous piles in the stream bed which have a decided tendency to obstruct the flow at high water, as the trestle is oblique to the current, and drift and ice lodging against it cause backwater which affects the gage heights.

Discharge measurements are made from the bridge and the trestle approaches at each end.

The datum of the chain gage, which is attached to the bridge, has remained unchanged since the gage was installed. Because of the inaccessibility of the gage it has not been possible to procure daily readings, but the records obtained are accurate and reliable.

The floods of February and March, 1907, and May, 1908, reached a height of about 21 feet on the present gage datum.

Discharge measurements of Sangamon River near Oakford, Ill., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
October 26	H. J. Jackson	223	591	3.10	817
Novembr 27	do	255	1,480	6.82	2,920

Daily gage height in feet and discharge in second-feet of Sangamon River near Oakford, Ill., for 1909.

[Bert Weaver, observer.]

Day.	October.		November.		December.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			2.6	670	5.7	2,110
2			2.6	670	5.45	1,940
3			2.6	670	5.3	1,850
4				670		1,770
5			2.6	670		1,690
6			2.55	658	4.9	1,610
7				664		1,520
8				670	4.6	1,440
9				676	4.25	1,260
10			2.65	682	4.05	1,170
11				716		1,280
12			2.9	750		1,390
13			4.85	1,580	4.7	1,500
14				2,000		1,750
15			6.15	2,430	5.55	2,000
16			6.5	2,700	6.0	2,320
17				3,460		2,470
18			8.4	4,220	6.4	2,620
19				4,540		2,500
20			9.1	4,860	8.4	2,400
21				4,540		2,300
22			8.4	4,220	8.0	2,200
23			7.9	3,780		2,100
24				3,590	7.6	2,000
25				3,410		1,900
26	3.1	810	7.2	3,220		1,800
27	3.1	810	6.8	2,920		1,650
28	2.95	765		2,850	6.6	1,500
29	2.85	735	6.3	2,540		1,400
30	2.7	695	5.9	2,250	5.75	1,300
31		682			5.7	1,200

NOTE.—Ice conditions existed from December 12 to 31. Gage heights are to top of ice December 20 to 31. An ice gorge at railroad bridge 2½ miles below gage caused rise in gage height on December 18. The daily discharges were obtained from a rating, based on measurements in 1909 and 1910, and are well defined between 810 and 7,180 second-feet. Discharges estimated for December 18 to 31 because of ice conditions and interpolated for days of no gage height previous to December 18.

Monthly discharge of Sangamon River near Oakford, Ill., for 1909.

[Drainage area, 5,000 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
October 26-31	810	682	750	0.150	0.03	B.
November	4,860	658	2,240	.448	.50	B.
December			1,800	.360	.42	C.

SOUTH FORK OF SANGAMON RIVER NEAR TAYLORVILLE, ILL.

This station, which is located at the Wabash Railroad bridge, about 3½ miles southwest of Taylorville, Ill., and about one-fourth mile upstream from the highway bridge across the South Fork known as the Half Acre Bridge, was established February 11, 1908, for the purpose of obtaining data for use in studying drainage, flood control, and water-supply problems.

Bear Creek, a small tributary, enters the stream on the left bank a few miles below the station. The drainage area above the gaging station is 427 square miles.

Discharge measurements are made from the railroad bridge to which the gage is attached.

In August, 1909, a drainage ditch was dug along the river in this vicinity, straightening the course of the stream but coinciding with the original channel at the gaging station. The cross section of the stream at the gaging station was not altered, but the relation between gage height and discharge was materially changed as the result of the change in slope. The gage heights from February 11, 1908, to August 10, 1909, inclusive, refer to the section before the change; gage heights from August 11 to September 1, 1909, inclusive, are of no value, because the stream was dammed up for purposes of construction during that period. On September 2, 1909, the datum of the chain gage was lowered 2 feet, and the gage heights from that date on refer to the new conditions. In making comparisons between the data for the original and the new conditions it should be noted that the gage datum has been changed. The records are accurate and reliable.

Discharge measurements of South Fork of Sangamon River near Taylorville, Ill., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 25	R. J. Taylor	122	484	4.55	159
June 9	do	85	345	3.3	88
1909.					
February 8	R. J. Taylor	100	422	4.10	143
March 17	W. M. O'Neill	119	429	4.09	144
March 22	do	92	390	3.60	121
May 17	H. J. Jackson	122	462	4.57	214
November 29[a]	do	59	237	3.98	95

[a] New channel caused by the construction of a drainage ditch coinciding with the natural channel at the bridge.

Daily gage height, in feet, of South Fork Sangamon River near Taylorville, Ill., for 1909.

[R. J. Hanon, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.3	1.5	6.5	3.25	4.45	6.45	6.15	3.0		1.65	2.4	3.75
2	1.3	1.7	5.9	3.15	4.9	6.6	5.0	2.8	1.65	1.65	2.35	3.6
3	1.3	1.9	5.6	3.3	4.75	6.6	3.9	2.7	1.65	1.6	2.2	3.55
4	1.3	2.3	5.0	3.2	4.5	6.6	2.7	2.55	1.65	1.6	2.3	3.45
5	1.3	2.5	4.9	3.05	4.15	6.4	6.5	2.5	1.7	1.6	2.2	3.65
6	1.3	3.4	4.7	3.25	4.0	6.1	8.2	2.4	1.6	1.6	2.2	3.6
7	1.3	4.1	4.4	4.8	3.85	5.85	9.1	2.3	1.8	1.6	2.8	3.6
8	1.1	4.2	4.1	5.65	4.7	5.55	10.1	2.0	1.75	1.6	3.3	3.6
9	1.0	4.5	4.2	5.55	7.2	4.85	9.9	2.0	1.7	1.55	3.95	3.55
10	.9	4.2	4.6	4.85	7.85	5.2	9.3	1.9	1.7	1.55	3.7	3.5
11	.8	3.9	4.9	4.75	8.7	5.75	9.3		1.65	1.55	3.42	3.5
12	.8	3.7	5.6	6.6	8.25	5.6	9.2		1.65	1.6	3.35	3.95
13	.7	3.4	5.2	6.9	7.7	5.65	9.05		1.65	1.55	4.5	4.65
14	.7	5.4	4.8	8.6	6.9	5.15	8.8		1.65	1.5	6.2	6.75
15	.7	6.2	4.5	8.55	6.2	4.6	8.45		2.0		6.3	7.2
16	.8	6.4	4.1	8.55	5.1	4.25	8.15		1.8		6.5	6.75
17	.8	5.8	3.95	8.0	4.6	4.15	7.7		1.75		7.35	6.15
18	.9	6.3	3.85	7.15	4.15	3.9	6.05		1.7		7.2	5.75
19	.9	6.5	3.75	6.95	3.9	3.55	5.5		1.7		6.85	5.3
20	1.0	7.0	3.65	6.75	3.85	3.4	4.5		1.65	3.65	6.0	5.15
21	1.4	7.95	3.55	8.25	3.75	3.0	4.35		1.65	3.2	5.45	4.95
22	2.05	8.4	3.55	9.4	3.55	3.2	4.0		1.65	3.1	5.4	4.85
23	3.0	8.6	3.7	10.0	3.4	2.9	3.85		2.5	5.05	5.15	4.55
24	3.4	8.6	3.65	9.55	3.4	2.15	3.7		2.65	4.2	4.85	4.45
25	3.5	8.6	3.6	8.25	5.1	2.45	3.65		2.1	4.0	4.5	4.3
26	3.2	8.5	3.55	7.7	5.9	2.8	3.6		1.75	3.95	4.3	4.0
27	1.6	8.0	3.75	6.65	6.9	3.2	3.55		1.75	3.65	4.2	3.95
28	1.9	7.5	3.55	6.25	7.25	4.75	3.5		1.7	3.15	4.1	3.95
29	2.0		3.4	5.9	7.1	6.0	3.45		1.7	3.0	3.95	3.95
30	2.1		3.35	5.25	6.45	6.55	3.4		1.65	2.85	3.9	3.95
31	1.9		3.3		6.5		3.35			2.4		3.95

NOTE.—Ice conditions existed from January 3 to February 13, and December 8 to 31. Gage heights are to top of ice December 17 to 31. Gage heights from August 11 to September 1 were of no value, because of the construction of a drainage ditch which coincided with the natural channel at the bridge.

Daily discharge, in second-feet, of South Fork of Sangamon River near Taylorville, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	......	......	800	762	800	238	......	8	8	6	6	9
2	......	......	1,030	690	554	223	......	7	7	6	6	9
3	......	......	1,270	876	654	209	......	7	6	5	6	9
4	......	......	1,270	952	762	183	......	7	6	5	6	10
5	......	......	1,110	800	2,560	150	......	6	6	5	6	8
6	......	......	1,150	690	3,300	118	......	7	6	5	6	8
7	......	......	1,190	726	3,110	86	......	7	6	5	6	7
8	......	......	1,230	800	3,060	79	......	6	6	5	6	7
9	......	......	1,390	800	2,970	86	......	6	6	5	6	7
10	......	......	1,190	990	2,020	93	......	7	6	5	6	7
11	......	800	1,110	952	1,600	93	......	7	6	5	6	7
12	......	524	1,110	838	1,730	86	......	7	5	5	6	7
13	......	424	952	654	1,640	79	......	7	5	5	6	7
14	......	586	762	524	1,430	55	......	7	5	5	6	7
15	......	800	586	424	1,440	86	......	7	5	5	6	7
16	......	1,730	470	361	1,460	60	......	6	5	5	6	7
17	......	1,560	424	286	1,470	50	......	6	5	5	6	7
18	......	1,420	341	253	1,480	50	......	6	5	5	6	7
19	......	1,270	269	238	1,500	41	......	6	5	5	6	7
20	......	1,070	322	238	1,510	37	......	6	5	5	6	7
21	......	914	286	209	1,520	41	......	6	5	6	6	7
22	......	762	253	171	1,530	33	......	6	5	6	7	7
23	......	690	223	150	1,550	30	......	6	5	6	8	7
24	......	690	209	762	1,560	24	......	6	6	6	9	7
25	......	1,030	196	1,070	1,230	22	......	5	6	6	10	7
26	......	1,980	196	1,190	1,070	20	......	5	6	7	8	7
27	......	2,160	150	1,310	762	20	......	5	6	7	8	6
28	......	1,810	160	1,270	726	16	......	5	6	6	7	6
29	......	1,430	209	1,190	690	22	12	37	6	6	7	12
30	......	......	209	1,030	464	20	10	16	6	6	12	12
31	......	......	196	......	238	......	8	10	......	6	......	10
1909.												
1	10	10	620	82	190	603	510	66	8	8	27	84
2	10	15	447	76	253	654	269	55	8	8	26	77
3	10	22	381	86	230	654	132	50	8	7	21	74
4	10	33	269	79	196	654	50	43	8	7	24	69
5	8	41	253	69	155	586	620	41	9	7	21	79
6	8	93	223	82	140	496	1,270	37	7	7	21	77
7	8	150	183	238	128	436	1,640	33	11	7	42	77
8	6	160	150	392	223	371	2,060	24	10	7	62	70
9	5	196	160	371	876	246	1,980	24	9	6	94	60
10	5	160	209	246	1,130	304	1,730	22	9	6	82	50
11	4	132	253	230	1,470	413	1,730	......	8	6	68	60
12	4	116	381	654	1,290	381	1,680	......	8	7	64	94
13	4	93	304	762	1,070	392	1,620	......	8	6	127	136
14	4	341	238	1,430	762	295	1,520	......	8	5	265	333
15	4	524	196	1,410	524	209	1,370	......	15	8	276	403
16	5	586	150	1,410	286	166	1,250	......	11	12	299	333
17	5	424	136	1,190	209	155	1,070	......	10	20	430	240
18	7	554	128	857	155	132	483	......	9	30	403	200
19	7	620	120	781	132	104	361	......	9	40	348	170
20	7	800	112	708	128	93	196	......	8	80	245	150
21	12	1,170	104	1,290	120	66	177	......	8	58	197	130
22	26	1,350	104	1,770	104	79	140	......	8	54	193	110
23	66	1,430	116	2,020	93	60	128	......	30	165	173	90
24	93	1,430	112	1,830	93	28	116	......	36	109	150	80
25	100	1,430	108	1,290	286	39	112	......	18	97	127	75
26	79	1,390	104	1,070	447	55	108	......	10	94	115	70
27	16	1,190	120	672	762	79	104	......	10	80	109	70
28	22	990	104	539	895	230	100	......	9	56	103	65
29	24	......	93	447	838	470	96	......	9	50	94	65
30	20	......	90	313	603	637	93	......	8	44	92	60
31	15	......	86	......	620	......	89	......	......	27	......	60

NOTE.—Daily discharges from February 11, 1908, to August 10, 1909, were obtained from a rating based on measurements in 1908 to 1909, and fairly well defined between 86 and 269 second-feet. July 1 to 28, 1908, has been estimated as equivalent to 19 second-feet per day. Discharges after September 2, 1909, were obtained from a rating well defined between 87 and 1,390 second-feet and based on measurements made in 1909 to 1910. Discharge estimated equivalent to 20 second-feet per day for August 11 to 31, 1909, and estimated because of ice conditions for January 5 to 17, January 30 to February 2, and December 8 to 11 and 17 to 31, 1909. Also estimated for October 15 to 19, 1909.

Monthly discharge of South Fork of Sangamon River near Taylorville, Ill., for 1908–9.

[Drainage area, 427 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
February 11-29	2,160	424	1,140	2.67	1.89	B.
March	1,390	150	654	1.53	1.76	B.
April	1,310	150	707	1.66	1.85	B.
May	3,300	238	1,500	3.51	4.05	C.
June	238	16	78.3	.183	.20	B.
July	....	8	18.1	.042	.05	D.
August	37	5	7.7	.018	.02	C.
September	8	5	5.7	.013	.01	C.
October	7	5	5.5	.013	.01	C.
November	12	6	6.7	.016	.02	C.
December	12	6	7.7	.018	.02	C.
1909.						
January	100	....	19.5	.046	.05	C.
February	1,430	....	552	1.29	1.34	B.
March	620	86	192	.450	.52	A.
April	2,020	69	746	1.75	1.95	B.
May	1,470	93	465	1.09	1.26	B.
June	654	28	303	.710	.79	A.
July	2,060	50	736	1.72	1.98	B.
August	....	....	26.3	.062	.07	D.
September	36	7	10.9	.026	.03	C.
October	165	5	36.1	.085	.10	C.
November	430	21	143	.335	.37	B.
December	403	....	120	.281	.32	D.
	2,060	....	279	.654	8.78	

SALT CREEK NEAR KENNEY, ILL.

Salt Creek is a tributary of Sangamon River.

The gaging station, which is located at the highway bridge about 2 miles west of Kenney, Ill., a short distance below the Vandalia Railroad bridge, was established February 14, 1908, to collect data for use in the study of drainage and flood control problems.

Tenmile Creek enters on the right bank about 4 miles above the gaging station. The drainage area above the section is 459 square miles.

The chain gage is attached to the bridge; its datum has not been changed.

The records are reliable and accurate. Discharge measurements are made from the bridge and small approach spans at each end.

The high water of 1882 is said to have been about 1 or 1½ feet higher than that of the spring of 1908, or to have reached a height of about 16 feet on the present gage.

Discharge measurements of Salt Creek near Kenney, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 8	R. J. Taylor	157	1,280	10.5	3,240
July 28	do	107	178	2.1	64
1909.					
February 6	R. J. Taylor	102	119	1.91	27
March 19	W. M. O'Neill	109	258	2.89	201
May 19	H. J. Jackson	110	254	2.92	215
November 24	do	111	265	3.17	236

Daily gage height, in feet, of Salt Creek near Kenney, Ill., for 1909.

[Chris McDermott, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.9	2.1	4.8	2.5	6.0	3.1	2.2	2.0	1.45	1.45	1.5	2.4
2	1.8	2.1	4.6	2.5	5.25	2.9	2.1	1.95	1.4	1.3	1.9	2.4
3	1.8	2.1	4.2	2.5	4.7	2.9	2.05	1.9	1.7	1.35	1.85	2.3
4	1.8	2.1	4.0	2.45	4.2	2.85	1.95	1.85	1.65	1.35	1.75	2.3
5	1.8	2.0	3.8	2.4	3.9	2.8	2.5	1.85	1.5	1.4	1.75	2.3
6	1.7	2.0	3.7	2.45	3.75	3.1	2.8	1.8	1.45	1.35	1.75	2.25
7	1.7	2.1	3.5	3.1	3.5	2.9	5.75	1.75	1.5	1.35	1.75	2.3
8	1.7	2.2	3.4	3.55	3.3	2.7	6.25	1.7	1.45	1.3	1.65	1.95
9	1.7	3.0	3.7	3.3	3.9	3.8	6.0	1.7	1.4	1.3	1.4	2.1
10	1.6	3.7	3.9	3.0	4.6	4.9	5.2	1.65	1.4	1.4	1.75	2.15
11	1.6	3.2	3.9	2.8	4.7	5.0	4.3	1.6	1.4	1.3	1.65	2.15
12	1.6	3.0	3.7	2.75	4.35	4.15	6.6	1.6	1.3	1.35	2.8	2.2
13	1.7	2.7	3.6	5.1	4.0	4.3	7.25	1.5	1.3	1.3	3.0	2.5
14	1.7	4.0	3.5	5.75	3.8	5.45	5.3	1.55	1.5	1.45	2.6	2.8
15	1.7	5.5	3.3	5.15	3.65	5.4	4.8	1.55	1.3	1.4	2.35	3.1
16	1.7	4.1	3.2	4.55	3.45	3.9	4.2	1.5	1.35	1.5	4.4	3.35
17	1.7	4.9	3.1	4.15	3.25	3.75	3.75	1.5	1.4	1.3	4.85	3.4
18	1.7	4.7	2.9	3.9	3.05	3.3	3.45	1.5	1.3	1.5	4.4	3.45
19	1.7	5.0	2.9	4.9	2.9	3.05	3.2	1.5	1.3	1.6	3.8	2.85
20	1.7	5.6	2.85	5.2	2.85	2.85	3.0	1.5	1.3	1.5	3.3	2.65
21	1.7	5.7	2.8	6.25	2.75	2.7	2.8	1.4	1.3	1.7	3.15	2.55
22	2.0	6.1	2.65	7.4	2.7	2.6	2.7	1.4	1.7	1.6	3.05	2.6
23	2.1	7.5	2.6	7.7	2.6	2.65	2.6	1.4	2.5	2.4	3.15	2.5
24	2.1	8.4	2.65	5.85	2.55	2.55	2.45	1.35	2.05	1.9	3.2	2.45
25	1.8	7.4	2.85	5.4	2.55	2.7	2.3	1.4	1.8	1.75	3.0	2.4
26	1.7	6.4	2.95	4.85	4.0	3.75	2.3	3.85	1.6	1.75	2.9	2.4
27	1.8	5.5	2.95	4.65	4.35	2.75	2.3	2.1	1.5	1.7	2.7	2.35
28	1.8	5.2	2.85	4.3	4.05	2.7	2.3	1.8	1.5	1.6	2.6	2.35
29	2.0	......	2.8	4.05	3.7	2.4	2.2	1.6	1.5	1.55	2.5	2.4
30	2.1	......	2.65	5.55	3.4	2.3	2.15	1.55	1.45	1.5	2.45	2.4
31	2.1	......	2.55	......	3.2	......	2.1	1.45	......	1.55	......	2.4

NOTE.—Varying ice conditions existed during January and from December 7 to 31. Stream was frozen over on December 12. Gage heights were to top of ice from December 12 to 31. Maximum thickness of ice reported was 8 inches on December 26.

Daily discharge, in second-feet, of Salt Creek near Kenney, Ill., for 1908-9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	......	......	1,070	301	966	645	167	33	14	10	33	33
2	......	......	1,330	352	834	524	167	25	14	10	33	25
3	......	......	1,490	277	707	465	129	25	14	10	25	25
4	......	......	1,490	253	1,950	465	96	33	14	14	25	25
5	......	......	1,530	301	2,430	407	81	33	14	14	25	25
6	......	......	1,810	277	3,350	436	96	33	14	14	25	25
7	......	......	1,850	379	3,020	379	96	33	14	10	25	25
8	......	......	1,530	524	3,350	352	81	25	14	14	25	25
9	......	......	1,330	645	3,870	277	67	25	14	10	18	25
10	......	......	1,100	707	3,240	253	54	33	10	10	25	25
11	......	......	770	676	2,850	253	54	33	14	10	33	18
12	......	......	834	584	4,680	208	54	33	14	10	18	18
13	......	......	738	465	5,840	187	43	43	18	10	33	18
14	......	1,950	676	436	4,100	187	43	43	14	10	18	18
15	......	2,480	645	738	4,510	208	54	33	10	10	18	18
16	......	3,020	465	834	2,960	187	253	25	7	14	25	18
17	......	2,480	436	738	2,290	167	129	33	7	18	25	18
18	......	1,140	407	738	1,950	167	112	25	5	10	18	25
19	......	524	524	645	2,240	187	67	25	7	25	25	18
20	......	352	645	524	2,380	187	54	33	7	33	33	18
21	......	465	584	465	1,950	167	54	25	7	33	25	18
22	......	645	465	379	2,000	167	43	18	7	33	25	18
23	......	707	465	253	1,490	167	301	18	7	25	25	18
24	......	900	436	1,030	1,330	148	67	18	7	33	25	14
25	......	1,670	407	1,490	1,070	129	43	14	7	25	25	18
26	......	1,950	407	1,760	1,070	112	43	14	10	25	25	18
27	......	2,090	301	1,760	966	96	407	14	18	25	25	25
28	......	1,810	352	1,710	802	81	208	14	14	25	25	18
29	......	1,410	326	1,410	933	148	67	18	10	25	25	33
30	......	......	277	1,100	867	167	43	14	10	25	25	81
31	......	......	277	......	738	......	33	14	......	33	......	54
1909.												
1	25	54	707	112	1,100	230	67	43	8	8	10	96
2	25	54	645	112	850	187	54	38	7	5	33	96
3	25	54	524	112	676	187	48	33	18	6	29	81
4	25	54	465	104	524	177	38	29	16	6	22	81
5	25	43	407	96	436	167	112	29	10	7	22	81
6	15	43	379	104	393	230	167	25	8	6	22	74
7	15	54	326	230	326	187	1,020	22	10	6	22	81
8	10	67	301	339	277	148	1,190	18	8	5	16	38
9	10	208	379	277	436	407	1,100	18	7	5	7	54
10	5	379	436	208	645	738	834	16	7	7	22	60
11	5	253	436	167	676	770	554	14	7	5	16	60
12	5	208	379	157	569	509	1,330	14	5	6	167	50
13	8	148	352	802	465	554	1,600	10	5	5	208	70
14	8	465	326	1,020	407	916	867	12	10	8	129	100
15	10	933	277	818	366	900	707	12	5	7	88	180
16	10	494	253	630	314	436	524	10	6	10	584	250
17	10	738	230	509	265	393	393	10	7	5	722	270
18	10	676	187	436	219	277	314	10	5	10	584	200
19	18	770	187	738	187	219	253	10	5	14	407	60
20	18	966	177	834	177	177	208	10	5	10	277	50
21	18	999	167	1,190	158	148	167	7	5	18	242	40
22	43	1,140	138	1,670	148	129	148	7	18	14	219	30
23	54	1,710	129	1,810	129	138	129	7	112	96	242	35
24	54	2,140	138	1,050	120	120	104	6	48	33	253	20
25	25	1,670	177	900	120	148	81	7	25	22	208	20
26	18	1,250	198	722	465	393	81	422	14	22	187	15
27	25	933	198	660	569	153	81	54	10	18	148	15
28	25	834	177	554	480	148	81	25	10	14	129	15
29	43	......	167	480	379	96	67	14	10	12	112	10
30	54	......	138	950	301	81	60	12	8	10	104	10
31	54	......	120	......	253	......	54	8	......	12	......	8

NOTE.—These daily discharges for 1908 to 1909 were obtained from a rating fairly well defined between 33 and 3,240 second-feet and based on measurements made 1908 to 1910. The daily discharges for January 6 to 18, 1909, and December 7 to 31, 1909, have been estimated because of ice conditions.

Monthly discharge of Salt Creek near Kenney, Ill., for 1908–9.

[Drainage area, 459 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
February 14-29	3,020	352	1,470	3.20	1.91	B.
March	1,850	277	805	1.75	2.02	B.
April	1,760	253	725	1.58	1.76	B.
May	5,840	707	2,280	4.97	5.73	B.
June	645	81	251	.547	.61	A.
July	407	33	103	.224	.26	A.
August	43	14	26.0	.057	.07	B.
September	18	5	11.2	.024	.03	C.
October	33	10	18.5	.040	.05	B.
November	33	18	25.2	.055	.06	B.
December	81	14	24.5	.053	.06	B
1909.						
January	54		22.4	.049	.06	C.
February	2,140	43	619	1.35	1.41	B.
March	707	120	294	.641	.74	B.
April	1,810	96	593	1.29	1.44	B.
May	1,100	120	401	.874	1.01	A.
June	916	81	312	.680	.76	A.
July	1,600	38	401	.874	1.01	B
August	422	6	30.7	.067	.08	C.
September	112	5	14.0	.031	.03	C.
October	96	5	13.3	.029	.03	C.
November	722	7	174	.379	.42	B.
December			72.6	.158	.18	C.
The year	2,140		246	.535	7.17	

CAHOKIA CREEK DRAINAGE BASIN.

DESCRIPTION.

The drainage area of Cahokia Creek lies in the southwestern part of the State of Illinois. The creek rises in the southern part of and about on line between Montgomery and Macoupin counties, flows in a southwesterly direction diagonally across the southeast corner of Macoupin County and the northwest portion of Madison County, past Edwardsville, through East St. Louis, Ill., and empties into Mississippi River.

The creek is very crooked and its length is approximately 55 miles. Its basin is about 45 miles long, has an average width of about 8 miles and a maximum width of about 12 miles, and comprises 360 square miles. Its principal tributary is Indian Creek, which enters from the right bank about three-fourths of a mile north of the Wabash Railroad bridge near Poag, Ill. The area drained is low, level, or undulating, and is crossed by a chain of bluffs just north of Poag, Ill. The sources of the creek are about 680 feet, and the mouth about 385 feet above sea level.

The basin contains no forested areas. The mean annual rainfall is about 40 inches. In general the winters are mild. The opportunities for storage and water-power development have not been investigated but are undoubtedly not worthy of consideration. Flood control, especially in its relation to the proposed flood protection works of the East Side levee and sanitary district of East St. Louis, Ill., is the most important problem under consideration at present in connection with this drainage basin.

CAHOKIA CREEK AT POAG, ILL.

This station, which is located at the Wabash Railroad bridge about three-fourths of a mile northeast of the Wabash Railroad station at Poag, Ill., was established December 13, 1909, to obtain data for use in studying drainage and flood control problems. The data collected will be used by the East Side levee and sanitary district of East St. Louis, Ill., in its study of flood control and prevention at that place.

Indian Creek enters on the right bank about three-fourths of a mile above the section. The total drainage area above the gaging station is 259 square miles.

Discharge measurements can be made from the railroad bridge over the main channel and a plate girder bridge over the flood channel about one-fourth mile north of the main channel. No measurements were made in 1909.

The datum of the chain gage, which is located on the railroad bridge, has remained unchanged since the installation of the gage.

The records are accurate and reliable.

Daily gage height, in feet, of Cahokia Creek at Poag, Ill.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1		6		11		16	7.0	21	2.8	26	1.9
2		7		12		17	6.2	22	2.3	27	1.9
3		8		13	12.0	18	5.0	23	2.1	28	1.8
4		9		14	11.0	19	3.6	24	2.0	29	1.8
5		10		15	8.5	20	3.0	25	1.9	30	1.7
										31	2.0

NOTE.—The flow at this station was affected by ice from December 18 to 31.

KASKASKIA RIVER DRAINAGE BASIN.

DESCRIPTION.

Kaskaskia River, also called the Okaw, lies wholly in the State of Illinois. The river rises in the center of Champaign County, flows southwestward, and empties into the Mississippi in Randolph County, near the city of Chester, Ill. It is about 190 miles in length, not following the bends, but as it is very crooked its length by course is not far from 400 miles. The total drainage area is 5,840 square miles. It has few tributaries worthy of mention, the most important being Shoal and Silver creeks, which enter from the north at the lower part of the river.

The drainage basin is long and comparatively narrow, the average width being about 30 miles and the maximum width about 60 miles. The ground is low, level, or undulating, and in consequence the slope of the river is small. The sources of the river are about 740 feet and its mouth about 350 feet above sea level. The soil of the area is mostly black loam. In the lower portion of the drainage area the soil gradually changes to a yellowish brown clay. The only rock exposure along this stream is found about 20 miles above Shelbyville. In this 15 or 20 mile section the banks and bed are largely of limestone and sandstone; elsewhere the banks and bed are mostly soft soil with some gravel.

The basin contains no forested areas. The annual rainfall is about 40 inches. As a rule the winters are mild.

The question of storage has not been investigated to any extent. Opportunities for important water-power development are entirely lacking.

Because of the lowness of its drainage area the basin affords little ground storage. During wet weather the ground-water plane rises to the surface, and the rains run off into the streams very quickly, producing very sudden rises and floods; in dry weather, as there is little or no ground water stored, the flow of the stream becomes very small and in some places dries up entirely. The banks of the river are low, and in times of floods large areas are covered with water, delaying the planting of crops and at times destroying growing crops. Storage, land drainage, and flood control are subjects of considerable importance in this basin.

KASKASKIA RIVER NEAR ARCOLA, ILL.

This station, which is located at the highway bridge known as the Bagdad Bridge, about 4 miles west of Arcola, Ill., was established April 11, 1908, for the purpose of obtaining data for use in studying drainage, flood protection, and storage problems.

Lake Fork is tributary from the west 3 or 4 miles above the gaging station. The drainage area above the station is 390 square miles.

Discharge measurements are made from the highway bridge and a small approach span.

The datum of the chain gage, attached to the bridge, has remained unchanged since the gage was installed.

The records are accurate and reliable.

The river at this point is said to go dry at times and was dry for about two months in 1908. The high water of May, 1908, reached a height of 17.3 feet on the gage.

Discharge measurements of Kaskaskia River near Arcola, Ill., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec. ft.*
April 29	R. J. Taylor	226	1,180	10.0	1,250
July 24	do	68.5	75	2.75	44
1909.					
March 22	W. M. O'Neill	96	234	4.58	182
May 21	H. J. Jackson	103	308	5.32	248
November 23	do	107	337	5.65	255

Daily gage height, in feet, of Kaskaskia River near Arcola, Ill., for 1909.

[L. L. Pfeifer, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1.4	11.0	4.0	7.6	9.8	4.8		2.7	1.7	3.6	4.8
2		1.4	10.9	4.0		8.7	4.6	3.6	2.6	1.6	3.6	4.6
3		1.6	10.1	3.9	7.5	8.2	4.5	3.4	2.5		3.4	4.5
4		2.0	9.8		7.5	7.6		3.4	2.3	1.6	3.2	4.2
5		3.6	9.4	3.9	7.4	8.6		3.2		1.6	3.1	
6		5.4	8.9	7.7	7.3		5.1	3.1		1.6	3.0	4.1
7				11.7	7.2	8.2	7.0	2.9	2.1	1.5		4.1
8		5.7	7.1	11.4	7.1	7.5	8.4		2.0	1.5	2.9	3.9
9		6.1	9.2	11.0		7.2	9.2	2.6	1.9	1.5	2.9	3.9
10		6.4	8.6	10.8	9.4	7.8	9.4	2.5	1.8		2.8	3.8
11		6.6	7.4		10.0	7.4		2.4	1.8	1.5	2.8	3.7
12		6.4	6.5	10.4	9.6	6.2	7.7	2.3		1.4	2.8	
13		6.0	6.1	13.2	8.9		10.4	2.3	1.7	1.4	2.9	5.1
14				15.0	8.3	6.4	14.1	2.2	1.7	1.4		6.2
15		6.5	6.0	14.1	7.5	6.0	15.4		1.6	1.4	4.6	8.1
16		6.9	5.9	13.4		5.5	15.7	2.1	1.6	1.4	4.9	8.3
17		7.1	5.8	12.2	6.5	5.4	13.2	2.1	1.6		5.9	8.1
18		7.7	5.8		6.1	5.2		2.0	1.5	2.4	7.2	8.0
19		8.4	5.7	11.4	5.8	4.9	10.4	2.0		2.6	7.1	
20		9.1	5.2	11.6	5.7		9.2	1.9	1.4	2.6	6.9	7.9
21				11.9	5.3	4.8	8.0	1.9	1.4	2.5		7.8
22		10.0	5.0	12.2	5.2	4.7	7.1		1.9	2.5	6.2	7.8
23		10.0	4.9	12.4		5.0	7.0	1.7	2.3	3.0	5.7	7.7
24		11.1	4.7	11.2	5.0	5.6	6.8	1.7	2.2		5.8	7.6
25	0.8	14.4	4.5		5.3	4.9		1.6	2.1	4.0	5.6	7.5
26	.8	13.6	4.5	10.1	6.1	4.7	6.1	1.9		3.9	5.4	
27	.9	12.2	4.4	9.4	8.0		5.8	3.2	2.0	3.9	5.2	7.2
28	.9			8.8	12.9	4.2	5.2	3.1	1.9	3.8		7.2
29	1.0		4.2	8.1		4.2	4.5		1.8	3.7	5.1	7.1
30	1.0		4.1	7.8		4.0	4.1	2.8	1.7	3.7	5.0	7.0
31			4.0		10.2		3.9	2.8				6.9

NOTE.—No flow from January 1 to 24. Varying ice conditions existed from December 7 to 31. Gage heights are to top of ice December 22 to 31. Maximum thickness of ice 5 inches.

Daily discharge, in second-feet, of Kaskaskia River near Arcola, Ill., for 1908-9.

Day.	Apr.	May.	June.	July.	Aug.	Day.	Apr.	May.	June.	July.	Aug.
1908.						1908.					
1		850	298	64	38	16	416	1,740	187	98	8
2		714	287	58	34	17	358	1,450	178	84	6
3		690	265	58	29	18	332	1,160	162	84	6
4		665	287	84	21	19	320	1,130	154	88	6
5		1,960	276	77	18	20	309	1,190	154	91	5
6		2,430	254	70	18	21	276	1,260	146	91	5
7		3,470	244	98	15	22	254	1,160	138	84	5
8		3,870	234	84	15	23	244	1,030	130	77	4
9		3,650	254	70	14	24	372	926	122	58	3
10		3,290	265	58	12	25	714	822	114	53	3
11	794	2,930	254	53	12	26	952	689	106	50	2
12	696	2,500	244	48	12	27	1,190	598	91	48	2
13	598	2,280	234	43	10	28	1,230	518	84	48	1.5
14	518	1,920	215	43	10	29	1,260	465	77	43	1.0
15	465	1,820	196	38	10	30	1,070	448	77	43	.8
						31		432		43	.7

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1		4	1,600	130	577	1,190	196	110	43	8	98	196
2		4	1,560	130	567	850	178	98	38	6	98	178
3		6	1,290	122	557	714	170	84	33	6	84	170
4		15	1,190	122	557	577	188	84	25	6	70	146
5		98	1,070	122	537	822	206	70	23	6	64	142
6		254	909	598	518	768	224	64	20	6	58	138
7		270	696	1,850	500	714	465	53	18	5	56	138
8		287	482	1,740	482	557	767	46	15	5	53	122
9		332	1,000	1,600	776	500	1,000	38	12	5	53	122
10		372	822	1,530	1,070	620	1,070	33	10	5	48	114
11		401	537	1,460	1,260	537	834	29	10	5	48	106
12		372	386	1,390	1,130	345	598	25	9	4	48	165
13		320	332	2,390	909	358	1,390	25	8	4	53	224
14		353	326	3,040	740	372	2,720	21	8	4	116	345
15		386	320	2,720	557	320	3,180	20	6	4	178	689
16		448	309	2,460	472	265	3,290	18	6	4	205	740
17		482	298	2,030	386	254	2,390	18	6	16	309	689
18		598	298	1,880	332	234	1,890	15	5	29	500	665
19		767	287	1,740	298	205	1,390	15	4.5	38	482	550
20		971	234	1,820	287	200	1,000	12	4	38	448	500
21		1,120	224	1,920	244	196	665	12	4	33	396	450
22		1,260	214	2,030	234	187	482	11	12	33	345	400
23		1,260	205	2,100	224	214	465	10	25	58	287	350
24		1,640	187	1,670	214	276	432	10	21	94	298	300
25	0.5	2,820	170	1,480	244	205	382	6	18	130	276	250
26	.5	2,540	170	1,290	332	187	332	12	16	122	254	200
27	.7	2,030	162	1,070	665	166	298	70	15	122	234	170
28	.7	1,820	154	879	2,280	146	234	64	12	114	229	150
29	1.0		146	689	1,960	146	170	56	10	106	224	130
30	1.0		138	620	1,640	130	138	48	8	106	214	100
31	2.5		130		1,330		122	48		102		100

NOTE.—There was no flow from September 1, 1908, to January 24, 1909. Discharges for December 19 to 31, 1909, have been estimated because of ice conditions. Discharges interpolated for days of missing gage heights. Daily discharges were obtained from a rating well defined between 43 and 1,260 second-feet and based on measurements made during 1908 to 1910.

Monthly discharge of Kaskaskia River near Arcola, Ill., for 1908-9.

[Drainage area, 390 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
April 11-30	1,260	244	618	1.58	1.18	A.
May	3,870	432	1,550	3.97	4.58	B.
June	298	77	191	.490	.55	A.
July	98	43	65.5	.168	.19	B.
August	38	.7	10.5	.027	.03	C.
September [a]	0	0	.0	.00	.00	
October [a]	0	0	.0	.00	.00	
November [a]	0	0	.0	.00	.00	
December [a]	0	0	.0	.00	.00	
1909.						
January [a]	2.5	0	.22	.00056	.0006	D.
February	2,820	4	758	1.94	2.02	B.
March	1,600	130	511	1.31	1.51	A.
April	3,040	122	1,420	3.64	4.06	B.
May	2,280	214	706	1.81	2.09	A.
June	1,190	130	408	1.05	1.17	A.
July	3,290	122	867	2.22	2.56	B.
August	110	6	39.5	.101	.12	B.
September	43	4	14.8	.038	.04	B.
October	130	4	39.5	.101	.12	B.
November	500	48	194	.497	.55	A.
December	740	....	282	.723	.83	C.
The year	3,290	0	437	1.12	15.08	

[a] No flow from September 1, 1908, to January 24, 1909.

KASKASKIA RIVER AT SHELBYVILLE, ILL.

This station, which is located at the highway bridge at the edge of Shelbyville, just above the Chicago & Eastern Illinois and Big Four railroad bridges and just below the pumping station of the City Water Company of Shelbyville, was established February 25, 1908, for the purpose of collecting data for use in studying drainage and flood-control problems.

No important tributaries enter the stream near Shelbyville. The drainage area above the gaging station is 1,030 square miles.

Discharge measurements are made from the bridge to which the chain gage is attached.

The datum has remained unchanged since the gage was installed. Gage heights may be affected during high water by backwater caused by the lodging of drift at the two railroad bridges below the gaging station.

The records are accurate and reliable.

Discharge measurements of Kaskaskia River at Shelbyville, Ill., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 24	R. J. Taylor	147	975	11.53	2,350
April 29	do	149	1,020	12.2	2,720
June 10	do	113	1,010	8.7	1,080
July 21	do	103	713	6.3	218
1909.					
February 8	do	105	788	6.85	402
February 9	do	108	852	7.32	572
March 17	W. M. O'Neill	110	560	8.00	761
May 14	H. J. Jackson	151	995	11.48	2,130
May 15	do	124	892	10.76	1,910
December 9	do	102	224	6.40	a 216

a Partial ice cover; 47 per cent of the discharge was under ice.

Daily gage height, in feeet, of Kaskaskia River at Shelbyville, Ill., for 1909.

[Homer Pound, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.4	5.7	12.8	6.8	13.3	14.9	6.9	6.7	5.4	5.2	5.9	6.8
2	5.4	5.8	12.0	6.8	10.5	14.3	6.5	6.6	5.4	5.2	5.8	6.7
3	5.4	5.8	11.0	6.7	10.4	14.2	6.5	6.4	5.4	5.2	5.8	6.7
4	5.4	5.9	10.3	6.7	10.4	13.5	6.4	6.3	5.4	5.2	5.7	6.6
5	5.4	6.1	9.7	6.7	10.3	12.5	11.1	6.2	5.3	5.2	5.7	6.6
6	5.4	6.2	9.3	15.9	9.9	11.9	12.2	6.0	5.3	5.1	5.7	6.5
7	5.4	6.6	9.4	15.8	9.8	11.5	17.3	5.9	5.2	5.1	5.8	6.6
8	5.4	7.0	9.6	15.0	9.9	10.9	17.7	5.8	5.2	5.1	5.8	6.6
9	5.4	7.1	9.8	14.1	13.9	10.5	16.6	5.8	5.3	5.1	5.7	6.6
10	5.4	7.3	9.6	13.0	13.9	11.9	13.2	5.8	5.3	5.1	5.7	6.6
11	5.4	7.5	9.3	12.8	13.8	11.9	11.9	5.8	5.3	5.1	5.6	6.5
12	5.3	7.9	9.1	14.7	13.6	10.9	11.9	5.7	5.2	5.1	5.8	6.9
13	5.3	8.2	9.0	19.4	11.9	10.3	13.8	5.7	5.2	5.1	5.8	7.6
14	5.3	8.6	8.7	20.8	11.65	10.2	12.9	5.6	5.2	5.1	5 9	8.7
15	5.3	8.8	8.4	19.8	11.0	10.4	12.5	5.5	5.2	5.1	5.9	9.7
16	5.3	9.0	8.1	18.9	10.1	9.8	11.9	5.4	5.2	5.1	6.9	9.9
17	5.3	9.7	8.6	18.0	9.3	10.6	12.6	5.4	5.2	5.1	6.8	9.8
18	5.3	11.0	7.8	17.3	8.9	9.6	13.7	5.3	5.2	5.3	7.6	9.6
19	5.4	12.1	7.7	16.3	8.6	8.9	13.9	5.3	5.2	5.6	7.6	8.9
20	5.5	13.2	7.6	14.8	8.2	7.9	13.3	5.3	5.2	5.7	7.6	9.2
21	5.6	13.5	7.5	17.5	7.2	7.5	11.9	5.3	5.2	5.7	7.8	9.1
22	5.7	13.6	7.3	18.9	7.7	7.4	11.7	5.2	5.2	5.6	8.4	8.9
23	5.8	13.7	7.1	19.8	7.6	7.4	10.5	5.1	5.2	6.0	8.3	8.8
24	5.8	14.2	7.3	17.3	7.4	7.2	9.6	5.1	5.6	6.0	8.2	8.7
25	5.8	14.3	7.4	17.2	7.7	7.2	7.6	5.1	5.6	6.0	8.1	8.2
26	5.7	14.3	7.5	16.8	9.4	7.8	7.7	5.3	5.4	6.0	7.7	8.1
27	5.7	13.9	7.4	15.7	11.2	7.7	7.5	5.2	5.3	6.0	7.5	7.9
28	5.7	13.3	7.1	13.9	11.0	7.6	7.2	5.2	5.3	6.0	7.3	7.9
29	5.7	....	7.1	13.8	11.2	7.3	6.9	5.4	5.3	6.0	7.1	7.6
30	5.7	....	7.0	12.0	12.6	7.2	6.8	5.4	5.3	6.0	6.9	7.6
31	5.7	....	6.9	....	14.2	....	6.7	5.5	....	5.9	....	7.6

NOTE.—Ice conditions existed January 1 to February 11, and December 7 to 31.

Daily discharge, in second-feet, of Kaskaskia River at Shelbyville, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	......	......	4,260	2,400	2,500	1,030	256	90	34	25	8	34
2	......	......	4,480	3,000	2,300	956	224	73	25	18	10	34
3	......	......	4,990	2,500	1,810	918	256	73	25	18	10	34
4	......	......	4,760	2,300	7,820	1,110	224	58	18	18	13	25
5	......	......	4,540	1,580	8,780	956	224	58	18	13	13	25
6	......	......	4,420	1,450	8,480	846	256	45	18	13	18	25
7	......	......	4,650	1,400	8,720	738	358	45	18	13	18	25
8	......	......	4,870	2,350	10,600	666	392	45	18	13	18	25
9	......	......	5,100	2,450	9,260	810	426	58	13	13	18	25
10	......	......	5,330	2,500	7,820	956	324	73	13	13	18	34
11	......	......	5,220	2,350	7,220	918	290	73	10	13	18	34
12	......	......	4,650	2,250	6,800	774	290	58	10	13	18	34
13	......	......	4,090	2,150	6,480	666	224	73	10	13	18	34
14	......	......	3,760	2,100	5,850	630	192	58	10	13	18	34
15	......	......	3,430	1,680	5,330	562	130	58	10	10	18	34
16	......	......	3,160	1,450	4,990	460	130	45	10	10	25	34
17	......	......	2,550	1,150	4,700	426	109	45	13	10	25	25
18	......	......	2,050	1,110	4,200	358	90	45	13	10	25	25
19	......	......	1,630	1,070	4,140	324	160	34	13	10	25	25
20	......	......	1,680	1,030	3,480	392	160	34	13	10	25	25
21	......	......	1,490	994	3,000	358	160	34	13	10	25	25
22	......	......	1,450	956	3,480	358	130	25	10	10	34	25
23	......	......	1,400	918	3,160	324	130	25	10	8	34	25
24	......	......	1,360	1,680	2,900	290	109	25	10	8	45	25
25	......	3,760	1,310	1,910	2,600	290	90	25	10	8	45	18
26	......	4,990	1,190	2,200	2,350	256	90	25	10	10	58	18
27	......	5,330	1,070	2,500	2,250	224	73	25	10	10	58	18
28	......	5,100	994	2,700	1,630	160	73	18	13	10	45	25
29	......	4,370	1,150	2,800	1,540	192	58	18	18	8	45	25
30	......	......	1,150	2,550	1,360	224	73	25	25	8	45	34
31	......	......	1,070	......	1,190	......	90	25	......	8	......	34
1909.												
1	34	40	3,000	392	3,260	4,140	426	358	34	18	109	392
2	34	90	2,600	392	1,860	3,820	290	324	34	18	90	358
3	34	90	2,100	358	1,810	3,720	290	256	34	18	90	358
4	34	109	1,770	358	1,810	3,380	256	224	34	18	73	324
5	34	160	1,490	358	1,770	2,850	2,150	192	25	18	73	324
6	30	192	1,310	4,700	1,580	2,550	2,700	130	25	13	73	290
7	30	324	1,360	4,650	1,540	2,350	5,500	109	18	13	90	250
8	25	460	1,450	4,200	1,580	2,050	5,740	90	18	13	90	230
9	25	494	1,540	3,700	3,600	1,860	5,100	90	25	13	73	216
10	25	562	1,440	3,100	3,600	2,550	3,210	90	25	13	73	200
11	20	630	1,310	3,000	3,540	2,550	2,550	90	25	13	58	200
12	20	774	1,230	4,040	3,430	2,050	2,550	73	18	13	90	426
13	20	882	1,190	6,740	2,550	1,770	3,540	73	18	13	90	666
14	25	1,030	1,070	7,580	2,420	1,720	3,050	58	18	13	109	1,070
15	25	1,110	956	6,980	2,100	1,810	2,850	45	18	13	109	1,490
16	25	1,190	846	6,540	1,680	1,540	2,550	34	18	13	426	1,580
17	25	1,490	1,030	5,910	1,310	1,910	2,900	34	18	13	392	1,540
18	30	2,100	738	5,500	1,150	1,450	3,480	25	18	25	666	1,450
19	34	2,650	702	4,930	1,030	1,150	3,600	25	18	58	666	1,150
20	45	3,210	666	4,090	882	774	3,260	25	18	73	666	1,000
21	58	3,380	630	5,620	528	630	2,550	25	18	73	738	850
22	73	3,430	562	6,540	702	596	2,450	18	18	58	956	700
23	90	3,480	494	6,980	666	596	1,860	13	18	130	918	600
24	90	3,760	562	5,500	596	528	1,450	13	58	130	882	520
25	90	3,820	596	5,450	702	528	666	13	58	130	846	470
26	73	3,820	630	5,220	1,360	738	702	25	34	130	702	400
27	73	3,600	596	4,590	2,200	702	630	18	25	130	630	350
28	73	3,260	494	3,600	2,100	666	528	18	25	130	562	300
29	60	......	494	3,540	2,200	562	426	34	25	130	494	250
30	50	......	460	2,600	2,900	528	392	34	25	130	426	220
31	40	......	426	......	3,760	......	358	45	......	109	......	200

NOTE.—These daily discharges for 1908 and 1909 were obtained from a rating well defined between 224 and 2,700 second-feet, and based on measurements made during 1908 to 1910. The following periods in 1909 were estimated because of ice conditions: January 6 to 18; January 29 to February 1; December 7, 8, 10, 11, and December 20 to 31.

Monthly discharge of Kaskaskia River at Shelbyville, Ill., 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.						
February 25-29	5,330	3,760	4,710	4.57	0.85	B.
March	5,330	994	3,010	2.92	3.37	B.
April	3,000	918	1,920	1.86	2.08	A.
May	10,600	1,190	4,730	4.59	5.29	B.
June	1,110	160	572	.555	.62	B.
July	426	58	187	.182	.21	B.
August	90	18	45.5	.044	.05	C.
September	34	10	14.7	.014	.02	C.
October	25	8	11.8	.011	.01	C.
November	58	8	26.4	.026	.03	C.
December	34	18	27.8	.027	.03	C.
1909.						
January	90	....	43.4	.042	.05	C.
February	3,820	....	1,650	1.60	1.67	B.
March	3,000	426	1,090	1.06	1.22	B.
April	7,580	358	4,240	4.12	4.60	B.
May	3,760	528	1,940	1.88	2.17	B.
June	4,140	528	1,740	1.69	1.89	B.
July	5,740	256	2,190	2.13	2.46	B.
August	358	13	83.9	.081	.09	B.
September	58	18	25.4	.025	.03	C.
October	130	13	54.3	.053	.06	C.
November	956	58	375	.364	.41	B.
December	1,580	....	593	.576	.66	C.
The year	7,580	....	1,240	1.14	15.31	

KASKASKIA RIVER AT VANDALIA, ILL.

This station, which is located at the highway bridge at the east end of Main Street, Vandalia, Ill., was established February 26, 1908, to obtain data for use in studying drainage questions, flood protection, and levee construction.

No important tributaries enter the river near Vandalia. The drainage area above this point is 1,980 square miles.

Knowledge of winter conditions is as yet incomplete. The river for some miles above and below Vandalia is leveed along the left bank. It is claimed that these levees, by confining the floods, have caused floods of unusua height on the right side of the river, and a number of lawsuits have been instituted to recover damages to property on the right bank. During extreme floods these levees sometimes give way, thus reducing the flood flow; all the water, however, eventually passes the gaging section.

Discharge measurements are made from the bridge to which the gage is attached.

The datum has remained unchanged since the gage was installed.

The records are reliable and accurate.

Discharge measurements of Kaskaskia River at Vandalia, Ill., in 1908-9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
February 26	R. J. Taylor	155	2,350	18.53	6,870
March 19	do	128	1,510	10.1	2,400
March 20	do	128	1,430	9.6	2,130
April 30	do	151	1,890	12.9	3,600
July 6	do	112	713	3.6	287
August 6	do	106	563	2.3	84
1909.					
February 20	R. J. Taylor	156	2,440	15.78	5,330
March 16	W. M. O'Neill	132	1,150	7.26	1,340
March 24	do	121	908	5.33	702
May 13	H. J. Jackson	151	2,100	13.86	4,100
May 22	do	123	1,030	6.41	1,030
November 22	do	124	1,080	7.15	1,440

Daily gage height, in feet, of Kaskaskia River at Vandalia, Ill., for 1909.

[W. F. Radcliff, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	3.8	12.85	4.9	12.15	13.2	5.8	6.85	1.9	1.7	2.9	4.9
2	1.8	2.7	11.55	4.75	11.0	13.1	5.0	5.2	1.9	1.7	2.8	4.8
3	1.8	2.75	10.05	4.6	10.1	13.65	4.6	4.65	1.9	1.7	2.8	4.8
4	1.7	2.8	9.35	4.5	9.65	14.1	4.3	4.3	1.9	1.7	2.7	4.7
5	1.7	2.6	9.0	4.4	9.3	14.8	4.1	4.05	1.9	1.7	2.7	4.65
6	1.7	6.35	8.5	10.35	9.0	14.9	6.2	3.85	1.9	1.6	2.65	4.4
7	1.7	8.4	7.9	17.7	8.45	12.65	10.6	3.65	1.9	1.6	2.6	4.3
8	1.7	5.85	7.55	20.3	8.1	11.05	14.0	3.45	1.9	1.6	4.5	4.2
9	1.7	5.6	14.05	18.8	11.35	9.8	15.6	3.35	2.65	1.6	3.85	4.15
10	1.6	8.9	16.75	17.4	14.85	9.5	16.4	3.15	4.0	1.55	3.6	4.1
11	1.6	8.55	17.1	16.5	16.55	11.35	17.0	3.0	2.8	1.5	3.35	4.4
12	1.6	6.1	13.55	15.5	15.25	10.0	17.6	2.9	2.5	1.5	4.9	5.7
13	1.6	4.8	9.75	18.3	13.75	12.85	17.9	2.85	2.3	1.5	9.7	10.3
14	1.6	6.6	8.35	20.9	13.7	14.5	18.4	2.75	2.15	1.5	8.1	11.6
15	1.6	13.35	7.75	19.7	12.35	11.7	18.2	2.7	2.0	1.6	5.4	9.9
16	1.6	12.75	7.3	18.6	10.8	9.05	17.0	2.6	1.9	1.7	6.5	9.05
17	1.7	7.95	6.9	18.25	9.65	12.75	15.7	2.6	1.9	1.7	11.55	8.8
18	1.7	7.6	6.5	17.85	8.65	15.15	13.85	2.5	1.8	1.7	9.25	8.65
19	1.85	11.3	6.2	17.5	7.95	12.8	12.75	2.5	1.8	2.6	7.6	8.4
20	2.35	15.55	6.0	17.4	7.35	7.7	12.4	2.4	2.3	4.1	6.7	7.9
21	2.95	16.8	5.9	17.75	6.8	6.75	12.2	2.3	3.35	3.75	6.15	......
22	3.0	16.9	5.75	18.35	6.45	6.2	11.25	2.2	3.85	3.6	7.8	......
23	3.0	16.75	5.45	18.45	6.05	5.7	9.9	2.2	4.2	3.8	10.65	......
24	2.8	16.95	5.35	18.0	5.9	5.6	8.65	2.15	3.3	4.25	11.15	......
25	2.65	17.2	6.6	17.6	6.15	5.25	8.1	2.1	2.65	4.05	9.9	5.5
26	2.55	16.85	7.25	17.25	8.6	5.4	6.8	2.1	2.15	2.95	7.9	......
27	2.5	15.9	6.6	16.8	8.75	5.85	6.5	2.0	2.05	3.15	6.85	......
28	2.45	14.3	5.75	16.55	8.9	5.6	5.9	2.0	1.9	3.0	6.0	......
29	3.8	......	5.5	16.2	9.1	5.3	5.6	1.9	1.8	3.0	5.5	......
30	4.75	......	5.3	14.25	9.6	5.6	5.85	1.9	1.7	2.9	5.15	......
31	......	......	5.15	......	11.9	......	7.2	1.9	......	2.9	......	5.4

NOTE.—Ice conditions existed from December 8 to 31. Gage was read to top of ice on December 25 and 31. Maximum thickness of ice was 9 inches on December 31.

Daily discharge, in second-feet, of Kaskaskia River at Vandalia, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1			6,220	1,640	3,090	1,340	385	99	59	24	15	42
2			6,120	3,230	2,780	1,370	340	88	50	24	15	35
3			6,020	3,780	2,600	1,200	362	78	35	29	15	35
4			5,920	3,320	4,100	1,070	340	59	29	29	15	29
5			5,720	2,560	5,670	1,070	296	50	24	29	15	29
6			5,820	2,520	7,720	1,140	296	59	24	24	15	29
7			6,020	2,480	7,370	1,070	276	68	24	24	15	29
8			5,820	3,410	7,520	1,010	296	78	19	19	12	35
9			6,120	4,630	7,070	788	479	42	19	18	12	42
10			6,520	4,920	6,720	844	455	42	24	17	12	42
11			6,570	4,250	6,370	984	385	35	24	16	15	42
12			6,320	3,320	6,170	900	318	29	19	15	15	42
13			5,970	2,600	6,170	928	276	42	19	15	15	42
14			5,620	2,270	5,970	844	236	59	24	15	15	35
15			5,270	2,110	5,770	678	216	59	24	15	15	35
16			4,440	1,950	5,670	678	216	78	24	15	15	35
17			3,550	1,640	5,620	575	256	99	24	15	19	35
18			2,910	1,560	5,520	527	340	122	19	15	24	35
19			2,350	1,640	5,370	503	296	88	19	15	24	35
20			2,190	1,670	5,120	575	296	78	24	15	29	35
21			2,030	1,450	4,630	1,070	296	59	12	15	29	35
22			1,870	1,170	4,580	788	340	50	12	15	29	29
23			1,830	1,040	5,420	625	216	42	19	15	29	29
24			1,830	2,310	5,520	527	180	35	19	15	29	29
25			1,790	4,680	5,070	431	164	29	15	15	29	29
26		6,320	1,640	5,220	4,340	408	149	29	15	15	35	29
27		6,870	1,480	5,270	3,280	385	135	24	19	15	35	29
28		7,020	1,410	5,220	2,600	318	135	24	19	15	42	24
29		6,620	1,340	4,820	2,190	276	122	24	24	15	42	24
30			1,270	3,690	1,950	479	122	29	24	15	42	24
31			1,230		1,710		99	35		15		24
1909.												
1	35	340	3,620	600	3,300	3,780	844	1,150	50	35	164	600
2	42	135	3,020	563	2,780	3,740	625	678	50	35	149	575
3	42	142	2,370	527	2,390	3,990	527	539	50	35	149	575
4	35	149	2,090	503	2,210	4,200	455	455	50	35	135	551
5	35	122	1,950	479	2,070	4,530	408	396	50	35	135	539
6	35	999	1,750	2,500	1,950	4,580	956	351	50	29	128	479
7	35	1,710	1,520	5,970	1,730	3,530	2,600	307	50	29	122	455
8	35	858	1,390	7,270	1,600	2,800	4,150	266	50	29	503	400
9	35	788	4,170	6,520	2,930	2,270	4,920	246	128	29	351	380
10	29	1,910	5,500	5,820	4,560	2,150	5,320	207	388	26	296	360
11	29	1,770	5,670	5,370	5,400	2,930	5,620	180	149	24	246	479
12	29	928	3,940	4,870	4,750	2,350	5,920	164	110	24	600	816
13	29	575	2,250	6,270	4,040	3,620	6,070	156	88	24	2,230	2,480
14	29	1,070	1,690	7,570	4,010	4,390	6,320	142	73	24	1,600	3,050
15	29	3,850	1,460	6,970	3,390	3,090	6,220	135	59	29	732	2,310
16	29	3,580	1,300	6,420	2,690	1,970	5,620	122	50	35	1,040	1,970
17	35	1,540	1,170	6,240	2,210	3,580	4,970	122	50	35	3,020	1,870
18	35	1,410	1,040	6,040	1,810	4,700	4,080	110	42	35	2,050	1,810
19	46	2,910	956	5,870	1,540	3,600	3,580	110	42	122	1,410	1,710
20	94	4,900	900	5,820	1,320	1,450	3,410	99	88	408	1,100	1,520
21	172	5,520	872	6,000	1,140	1,120	3,320	88	246	329	942	1,200
22	180	5,570	830	6,300	1,030	956	2,890	78	351	296	1,480	1,200
23	180	5,500	746	6,340	914	816	2,310	78	431	340	2,630	1,000
24	149	5,600	718	6,120	872	788	1,810	73	236	443	2,850	800
25	128	5,720	1,070	5,920	942	692	1,600	68	128	396	2,310	500
26	116	5,540	1,280	5,740	1,790	732	1,140	68	73	172	1,520	500
27	110	5,070	1,070	5,520	1,850	858	1,040	59	64	207	1,150	500
28	104	4,290	830	5,400	1,910	788	872	59	50	180	900	400
29	340		760	5,220	1,990	705	788	50	42	180	760	400
30	563		705	4,270	2,190	788	858	50	35	164	664	400
31	452		664		3,180		1,270	50		164		400

NOTE.—Daily discharges for 1908 to 1909 were obtained from a rating well defined between 88 and 4,150 second-feet and based on measurements of 1908 to 1910. Discharge estimated for December 8 to 10 and 21 to 31, 1909, because of ice conditions.

Monthly discharge of Kaskaskia River at Vandalia, Ill., for 1908-9.

[Drainage area, 1,980 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
March	6,570	1,230	3,970	2.01	2.32	B.
April	5,270	1,040	3,010	1.52	1.79	B.
May	7,720	1,710	4,960	2.51	2.89	B.
June	1,340	276	780	.394	.44	A.
July	479	99	268	.135	.16	A.
August	122	24	55.1	.028	.03	B.
September	59	12	23.5	.012	.01	C.
October	29	15	17.8	.009	.01	C.
November	42	15	22.3	.011	.01	C.
December	42	24	33.0	.017	.02	B.
1909.						
January	563	29	104	.052	.06	B.
February	5,720	122	2,590	1.31	1.36	A.
March	5,670	664	1,850	.934	1.08	A.
April	7,570	479	4,970	2.51	2.80	B.
May	5,400	872	2,400	1.21	1.40	A.
June	4,700	692	2,520	1.27	1.42	A.
July	6,320	408	2,920	1.47	1.70	A.
August	1,150	50	215	.109	.13	B.
September	431	35	111	.056	.06	B.
October	443	24	127	.064	.07	B.
November	3,020	122	1,050	.530	.60	A.
December	3,050	....	975	.492	.57	C.
The year	7,570	....	1,650	.834	11.25	

KASKASKIA RIVER AT CARLYLE, ILL.

This station, which is located at the Baltimore & Ohio Southwestern Railroad bridge about one-fourth mile east of the railroad station at Carlyle, Ill., was established March 2, 1908, for the purpose of obtaining data for use in studying drainage, flood control, and water supply problems.

The river receives no important tributaries for 10 miles above and below this station. Shoal Creek comes in on the right bank about 15 miles below the station. The drainage area above the gaging station is 2,680 square miles.

The intake of the water supply system of Carlyle is above the gaging station. The dam is about 700 feet above the section and is about 3½ feet high. The average amount of water pumped is about 3,500,000 gallons every 30 days, and during June, July, and August the quantity is about 4,500,000 gallons every 30 days. The outfalls of one section of the city sewerage system and some private sewers are above the gaging station, so the diversion is small.

Discharge measurements are made from the bridge to which the chain gage is attached.

The datum has remained unchanged since the gage was installed.

The records are accurate and reliable.

The flood of 1882, which is the highest known, is said to have reached a height of 1½ feet higher than the flood of 1908, or about

32½ feet on the present gage. The stream never goes dry at this point. It has been noticed during periods of low water that the water is hard, a fact that indicates that the flow is maintained by springs.

Discharge measurements of Kaskaskia River at Carlyle, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 23	R. J. Taylor	196	1,770	16.7	2,830
May 4	do	512	3,770	21.35	5,360
July 8	do	131	335	8.1	426
August 7	do	124	239	7.1	289
September 24	do			5.6	*a* 62
October 22	do			5.6	*a* 32
1909.					
February 22	R. J. Taylor	514	3,660	20.70	4,710
March 15	W. M. O'Neill	531	4,480	22.29	7,110
March 25	do	149	773	10.86	1,260
May 7	H. J. Jackson	177	1,540	15.36	2,640
October 28	do	129	276	7.32	395
November 18	do	228	2,080	17.77	3,870
November 19	do	229	2,120	17.84	3,880
December 2	do	142	595	9.63	939
December 4	do	139	520	9.11	801

a Discharge partly estimated.

Daily gage height, in feet, of Kaskaskia River at Carlyle, Ill., for 1909.

[Michael Schilling, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.6	7.0	21.4	9.9	22.2	15.3	9.7	10.3	5.75	5.85	6.6	10.0
2	5.6	7.2	21.3	9.2	22.1	17.2	9.3	11.8	5.75	5.7	6.5	9.65
3	5.6	7.5	20.9	9.2	22.0	17.6	8.8	10.3	5.75	5.7	6.45	9.3
4	5.6	7.5	20.7	9.4	21.5	18.7	8.6	8.9	5.7	5.7	6.45	9.05
5	5.6	7.5	20.2	9.4	21.2	19.3	8.1	8.4	5.7	5.65	6.5	8.9
6	5.6	8.7	19.9	9.9	21.0	19.5	8.5	8.1	5.7	5.6	6.55	8.75
7	5.6	9.1	19.9	12.8	15.5	19.8	12.0	7.8	5.7	5.6	7.6	8.8
8	5.6	9.4	20.4	17.2	13.8	19.9	15.0	7.5	5.7	5.6	6.95	8.8
9	5.6	10.4	20.8	18.5	14.6	19.8	17.0	7.4	5.7	5.55	10.0	8.65
10	5.6	10.7	21.2	19.3	16.8	18.6	18.0	7.3	5.7	5.55	10.95	7.95
11	5.6	11.1	21.9	19.8	18.4	16.2	18.6	7.1	10.3	5.55	8.9	8.75
12	5.7	12.1	22.9	20.0	19.0	15.6	19.1	7.0	8.8	5.5	8.5	13.5
13	5.7	12.3	22.9	23.2	19.6	16.0	19.7	6.9	7.1	5.5	9.8	18.6
14	5.7	12.7	19.9	24.3	20.0	16.5	20.1	6.8	6.4	5.4	12.2	18.95
15	5.7	13.4	18.0	25.0	20.4	17.4	20.6	6.75	6.1	5.4	16.2	19.7
16	5.7	14.5	13.2	25.3	20.6	17.8	21.0	6.6	6.4	5.4	14.1	20.1
17	5.7	14.7	12.5	25.4	20.9	16.6	21.3	6.5	6.6	5.9	15.45	19.6
18	5.7	15.1	12.0	25.4	20.9	15.5	21.6	6.4	6.4	6.1	17.7	17.45
19	5.7	16.9	11.9	25.0	18.6	17.3	21.9	6.35	6.0	7.4	18.0	14.85
20	5.7	19.0	11.8	24.2	15.0	17.8	22.0	6.3	5.8	9.6	14.65	14.45
21	5.7	19.4	11.8	24.1	12.7	16.6	22.0	6.2	5.85	9.4	12.0	13.7
22	5.9	19.8	11.5	24.1	11.8	12.6	21.8	6.15	5.9	8.9	11.65	13.05
23	5.9	20.4	11.2	24.1	11.0	10.8	21.4	6.1	8.0	8.3	14.9	12.7
24	5.9	20.7	11.2	24.1	10.6	10.0	20.6	6.1	8.9	8.4	18.4	12.7
25	6.1	21.2	11.2	24.1	10.2	9.8	18.6	6.0	8.0	8.4	19.1	12.6
26	6.1	21.4	11.3	24.0	11.0	9.4	15.0	6.0	7.2	8.3	19.0	11.9
27	6.3	21.9	11.3	24.0	12.3	9.5	12.7	6.0	6.4	7.7	16.25	10.85
28	6.6	21.9	11.0	23.8	13.2	9.8	11.5	5.95	6.1	7.2	13.6	10.7
29	6.6		10.7	23.6	13.3	10.0	10.5	5.9	6.0	6.9	11.2	9.95
30	6.7		10.6	23.0	13.6	9.9	9.9	5.85	5.9	6.7	10.5	9.65
31	6.8		10.2		13.9		9.6	5.75		6.6		9.65

NOTE.—Ice conditions existed from December 8 to 31. The gage was read to top of the ice from December 25 to 31. The ice was 7½ inches thick on December 30 and gage reading to water surface was 8.9 feet.

Daily discharge, in second-feet, of Kaskaskia River at Carlyle, Ill., for 1908–9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1				2,120	6,870	3,840	515	394	116	47	47	47
2			9,150	2,790	6,720	2,640	565	346	100	47	47	47
3			9,000	3,290	6,270	1,940	565	280	100	47	47	86
4			8,550	3,500	5,510	1,710	540	240	86	47	47	86
5			8,240	3,610	6,270	1,540	515	220	72	47	47	86
6			7,940	3,570	8,240	1,460	540	302	72	47	47	86
7			7,790	3,430	11,000	1,490	540	302	86	47	47	86
8			7,790	3,430	17,400	1,350	515	324	86	47	47	86
9			7,790	3,800	19,900	1,330	515	260	72	47	47	59
10			8,240	4,220	18,700	1,540	442	220	86	47	47	59
11			9,000	4,750	16,900	1,300	640	220	59	47	47	59
12			9,150	5,360	14,600	1,190	565	184	59	47	47	59
13			8,700	5,810	13,100	1,190	515	202	59	47	47	59
14			8.550	5,810	11,900	1.160	515	202	59	47	47	59
15			8,090	5,510	11,000	1,140	466	184	59	47	47	59
16			7,630	4,580	10,200	978	418	184	47	47	47	59
17			7,180	3,840	9,610	952	442	184	59	47	47	59
18			6,870	3,110	9,000	874	490	166	59	47	47	59
19			6,420	2,730	8,550	796	466	166	47	47	47	59
20			5,960	2,390	8,090	744	565	166	59	47	47	59
21			4,850	2,140	7,630	848	540	148	59	47	47	59
22			3,540	1,790	8,240	1,110	666	116	47	47	47	47
23			2,950	1,650	7,940	1,110	848	100	59	47	47	47
24			2,420	2,570	7,630	848	822	100	59	47	47	47
25			2,020	3,470	7,330	770	590	86	47	47	47	47
26			1,880	4,220	6,870	666	640	86	47	47	47	47
27			1,740	5,360	6,570	640	874	86	47	47	47	47
28			1,650	6,110	6,420	615	848	86	47	47	47	47
29			1,770	6,570	6,270	640	565	116	47	47	47	47
30			1,790	6,870	6,270	590	515	184	47	47	47	47
31			1,820		4,660		418	184		47		47
1909.												
1	47	280	5,660	1,000	6,870	2,540	952	1,110	66	79	202	1,030
2	47	324	5,510	822	6,720	3,150	848	1,520	66	59	184	939
3	47	394	4,970	822	6,570	3,290	718	1,110	66	59	175	848
4	47	394	4,750	874	5,810	3,690	666	744	59	59	175	783
5	47	394	4,380	874	5,360	3,930	540	615	59	53	184	744
6	47	692	4,220	1,000	5,090	4,020	640	530	59	47	193	705
7	47	796	4,220	1,790	2,600	4,160	1,570	466	59	47	418	718
8	47	874	4,510	3,150	2,080	4,220	2,450	394	59	47	270	600
9	47	1,140	4,850	3,610	2,330	4,160	3,080	370	59	41	1,030	600
10	47	1,220	5,360	3,930	3,020	3,650	3,430	346	59	41	1,290	800
11	47	1,330	6,420	4,160	3,570	2,820	3,650	302	1,110	41	744	705
12	59	1,600	7,940	4,270	3,800	2,640	3,840	280	718	35	640	2,000
13	59	1,650	7,940	8,390	4,060	2,760	4,110	260	302	35	978	3,650
14	59	1,770	4,220	10,100	4,270	2,920	4,330	240	166	23	1,630	3,780
15	59	1,970	3,430	11,100	4,510	3,220	4,660	230	116	23	2,820	4,110
16	59	2,300	1,910	11,600	4,660	3,360	5,090	202	166	23	2,180	4,330
17	59	2,360	1,710	11,700	4.970	2,950	5,510	184	202	86	2,590	4,060
18	59	2,480	1,570	11,700	4,970	2,600	5,960	166	166	116	3,320	3,230
19	59	3,050	1,540	11,100	3,650	3,180	6,420	157	100	370	3,430	2,400
20	59	3,800	1,520	9,910	2,450	3,360	6,570	148	72	926	2,340	2,280
21	59	3,970	1,520	9,760	1,770	2,950	6,570	132	79	874	1,570	2,060
22	86	4,160	1,440	9,760	1,520	1,740	6,270	124	86	744	1,480	1,860
23	86	4,510	1,350	9,760	1,300	1,250	5,660	116	515	590	2,420	1,600
24	86	4,750	1,350	9,760	1,190	1,030	4,660	116	744	615	3,570	1,450
25	116	5,360	1,350	9,760	1,080	978	3,650	100	515	615	3,840	1,300
26	116	5,660	1,380	9,610	1,300	874	2,450	100	324	590	3,800	1,200
27	148	6,420	1,380	9,610	1,650	900	1,770	100	166	442	2,840	1,100
28	202	6,420	1,300	9,310	1,910	978	1,440	93	116	324	2,020	950
29	202		1,220	9,000	1,940	1,030	1,170	86	100	260	1,350	800
30	220		1,190	8,090	2,020	1,000	1,000	79	86	220	1,160	700
31	240		1,080		2,120		926	66		202		700

NOTE.—Daily discharges for 1908 to 1909 were obtained from a rating well defined between 280 and 7,030 second-feet, and based on measurements made during 1908 to 1910. Discharges for December 8 to 10 and 23 to 31, 1909, have been estimated because of ice conditions.

Monthly discharge of Kaskaskia River at Carlyle, Ill., for 1908–9.

[Drainage area, 2,680 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
March 2-31	9,150	1,650	5,950	2.22	2.48	B.
April	6,870	1,650	3,950	1.47	1.64	A.
May	19,900	4,660	9,550	3.56	4.10	A.
June	3,840	590	1,230	.459	.51	A.
July	874	418	570	.213	.25	A.
August	394	86	195	.073	.08	A.
September	116	47	64.9	.024	.03	B.
October	47	47	47.0	.018	.02	B.
November	47	47	47.0	.018	.02	B.
December	86	47	59.6	.022	.03	B.
1909.						
January	240	47	84.2	.031	.04	B.
February	6,420	280	2,500	.933	.97	A.
March	7,940	1,080	3,260	1.22	1.41	A.
April	11,700	822	6,880	2.57	2.87	B.
May	6,870	1,080	3,390	1.27	1.46	A.
June	4,220	874	2,640	.985	1.10	A.
July	6,570	540	3,250	1.21	1.40	A.
August	1,520	66	339	.127	1.15	B.
September	1,110	59	215	.080	.09	B.
October	926	23	248	.093	.11	B.
November	3,840	175	1,630	.608	.68	A.
December	4,330	....	1,670	.623	.72	C.
The year	11,700	....	2,180	.812	11.00	

KASKASKIA RIVER AT NEW ATHENS, ILL.

This station, which is located at the Illinois Central Railroad bridge about 600 feet north of the Illinois Central Railroad station at New Athens, Ill., and about 600 feet upstream from the highway bridge, was established November 1, 1909, for the purpose of obtaining data for use in studying problems of drainage, flood control, and navigation.

Silver Creek enters on the right bank about 1 mile above and Lively Creek on the left bank about 3 miles below the gaging station. The total drainage area above the gaging station is 5,220 square miles.

Discharge measurements are made from the railroad bridge and the trestle approaches at each end.

The datum of the chain gage attached to the railroad bridge has remained unchanged since the gage was installed. The records are accurate and reliable. The stream is fed by springs and never goes dry at this point. The flood of the fall of 1898 reached a height of about 34.5 feet on the present gage datum.

A record of river height at this point from January 23, 1907, to October 28, 1909, inclusive, was kept for the New Athens Journal by C. J. Von Roth Roffy. The river height was taken on Wednesday and Thursday mornings of each week, the river height for Thursday being published each Friday with the change in twenty-four hours, as obtained from the river height of Wednesday. This record of stage was kept by the Journal mainly for the information of farmers who lived on the west side of the river and who are cut off from reaching New Athens via the highway bridge when the river reaches a stage of about 30 feet. The record is authentic. These gage heights have been carefully reduced to the datum of the present gage. The maximum error is probably not over 0.4 foot; the lower the stage the greater the error.

Discharge measurements of Kaskaskia River at New Athens, Ill., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 2	H. J. Jackson	174	610	4.13	401
November 16	do	239	3,310	16.59	7,020
November 20	do	250	3,660	18.02	7,850
November 30	do	218	1,820	9.80	2,470
December 1	do	213	1,490	8.54	1,920
December 3	do	208	1,240	7.40	1,500

Daily gage height, in feet, of Kaskaskia River at New Athens, Ill., for 1907–1909.

[C. J. Van Roth Rossy, observer for New Athens Journal.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1					15.5			13.6				
2					17.5					4.0		
3				9.7						4.0		
4				9.1					6.6			4.6
5						19.1			6.4			4.4
6		18.0	11.7			19.7					6.8	
7		17.7	10.1					7.4			6.4	
8					11.1			8.7				
9					12.1					9.8		
10				8.1			7.6			5.7		
11				7.9			6.6		5.6			5.1
12						21.5			5.4			5.3
13		6.3	15.5			22.4					4.4	
14		5.7	19.6					17.0			4.3	
15					14.1			16.0				
16					17.5					4.4		
17				7.5			7.6			4.2		
18				7.1			7.9					6.6
19		7.9	22.2			22.8						7.7
20		7.6	21.3			21.2					5.8	
21								12.7			4.9	
22					14.1			15.6				
23	24.4				15.1					3.9		
24	24.3			10.3			13.6			3.8		
25				11.6			15.6		4.4			15.2
26						10.1			4.4			16.7
27		2.1	17.9			11.1					5.4	
28		9.1	17.6					13.5			5.2	
29					10.2			10.8				
30	24.4				8.9					4.3		
31	19.0						15.6			4.4		

Daily gage height, in feet, of Kaskaskia River at New Athens, Ill., fcr 1907–1909—Con.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1	16.2			14.1			14.8			3.5		
2	13.6			14.1			14.1		3.8			5.4
3									3.8			4.9
4			24.3								3.3	
5		10.5	24.2					5.4			3.3	
6		16.5			24.5			5.4				
7					27.3							
8	12.6			16.5			14.4					
9	10.8			18.8			13.5		3.8			3.9
10						14.7			3.7			3.8
11						15.1					3.3	
12		20.0						5.6			3.3	
13		19.6			33.2			6.3				
14					32.2					3.5		
15	17.1			20.1			10.3			3.5		
16	18.0			19.3			9.4		3.6			3.6
17						17.5			3.6			3.5
18			22.6			17.3					3.3	
19		23.9	22.2					4.7			3.3	
20		24.7			24.5			4.6				
21					23.8					3.3		
22	10.9			12.8			8.7			3.3		
23	10.5			11.8			8.8					3.4
24						17.5						3.5
25			17.1			17.2						
26		24.4	14.1					4.1				
27		24.3			23.9			4.0				
28					23.4					3.3		
29	8.0			21.1			12.1		3.5	3.3		
30	7.6			23.1			10.8					
31												
1909.												
1				9.1			11.5		3.4		4.35	8.6
2									3.3		4.2	7.9
3		7.6	21.8								4.05	7.45
4		7.2	21.2					9.7			4.0	7.1
5					21.3			9.7			3.95	6.8
6	3.9				20.7					3.5	3.9	6.85
7	3.9			10.6						3.4	4.05	7.1
8				14.8					3.6		5.2	7.4
9									3.6		6.8	7.5
10			22.6			14.7					8.7	7.35
11			23.6			15.1		5.5			10.9	6.85
12								5.4			10.3	9.3
13	3.7									3.1	11.25	14.1
14	3.7			22.1			20.9			3.1	12.5	15.95
15				23.2			21.2		5.3		14.45	17.3
16									4.8		16.05	18.05
17		18.0	22.7								17.15	18.4
18		18.5	22.0					4.7			17.4	18.1
19					17.4			4.6			17.7	17.3
20	3.6				16.5					8.5	18.0	15.45
21	3.6			26.6			18.7			10.1	18.2	12.2
22				26.5			18.0		4.6		16.6	9.95
23						18.2			5.5		14.9	9.4
24		21.5	9.6			18.8					15.2	8.5
25		22.2	11.3					4.0			15.8	8.1
26					9.2			3.9			16.2	8.6
27	5.8				10.1					7.4	16.0	8.45
28	5.8			25.1			14.5			6.9	14.9	8 3
29				24.3			11.3		4.8		12.6	8.3
30						10.3			4.4		10.05	8.0
31			9.8									7.7

NOTE.—Ice conditions existed from December 8 to 31, 1909, the river being entirely frozen over on December 30 and 31. The gage was read to the top of the ice on December 31.

Daily discharge, in second-feet, of Kaskaskia River at New Athens, Ill., for 1907–1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.[a]												
1					6,070			4,790				
2					7,680					378		
3				2,580						378		
4				2,260					1,090			494
5						9,230			1,010			454
6		8,130	3,680			9,940					1,170	
7		7,860	2,800					1,420			1,010	
8					3,360			2,050				
9					3,900					2,640		
10							1,510			770		
11				1,650			1,090		738			606
12						14,100			682			656
13		974	6,070			17,200					454	
14		770	9,820					7,260			434	
15					5,090			6,470				
16					7,680					454		
17				1,470			1,510			414		
18				1,290			1,650					1,090
19						18,600						1,560
20		1,650	16,500			13,000					802	
21		1,510	13,400					4,250			560	
22					5,090			6,150				
23	24,100				5,790					360		
24	23,700			2,920			4,790			344		
25				3,630			6,150		454			5,860
26						2,800			454			7,020
27		120	8,040			3,360					682	
28		2,260	7,770					4,730			630	
29					2,860			3,190				
30	24,100				2,150					434		
31	9,120						6,150			454		
1908.[a]												
1	6,620			5,090			5,580			296		
2	4,790			5,090			5,090		344			682
3									344			560
4			23,700								264	
5		3,020	23,400					682			264	
6		6,860			24,400			682				
7					34,100							
8	4,190			6,860			5,300					
9	3,190			8,910			4,730		344			360
10						5,510			328			344
11						5,790					264	
12		10,300						738			264	
13		9,820			54,400			974				
14					51,000					296		
15	7,340			10,500			2,920			296		
16	8,130			9,460			2,420		312			312
17						7,680			312			296
18			17,900			7,520					264	
19		22,300	16,500					516			264	
20		25,100			24,400			494				
21					22,000					264		
22	3,240			4,310			2,050			264		
23	3,020			3,740			2,100					280
24						7,680						296
25			7,340			7,430						
26		24,100	5,090					396				
27		23,700			22,400			378				
28					20,600					264		
29	1,700			12,700			3,900			264		
30	1,510			19,600			3,190		296			
31												

a See note on page 207.

Daily discharge, in second-feet, of Kaskaskia River at New Athens, Ill., for 1907–1909—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1				2,260			3,580		280		444	2,000
2									264		414	1,650
3		1,510	15,100								387	1,450
4		1,340	13,000					2,580			378	1,290
5					13,400			1,560			369	1,170
6	360				11,600					296	360	1,190
7	360			3,080						280	387	1,290
8				5,580					312		630	1,420
9									312		1,170	1,470
10			17,900			5,510					2,050	1,400
11			21,300			5,790		710			3,240	1,190
12								682			2,920	2,360
13	328									236	3,440	5,090
14	328			16,100			12,100			236	4,130	6,430
15				19,900			13,000		656		5,340	7,520
16									538		6,510	8,180
17		8,130	18,200								7,390	8,510
18		8,610	15,800					516			7,600	8,220
19					7,600			494			7,860	7,520
20	312				6,860					1,950	8,130	6,040
21	312			31,700			8,810			2,800	8,310	3,960
22				31,300			8,130		494		6,940	2,720
23						8,310			710		5,650	2,420
24		14,100	2,530			8,910					5,860	1,950
25		16,500	3,460					378			6,310	1,750
26					2,310			360			6,620	2,000
27	802				2,800					1,420	6,470	1,920
28	802			26,500			5,370			1,210	5,650	1,600
29				23,700			3,460		538		4,190	1,450
30						2,920			454		2,780	1,300
31			2,640									1,200

NOTE.—Daily discharges for 1907 to 1909 were obtained from a rating well defined between 378 and 15,800 second-feet, and based on measurements made during 1909 to 1910. Discharges for December 28 to 31 were estimated because of ice conditions.

Monthly discharge of Kaskaskia River at New Athens, Ill., for 1907–1909.

[Drainage area, 5,220 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1907.						
January			20,300	3.89	4.48	C.
February			2,910	557	.58	B.
March			8,510	1.63	1.88	B.
April			2,190	.420	.47	B.
May			4,970	.952	1.10	B.
June			11,000	2.11	2.35	B.
July			3,260	.625	.72	B.
August			4,480	.858	.99	B.
September			738	.141	.16	B.
October			663	.127	.15	B.
November			718	.138	.15	B.
December			2,220	.425	.49	B.
The year			5,160	.989	13.52	
1908.						
January			4,370	.837	.96	B.
February			15,600	2.99	3.22	B.
March			15,700	3.01	3.47	B.
April			8,630	1.65	1.84	B.
May			31,700	6.07	7.00	B.
June			6,940	1.33	1.48	B.
July			3,730	.715	.82	B.
August			608	.116	.13	B.
September			326	.062	.07	B.
October			278	.053	.06	C.
November			264	.051	.06	C.
December			391	.075	.09	B.
The year			7,380	1.41	19.20	
1909.						
January			450	.086	.10	B.
February			8,360	1.60	1.67	B.
March			12,200	2.34	2.70	B.
April			17,800	3.41	3.80	B.
May			7,430	1.42	1.64	B.
June			6,290	1.20	1.34	B.
July			7,780	1.49	1.72	B.
August			910	.174	.20	B.
September			456	.087	.10	B.
October			1,050	.201	.23	B.
November	8,310	360	4,060	.778	.87	A.
December	8,510		3,150	.603	.70	C.
The year			5,830	1.12	15.07	

NOTE.—Monthly discharges for January, 1907, to October, 1909, are based on means for days when gage was read.

SHOAL CREEK NEAR BREESE, ILL.

Shoal Creek is tributary to Kaskaskia River in Clinton County about 15 miles below Carlyle.

The gaging station, which is located at the Baltimore & Ohio Southwestern Railroad bridge about 1½ miles east of Breese, Ill., was established November 5, 1909, for the purpose of obtaining data for use in studying problems of drainage, flood control, water supply, and storage.

Beaver Creek enters on the left bank about 3 miles below the gaging section. The total drainage area above the gaging station is 760 square miles. The intake of the pumping station of the water supply system of Breese is about one-fourth mile above the gaging section.

Discharge measurements are made from the railroad bridge and a wooden trestle over a flood channel east of the main channel.

The datum of the chain gage attached to bridge has remained unchanged since the gage was installed. The records are accurate and reliable.

The creek is fed by springs and has not been known to go dry at this point. The flood of 1907 reached a height of about 22 feet on the present gage datum.

Discharge measurements of Shoal Creek near Breese, Ill., in 1909.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
October 29	H. J. Jackson	59	62	1.77	96
November 19	do	126	1,280	15.93	2,720
December 2	do	68	102	2.54	166

Daily gage height in feet and discharge in second-feet of Shoal Creek near Breese, Ill., for 1909.

[John Nordman, observer.]

Day.	November.		December.		Day.	November.		December.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			2.6	185	16	15.8	2,810	8.95	1,290
2			2.2	137	17	16.4	3,050	6.5	840
3			2.5	173	18	16.1	2,920	5.7	696
4			2.2	137	19	15.4	2,680	5.2	606
5	1.7	90	2.5	173	20	8.5	1,200		500
6	1.6	84	2.95	228	21	5.2	606		400
7	1.7	90	3.2	267	22	6.5	840		300
8	2.6	185	2.9	180	23	9.7	1,440	4.15	240
9	11.5	1,800	2.3	130	24	11.1	1,720		220
10	7.5	1,020	2.25	120	25	7.9	1,090		200
11	3.3	283	3.2	267	26	4.6	502		170
12	2.9	222	5.6	678	27	3.5	315		130
13	13.55	2,240	12.9	2,100	28	2.9	222		100
14	15.5	2,710	14.5	2,450	29	2.9	222		80
15	15.1	2,600	11.5	1,800	30	2.7	197	2.8	70
					31				70

NOTE.—Ice conditions existed from December 8 to 31. Ice was 8 inches thick on December 23 at the gage and 13 inches on December 30. The daily discharges were obtained from a rating fairly well defined between 90 and 3,930 second-feet and based on measurements made during 1909 and 1910. Discharge estimated for December 8 to 10 and 20 to 31 because of ice conditions.

Monthly discharge of Shoal Creek near Breese, Ill., for 1909.

[Drainage area, 760 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
November 5-30	3.050	84	1,200	1.58	1.53	B.
December	2,450		482	.634	.73	C.

SILVER CREEK NEAR LEBANON, ILL.

Silver Creek is a tributary of Kaskaskia River about 1 mile above the gaging station at New Athens, Ill.

The gaging station, which is located at the highway bridge at Wrights Crossing, about 2 miles west of Lebanon, Ill., between the Baltimore & Ohio Southwestern and the East St. Louis & Suburban railway bridges across Silver Creek, was established March 3, 1908, for the purpose of collecting data for use in studying drainage and flood control problems.

The creek receives no tributaries near the gaging station.

Discharge measurements are made from the bridge and approach spans, and during high water also from three steel viaducts on road west of bridge.

The datum of the chain gage, which is located on the bridge, has remained unchanged since the gage was installed. From March 3, 1908, to May 10, 1909, this gage was so situated that 2 feet was the lowest obtainable reading, and the gage reader noted that the stream was dry whenever the water surface was below 2 feet. On inquiry he stated that the stream was dry for only one week during 1908. The position of the gage was changed on May 10, 1909, so as to obviate this difficulty. Except as noted above, the records are accurate and reliable.

Discharge measurements of Silver Creek near Lebanon, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 21	R. J. Taylor	38	111	3.5	71
May 2	do	41	130	4.25	107
July 9	do	35	107	3.5	58
1909.					
February 23	R. J. Taylor	378	1,610	12.56	1,760
March 14	W. M. O'Neill	46	185	5.34	180
March 25	do	50	254	6.66	314
May 8 [a]	H. J. Jackson	32	90	2.77	34
May 10	do	62	434	10.03	761
August 14	do	24	70	2.24	6
November 4	do	26	77	2.28	6
November 17	do	360	1,320	12.04	1,124
November 20	do	53	347	8.54	410

[a] Measurement not made at regular section.

Daily gage height, in feet, of Silver Creek near Lebanon, Ill., for 1909.

[F. P. Myers, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.0	9.3	3.1	3.1	5.1	3.0		0.6	1.0	2.2	3.1
2		4.5	8.7	3.1		7.6	2.3	2.1	.6	.9	2.2	3.15
3		3.2	5.0	3.2	3.0	8.8	1.8	2.0	.6	.8	2.2	3.2
4		4.0	3.6		3.0	10.4		2.0	.6	.7	2.2	3.15
5		4.7	3.2	3.0	3.0	11.5	4.3	1.9	.6	.7	2.2	3.3
6		7.5	2.7	2.8	2.9		6.5	1.7	.6	.6	2.2	3.35
7				7.1	2.9	11.7	11.2	1.7	.7	.6	2.65	3.5
8		6.2	9.5	5.6	2.8	10.9	13.6		.7	.6	5.15	3.45
9		5.3	12.6	4.4		10.4	14.0	1.6	.8	.6	8.6	3.45
10		5.0	13.0	3.5	10.0	10.0	12.0	1.6	.9	.6	9.0	3.45
11		4.7	12.8		8.5	8.2		1.5	.9	.6	5.75	3.0
12		4.2	11.0	3.0	8.0	4.5	12.2	1.5	1.2	.55	5.0	5.4
13		3.5	9.2	12.3	8.7		12.6	1.5	1.9	.55	9.2	9.9
14				13.5	10.4	3.7	8.5	4.5	1.9	.5	10.3	10.7
15		10.4	7.8	13.0	11.0	3.4	6.2	2.0	1.7	.55	12.9	11.0
16		10.7	6.7	12.5		2.5	3.5	1.5	1.7	.6	12.6	10.4
17		8.5	5.0	9.8	5.7	2.5	3.1	1.5	1.5	.7	12.1	6.9
18		6.4	3.6		4.1	2.5		1.4	1.0	8.8	11.95	6.1
19		11.2		9.9	3.3	2.5	2.8	1.2	1.0	10.0	11.9	5.7
20		12.1		11.3	3.0		2.5	1.0	1.0	9.9	10.35	4.5
21	2.7			12.8	3.0	2.4	2.3	1.0	1.2	10.0	5.4	3.8
22	4.0	12.2		14.0	2.7	2.4	2.0	1.0	6.0	9.7	4.2	3.25
23	4.2	12.7		13.8		3.5	1.9	.9	5.1	6.1	9.0	3.0
24		12.5	5.4	12.5	2.7	3.2	1.7	.8	3.5	5.0	7.4	3.0
25	4.2	12.5	8.7		3.6	3.0		.7	2.3	4.1	5.1	3.0
26	3.7	11.2	6.5	8.2	5.5	2.7	10.0	.7	1.7	3.2	4.2	3.0
27	2.8	10.0	5.8	4.3	5.0		8.7	.7	1.5	2.8	3.7	3.0
28	3.6			3.8	4.3	2.5	5.1	.7	1.0	2.5	3.5	3.0
29	4.5		3.7	3.6	3.0	4.1	2.9	.7	1.0	2.3	3.3	3.0
30	8.2		3.5	3.3		3.5	2.5	.6	.9	2.3	3.2	3.0
31			3.3		3.5		2.3	.6		2.3		2.9

NOTE.—The gage was not placed over the main channel originally and 2.0 feet was the lowest obtainable reading. The gage heights for January 1 to 20 were less than 2.0 feet. Ice conditions existed from December 8 to 31, readings being taken to top of ice from December 17 to 31.

Daily discharge, in second-feet, of Silver Creek near Lebanon, Ill., for 1908-9.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1				122	164	74	23	10				49
2				116	116	59	10	10				29
3				110	110	49	17	10				
4				92	104	187	23	8				
5				92	3,080	253	23	8				
6				92	4,800	235	23	86				
7				110	5,240	203	92	280				
8				157	4,800	171	187	219				
9				730	3,300	235	64	188				
10				860	2,240	405	29	157				
11				860	1,190	157	17	136				
12				520	639	69	14	104				
13				179	219	104	10	41				
14				104	345	409	10	10				
15				104	253	814	17	10				
16				143	150	375	41					
17				143	220	157	92					
18				143	289	49	171					
19				133	235	33	100					
20				122	179	26	29					
21			64	86	98	45	104					
22			62	64	860	64	164					
23			59	171	1,400	29	69					
24			54	885	1,490	122	69					
25			54	945	1,580	49	69					
26			49	1,310	1,140	23	74					
27			45	1,680	492	10	80					
28			64	1,320	860	269	375					
29			69	1,090	405	528	280					
30			74	516	325	33	64				59	
31			110		200		23					
1909.												
1		157	576	45	45	164	41	14	0.1	1.0	14	45
2		122	504	45	43	385	17	12	.1	.7	14	47
3		49	157	49	41	516	7	10	.1	.4	14	49
4		92	69	45	41	730	58	10	.1	.2	14	47
5		136	49	41	41	1,010	110	8	.1	.2	14	54
6		375	29	33	37	1,050	280	6	.1	.1	14	56
7		314	314	335	37	1,090	915	6	.2	.1	28	64
8		253	600	203	33	836	2,780	5	.2	.1	168	60
9		179	1,780	116	349	730	3,190	5	.4	.1	492	50
10		157	2,180	64	665	665	1,240	5	.7	.1	540	40
11		136	1,980	52	480	447	1,320	4	.7	.1	215	35
12		104	860	41	425	122	1,400	4	2.0	.05	157	187
13		64	564	1,490	504	146	1,780	4	8	.05	564	652
14		397	484	2,680	730	74	480	122	8	.0	712	792
15		730	405	2,180	860	59	253	10	6	.05	2,080	860
16		792	298	1,680	536	23	64	4	6	.1	1,780	730
17		480	157	639	211	23	45	4	4	.2	1,320	250
18		271	69	646	98	23	39	3	1.0	516	1,220	200
19		915	89	652	54	23	33	2.0	1.0	665	1,190	150
20		1,320	108	945	41	22	23	1.0	1.0	652	721	100
21	29	1,360	128	1,980	41	20	17	1.0	2.0	665	187	80
22	92	1,400	148	3,190	29	20	10	1.0	235	626	104	60
23	104	1,880	167	2,980	29	64	8	.7	164	244	540	40
24	104	1,680	187	1,680	29	49	6	.4	64	157	365	30
25	104	1,680	504	1,060	69	41	336	.2	17	98	164	20
26	74	915	280	447	195	29	665	.2	6	49	104	20
27	33	665	219	110	157	26	504	.2	4	33	74	20
28	69	620	146	80	110	23	164	.2	1.0	23	64	20
29	122		74	69	41	98	37	.2	1.0	17	54	15
30	447		64	54	52	64	23	.1	.7	17	49	15
31	302		54		64		17	.1		17		15

NOTE.—Daily discharges for 1908 to 1909 were obtained from a rating fairly well defined between 29 and 1,780 second-feet, being based on measurements made 1908 to 1910. No estimates are possible for period August 15, 1908, to January 20, 1909, when gage heights were less than 2.0 feet and could not be read because of the position of the gage. Discharges were estimated for December 8 to 11 and 17 to 31, 1909, and interpolated for days of no gage height, except for the period mentioned above.

Monthly discharge of Silver Creek near Lebanon, Ill., for 1908-9.

[Drainage area, 335 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
March 21-31	110	45	64.0	0.191	0.08	B.
April	1,680	64	433	1.29	1.44	B.
May	5,240	98	1,180	3.52	4.06	C.
June	814	10	175	.522	.58	B.
July	375	10	76.2	.227	.26	B.
August 1-15	280	....	85.1	.254	.14	C.
1909.						
January 21-31	447	29	135	.403	.16	C.
February	1,880	49	616	1.84	1.92	B.
March	2,180	29	427	1.27	1.46	B.
April	3,190	33	788	2.35	2.62	B.
May	860	29	196	.585	.67	B.
June	1,090	20	286	.854	.95	B.
July	3,190	6	512	1.53	1.76	B.
August	122	.1	7.85	.023	.03	C.
September	235	.1	17.8	.053	.06	C.
October	665	.0	122	.364	.42	C.
November	2,080	14	433	1.29	1.44	B.
December	860	....	155	.463	.53	C.

NOTE.—The gage at this station was not set over the main channel, hence for stages below 2.0 feet, which occurred August 4 and 5, August 16 to November 29, and December 3, 1908, to January 19, 1909, the stream was dry immediately under the gage. There was water flowing in the main channel for all but about one week during these periods.

BIG MUDDY RIVER DRAINAGE BASIN.

DESCRIPTION.

The drainage basin of Big Muddy River lies in southern Illinois. The river rises in the northwestern part of Jefferson County, flows southward to the town of Zeigler, in Franklin County, thence westward to Murphysboro, in Jackson County, and then southward to its junction with the Mississippi about 40 miles above Cairo, Ill. Below Zeigler the river is extremely crooked. The river is about 100 miles long, including bends. The total drainage area is 2,390 square miles. The principal tributaries are Beaucoup Creek, Little Muddy River, Caseys Creek, and Middle Fork Creek, all small streams of little importance.

The drainage basin is elliptical in shape, with a major axis about 70 miles long and a minor axis about 50 miles long. The country is level or undulating. The soil is known as "mulatto soil"—a yellowish-brown clay. Winter wheat is the staple crop. The southeastern part is underlain with valuable coal veins, and coal mining is carried on extensively.

The slope of the river is small. Its sources are about 710 feet, and its mouth is about 310 feet above sea level. The banks and bed of the stream are soft and insecure.

The area is timberless except for scattered groves and the growth along the banks of the stream.

The mean annual rainfall is about 42 inches. The winters are mild. Ice does not form very thick, and, as a rule, the snowfall is light and does not last long.

The subject of storage has not been investigated, but owing to the growing demand for water in this section it should receive careful attention.

The basin offers no opportunities for power development. Like the other rivers in central and southern Illinois this stream is subject to high floods and very low water. During floods some sections resemble lakes, high water overflowing the land on each bank for 2 or 3 miles. Backwater from the Mississippi frequently extends to Murphysboro, said to be 60 miles distant following the river, and floods reach the height of 30 feet above low water.

BIG MUDDY RIVER NEAR CAMBON, ILL.

This station, which is located at the Chicago, Burlington & Quincy Railroad bridge about 1 mile north of Cambon railroad station and about 1½ miles east of Plumfield, Ill., was established June 16, 1908, to obtain data for use in studying the problems of drainage, flood control, and navigation.

The Middle Fork of the Big Muddy enters on the left bank about one-fourth mile above the station. The drainage area above the section is 735 square miles.

Discharge measurements are made from the railroad bridge and a trestle approach.

The datum of the chain gage attached to the bridge has not been changed; the records are reliable and accurate. The water was standing in pools in the river at this point in the fall of 1908.

Discharge measurements of Big Muddy River near Cambon, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 15	R. J. Taylor	41.5	53	2.7	19
1909.					
February 18	R. J. Taylor	589	3,230	16.58	3,040
March 12	W. M. O'Neill	641	8,250	24.54	10,300
March 27	do	102	455	8.28	542
May 12	H. J. Jackson	95	455	8.27	548
November 13	do	26	12	1.79	1

Daily gage height, in feet, of Big Muddy River near Cambon, Ill., for 1909.

[W. O. Bourland, observer.]

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.5	2.6	16.8	3.65	9.95	4.9	6.3	4.9	1.6	2.4	1.8	3.0
2	1.5	2.6	14.8	3.35	10.45	4.3	4.5	10.0	1.6	2.3	1.75	2.8
3	1.5	2.6	12.9	3.25	7.65	3.8	3.65	10.2	1.6	2.2	1.75	2.7
4	1.4	2.6	10.2	3.25	5.2	3.75	3.0	5.4	1.6	2.15	1.75	2.6
5	1.4	3.7	6.8	3.25	4.0	4.85	2.7	5.0	1.55	2.15	1.75	2.55
6	1.4	3.9	5.5	6.2	3.9	10.65	2.55	3.4	1.55	2.1	1.75	2.55
7	1.4	4.1	4.7	10.3	5.35	11.3	2.4	3.1	1.55	1.9	1.75	2.55
8	1.4	5.2	4.1	11.6	4.7	10.6	5.7	5.1	1.7	1.9	1.8	2.5
9	1.4	5.8	16.4	11.2	4.5	9.65	6.1	6.9	1.7	1.9	1.85	2.5
10	1.4	5.9	21.2	10.3	7.3	6.5	5.65	4.3	1.7	1.9	1.85	2.5
11	1.4	6.0	24.3	9.9	8.5	4.2	8.45	3.4	1.65	1.85	1.85	3.2
12	1.4	6.1	24.7	7.1	7.4	3.5	13.95	3.3	1.65	1.85	1.85	7.3
13	1.4	6.7	23.8	13.9	6.7	5.3	15.4	3.3	1.65	1.85	1.85	10.4
14	1.4	11.7	21.9	14.95	5.05	9.2	18.95	3.15	1.65	1.8	1.9	12.5
15	1.4	14.2	20.6	16.45	4.2	10.6	20.55	3.05	1.65	1.8	3.5	13.25
16	1.4	14.5	18.75	17.45	4.2	11.2	20.4	3.65	2.2	1.75	4.8	13.55
17	1.5	15.9	16.9	18.4	4.2	10.1	19.75	2.4	2.1	1.7	4.5	13.65
18	1.5	16.0	12.7	17.1	4.1	6.85	18.7	2.3	2.05	1.7	6.1	13.4
19	1.5	16.4	10.5	16.3	3.6	3.8	16.7	2.2	2.0	1.7	6.8	9.5
20	1.5	16.2	9.7	17.4	3.2	3.2	12.1	2.0	2.0	1.7	6.1	6.2
21	1.5	15.2	8.2	18.95	2.9	2.9	8.25	1.8	1.95	1.7	5.6	5.4
22	1.7	15.3	7.75	20.05	2.7	2.8	5.15	1.75	2.45	1.7	5.1	4.55
23	2.5	16.4	6.45	20.15	2.5	2.65	3.9	1.75	5.6	1.7	6.7	3.75
24	4.1	18.7	4.9	20.25	2.5	2.45	3.05	1.7	8.65	1.7	7.0	3.2
25	3.9	20.5	6.85	20.2	2.45	4.8	2.7	1.7	7.95	1.75	8.7	2.9
26	3.6	21.0	8.75	18.25	3.4	7.55	2.5	1.7	5.6	1.8	7.6	2.8
27	3.3	20.5	7.9	17.05	5.5	8.2	3.4	1.7	4.2	1.8	5.5	2.7
28	3.2	18.9	6.2	14.5	8.5	6.95	3.6	1.7	3.4	1.8	5.5	2.6
29	3.2	....	5.7	8.9	9.95	7.35	3.2	1.7	3.0	1.8	4.8	2.55
30	3.1	....	4.5	9.85	8.75	6.5	2.9	1.65	2.7	1.8	3.35	2.5
31	2.6	....	4.0	....	6.6	....	2.7	1.65	....	1.8	....	2.45

NOTE.—Ice conditions existed from December 8 to 31.

Daily discharge, in second-feet, of Big Muddy River near Cambon, Ill., for 1908–9.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.							
1	......	3	67	2	1	1	2
2	......	3	30	2	1	1	2
3	......	3	21	2	1	1	2
4	......	3	15	2	1	1	2
5	......	3	11	2	1	1	2
6	......	3	17	2	1	1	2
7	......	3	52	2	1	1	2
8	......	3	38	2	1	1	2
9	......	3	30	2	1	1	2
10	......	3	67	2	1	1	2
11	......	3	52	2	1	1	2
12	......	3	52	2	1	1	2
13	......	3	21	2	1	1	2
14	......	3	17	2	1	1	2
15	......	3	13	2	1	1	2
16	17	3	9	2	1	1	2
17	13	3	6	2	1	1	2
18	11	3	6	2	1	1	2
19	9	3	5	2	1	1	2
20	7	3	5	2	1	1	2
21	7	3	4	2	1	1	2
22	6	3	4	2	1	1	2
23	6	84	3	2	1	1	2
24	5	24	3	2	1	2	2
25	5	9	3	2	1	2	2
26	4	6	3	2	1	2	2
27	4	5	3	2	1	2	2
28	3	4	3	2	1	2	2
29	3	3	2	2	1	2	2
30	3	124	2	2	1	2	2
31	......	140	2	......	1	......	2

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	2	19	3,180	60	851	140	286	140	3	15	5	30
2	2	19	2,200	44	950	96	110	860	3	13	4.5	24
3	2	19	1,530	40	461	67	60	900	3	11	4.5	21
4	2	19	900	40	166	64	30	186	3	10	4.5	19
5	2	62	350	40	78	136	21	148	2.5	10	4.5	18
6	2	72	196	274	72	993	18	47	2.5	9	4.5	18
7	2	84	124	920	181	1,140	15	34	2.5	6	4.5	18
8	2	166	84	1,200	124	982	217	157	4	6	5	15
9	2	228	2,950	1,110	110	797	262	363	4	6	5.5	12
10	2	239	6,710	920	415	311	212	96	4	6	5.5	10
11	2	250	9,940	842	590	90	582	47	3.5	5.5	5.5	38
12	2	262	10,400	389	428	52	1,860	42	3.5	5.5	5.5	415
13	2	337	9.420	1,850	337	176	2,450	42	3.5	5.5	5.5	940
14	2	1,220	7,420	2,260	152	716	4,700	36	3.5	5	6	1,420
15	2	1,960	6,120	2,980	90	982	6,080	32	3.5	5	52	1,640
16	2	2,080	4,490	3,600	90	1,110	5,940	60	11	4.5	132	1,730
17	2	2,700	3,240	4,260	90	880	5,360	15	9	4	110	1,760
18	2	2,750	1,470	3,360	84	356	4,450	13	8	4	262	1,680
19	2	2,950	960	2,900	57	67	3,120	11	7	4	350	770
20	2	2,850	806	3,560	38	38	1,310	7	7	4	262	274
21	2	2,360	542	4,700	27	27	550	5	6.5	4	206	186
22	4	2,400	475	5,620	21	24	162	4.5	16	4	157	114
23	17	2,950	304	5,720	17	20	72	4.5	206	4	337	64
24	84	4,450	140	5,800	17	16	32	4	617	4	376	38
25	72	6,030	356	5,760	16	132	21	4	503	4.5	626	25
26	57	6,510	635	4,160	47	448	17	4	206	5	454	20
27	42	6,030	496	3,330	196	542	47	4	90	5	196	15
28	38	4,660	274	2,080	590	370	57	4	47	5	196	10
29	38	......	217	662	851	422	38	4	30	5	132	8
30	34	......	110	833	635	311	27	3.5	21	5	44	5
31	19	......	78	......	324	......	21	3.5	......	5	......	5

NOTE.—Daily discharges for 1908 to 1909 were obtained from a rating fairly well defined, being based on measurements made during 1908 to 1910. Daily discharges have been estimated because of ice conditions for December 8 to 10 and 24 to 31, 1909.

Monthly discharge of Big Muddy River near Cambon, Ill., for 1908–9.

[Drainage area, 735 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
June 16-30	17	3	6.9	0.0094	0.005	B.
July	140	3	15.0	.020	.02	B.
August	67	2	18.3	.025	.03	B.
September	2	2	2.0	.0027	.003	C.
October	1	1	1.0	.0014	.002	C.
November	2	1	1.2	.0016	.002	C.
December	2	2	2.0	.0027	.003	C.
1909.						
January	84	2	14.4	.020	.02	C.
February	6,510	19	1,920	2.61	2.72	B.
March	10,400	78	2,460	3.35	3.86	B.
April	5,800	40	2,310	3.14	3.50	B.
May	950	16	261	.355	.41	B.
June	1,140	16	384	.522	.58	B.
July	6,080	15	1,230	1.67	1.92	B.
August	900	3.5	106	.144	.17	B.
September	617	2.5	61.1	.083	.09	B.
October	15	4	6.13	.0083	.01	C.
November	626	4.5	132	.180	.20	B.
December	1,760	....	366	.498	.57	C.
The period	10,400	....	771	1.05	14.05	

BEAUCOUP CREEK NEAR PINCKNEYVILLE, ILL.

Beaucoup Creek is tributary to Big Muddy River about 5 miles above Murphysboro in Jackson County.

The gaging station, which is located at the Illinois Central Railroad bridge about 1½ miles east of Pinckneyville, Ill., was established June 17, 1908, for the purpose of obtaining data for use in studying drainage and flood control problems.

Little Beaucoup Creek enters on the left bank below the gaging station, and Galum Creek on the right bank about 10 miles below the station. The drainage area above the station is 227 square miles.

Except in extreme low water, discharge measurements are made from the wooden trestle of the railroad bridge, at which the gage is located.

The datum of the chain gage has remained unchanged since the gage was installed. During 1908 observations were taken whenever the gage reader happened to be in the vicinity of the gage. The monthly discharges based on means for days when gage was read are believed to be fairly accurate.

The flood of 1902 reached a height of about 27.5 feet on the present gage. The creek goes dry at times; the water then stands in pools near the gage.

Discharge measurements of Beaucoup Creek near Pinckneyville, Ill., in 1908–9.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet.*	*Sec.-ft.*
1908.					
June 17	R. J. Taylor	53	48	2.3	12
1909.					
February 21	do	130	916	9.67	602
March 13	W. M. O'Neill	87	289	3.97	76
March 26	do	130	862	8.95	502
Do	do	128	692	7.87	449
March 27	do	106	396	5.25	170
May 11	H. J. Jackson	128	652	7.42	304
Do	do	107	477	5.93	217
November 3	do	66	67	1.73	0

Daily gage height, in feet, of Beaucoup Creek near Pinckneyville, Ill., for 1909.

[R. C. Huggins, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.
1	1.8	2.5	3.9	2.8	2.8	4.5	3.5	5.2	1.6	1.8	1.7	2.4
2	......	......	......	2.85	2.75	3.1	2.2	3.1	1.6	1.8	1.7	2.3
3	......	......	3.7	2.75	2.7	2.7	2.1	2.45	1.6	1.8	1.75	2.3
4	1.8	2.5	3.1	2.7	2.6	3.7	2.0	2.3	1.6	1.8	1.7	2.2
5	......	......	......	3.2	2.55	5.0	1.95	2.2	1.6	1.75	1.7	2.25
6	......	3.3	2.7	8.9	2.75	4.5	1.9	2.1	1.6	1.7	1.7	2.3
7	......	......	......	12.8	3.9	3.8	1.9	2.75	1.75	1.7	1.7	2.3
8	......	4.1	......	12.75	4.6	2.9	7.4	2.65	1.7	1.65	1.7	2.5
9	1.8	......	20.85	4.6	7.8	2.5	12.0	2.55	1.75	1.65	1.6	2.5
10	......	......	20.7	3.75	12.6	2.1	5.4	2.2	1.85	1.65	1.8	2.6
11	1.8	3.3	17.3	2.7	5.9	2.0	14.5	2.1	1.8	1.65	1.9	3.1
12	......	......	......	2.6	4.4	2.0	15.85	2.0	1.75	1.65	1.95	8.2
13	......	3.4	4.0	16.0	4.1	1.95	18.8	1.9	1.7	1.6	1.9	13.25
14	......	......	......	19.7	3.4	1.9	16.0	1.85	1.7	1.6	3.75	11.35
15	......	14.1	3.1	11.3	4.3	1.9	6.7	1.8	1.7	1.6	3.9	6.85
16	1.7	12.0	3.1	7.5	5.0	1.9	4.1	1.8	1.65	1.6	3.3	5.6
17	......	5.1	2.8	5.2	4.5	1.9	2.75	1.75	1.65	1.6	3.2	4.55
18	......	4.5	2.7	4.9	4.1	1.85	2.5	1.75	1.6	2.0	4.2	3.45
19	......	......	2.7	9.1	2.6	1.8	2.45	1.7	1.6	1.95	3.9	3.2
20	......	13.6	2.9	12.8	2.5	1.8	2.2	1.7	1.55	1.85	2.9	3.1
21	1.7	......	3.55	19.2	2.4	1.75	2.1	1.6	1.95	1.85	2.55	2.75
22	......	......	3.6	17.9	2.3	1.7	2.5	1.6	2.5	2.0	2.5	2.35
23	2.3	9.1	3.7	14.1	2.2	1.7	2.0	1.65	4.3	1.95	3.55	2.2
24	......	16.6	3.85	10.3	2.1	1.7	1.9	1.7	5.2	1.9	9.2	2.1
25	......	16.4	6.6	8.1	2.1	1.7	1.9	1.65	5.0	1.85	4.4	2.15
26	2.3	4.9	9.9	6.3	......	1.7	2.1	1.65	3.1	1.85	3.2	2.2
27	......	4.1	5.25	5.4	4.3	3.0	2.55	1.65	2.2	1.8	2.75	2.2
28	......	......	......	4.0	3.4	2.95	5.0	1.65	2.1	1.8	2.55	2.15
29	2.2	......	3.1	3.1	2.5	2.5	3.75	1.6	2.0	1.75	2.5	2.1
30	......	......	3.0	2.9	3.6	4.9	2.7	1.6	1.95	1.75	2.5	2.1
31	......	......	2.1	......	4.9	......	3.45	1.6	......	1.7	......	2.1

NOTE.—Ice conditions existed from December 8 to 31. On December 29 the creek was frozen over, thickness of ice varying from 3½ to 6 inches.

Daily discharge, in second-feet, of Beaucoup Creek near Pinckneyville, Ill., for 1908.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		50					3.0	16							2.0
2				1				17	8				0		
3		8	3		0			18		2	2				
4								19	3	2.5		1			2.0
5				1		0	3.0	20	3						
6			28					21		2			0	0	2.0
7			227					22			1	0			
8		6						23					0		
9							2.0	24	2						
10					0	0		25	2	28	2				
11		3	8					26							1.0
12							2.0	27		55		0		0	
13				1				28					0		
14		3						29	2	24	2				1.0
15			3					30							
								31							1.0

Daily discharge, in second-feet, of Beaucoup Creek near Pinckneyville, Ill., for 1909.

Day.	Jan.	Feb.	Mar	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2	14	75	24	24	112	55	163	1	2	2	11
2	2	14	70	26	22	36	6	36	1	2	2	8
3	2	14	65	22	20	20	4	12	1	2	2	8
4	2	14	36	20	17	65	3	8	1	2	2	6
5	2	30	28	40	16	147	3	6	1	2	2	7
6	2	45	20	512	22	112	3	4	1	2	2	8
7	2	66	727	1,010	75	70	3	22	2	2	2	8
8	2	86	1,430	1,000	119	28	353	18	2	1.5	2	14
9	2	72	2,140	119	393	14	900	16	2	1.5	1	14
10	2	59	2,120	68	984	4	179	6	2.5	1.5	2	17
11	2	45	1,640	20	219	3	1,250	4	2	1.5	3	36
12	2	48	860	17	105	3	1,440	3	2	1.5	3	435
13	2	50	80	1,460	86	3	1,850	3	2	1	3	1,080
14	2	620	58	1,980	50	3	1,460	2.5	2	1	68	816
15	2	1,190	36	809	98	3	290	2	2	1	75	304
16	2	900	36	363	147	3	86	2	1.5	1	45	195
17	2	155	24	163	112	3	22	2	1.5	1	40	116
18	2	112	20	140	86	2.5	14	2	1	3	92	52
19	2	616	20	534	17	2	12	2	1	3	75	40
20	2	1,120	28	1,010	14	2	6	2	1	2.5	28	36
21	2	600	58	1,910	11	2	4	1	3	2.5	16	22
22	5	567	60	1,730	8	2	14	1	14	3	14	10
23	8	534	65	1,190	6	2	3	1.5	98	3	58	6
24	8	1,540	72	679	4	2	3	2	163	3	545	4
25	8	1,520	281	424	4	2	3	1.5	147	2.5	105	5
26	8	140	628	254	51	2	4	1.5	36	2.5	40	6
27	7	86	167	179	98	32	16	1.5	6	2	22	6
28	7	80	99	80	50	30	147	1.5	4	2	16	4
29	6		36	36	14	14	68	1	3	2	14	3
30	9		32	28	60	140	20	1	3	2	14	3
31	11		4		140		52	1		2		2

NOTE.—Daily discharges for 1908 to 1909 were obtained from a rating fairly well defined between 3 and 640 second-feet, being based on measurements made 1908 to 1910. Discharges were estimated because of ice conditions for December 29 to 31, 1909. Discharges were interpolated for days of missing gage heights during 1909.

Monthly discharge of Beaucoup Creek near Pinckneyville Ill., for 1908–9.

[Drainage area, 227 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1908.					
June 14–30			3.3	0.015	0.008
July			16.7	.074	.09
August			30.7	.135	.16
September			.7	.0031	.003
October			.0	.0	.0
November			.0	.0	.0
December			1.9	.0084	.01
1909.					
January			3.8	.017	.02
February	1,540		369	1.63	1.70
March	2,140	4	355	1.56	1.80
April	1,980	17	528	2.33	2.60
May	984	4	99.1	.437	.50
June	147	2	28.8	.127	.14
July	1,850	3	267	1.18	1.36
August	163	1	10.6	.047	.05
September	163	1	16.9	.074	.08
October	3	1	1.98	.0087	.01
November	545	1	43.2	.019	.02
December	1,080		106	.467	.54
The year	2,140		154	.678	8.82

NOTE.—Monthly discharges for 1908 are based on means for days when gage was read.

MISCELLANEOUS MEASUREMENTS.

The following measurements at points other than regular gaging stations were made in the upper Mississippi River drainage basin in 1908 and 1909:

Miscellaneous measurements in upper Mississippi River drainage basin.

Date.	Stream.	Tributary to—	Locality.	Gage height.	Discharge.
1908.				*Feet.*	*Sec.-ft.*
March 26	Sugar Creek	Sangamon River	Illinois Central railroad bridge, near Hartsburg, Ill.	2.7	285
1909.					
August 4	Mississippi River		At Grand Rapids, Minn.	2.46	1,080
September 22	Rum River	Mississippi River	Mille Lac Lake outlet, Minn.	1.04	77.6
November 1	do	do	do	.40	93.8
November 7	do	do	do	.38	93.1
July 25	Whetstone River	Minnesota River	State line bridge at Bigstone, S. Dak.		14.2
August 16	do	do	do		9.7
September 18	do	do	do		5.0
June 1	Blue Earth River	do	At highway bridge 4 miles above Mankato, Minn.	6.00	2,670
June 16	do	do	do	5.55	2,340

SUMMARY OF MEAN DISCHARGE PER SQUARE MILE.

The following summary of discharge per square mile is given to allow ready comparison of relative rates of run-off from different areas in the upper Mississippi and Hudson Bay drainage basins.

It shows in a general way the seasonal distribution of run-off, and the effect of snow, ground, surface, and artificial storage. The most important fact worth noting is the almost entire lack of uniformity or agreement between any two streams, which 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 in upper Mississippi River and Hudson Bay basins for 1909.

Gaging station.	Drainage area.	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Sq. miles.													
St. Mary River near Babb, Mont	177	....	....	....	....	2.71	15.1	7.46	4.38	2.18	1.23	2.25	....	....
St. Mary River near Cardston, Alberta	452	....	....	....	....	3.87	9.91	5.15	....	....	....	....	....	....
Swiftcurrent River near Babb, Mont	101	....	....	....	1.18	7.56	21.0	7.75	4.71	1.68	.96	....	....	....
Ottertail River near Fergus Falls, Minn	1,310	....	....	....	.30	.35	.38	.26	.29	.42	.39	.32	0.30	....
Red River at Fargo, N. Dak	6,020	....	....	....	.16	.16	.18	.10	.11	.13	.13	.10	....	....
Red River at Grand Forks, N. Dak	25,000	0.03	0.02	0.04	.17	.12	.12	.15	.22	.13	.09	.08	.10	0.11
Wild Rice River at Twin Valley, Minn	805	....	....	....	....	....	....	2.40	1.19	.36	.13	.17	....	....
Red Lake River at Crookston, Minn	5,320	.09	.07	.12	.42	.29	.18	.32	.43	.25	.28	....	....	....
Clearwater River at Red Lake Falls, Minn	1,310	....	....	....	....	....	....	.39	.91	.30	.29	.21	.20	....
Pembina River at Neche, N. Dak	2,940	....	....	....	....	....	....	....	.02	.01	.02	....	....	....
Mouse River at Minot, N. Dak	8,400	....	....	....	.09	.03	.04	.01	.00	.00	.00	.00	....	....
Mississippi River at Anoka, Minn	17,100	.16	.15	.25	.66	.64	.66	.36	.52	.37	.35	.34	.31	.40
Crow River at Rockford, Minn	2,520	....	....	....	....	....	....	.38	.13	.12	.10	.11	.13	....
South Fork of Crow River near Rockford, Minn	1,160	....	....	....	....	....	....	.31	.09	.12	.10	.13	....	....
Rum River near Anoka, Minn	1,430	....	....	....	....	....	....	.39	.31	.26	.23	....	....	....
Minnesota River near Montevideo, Minn	6,300	....	....	....	....	....	....	....	.07	.04	.04	.05	.04	....
Cottonwood River near New Ulm, Minn	1,190	....	....	....	....	....	....	.58	.37	.07	.05	.10	....	....
Kettle River near Sandstone, Minn	825	.16	.14	.15	.82	1.81	.90	.35	1.28	.39	.36	.54	.24	.60
Snake River at Mora, Minn	422	....	....	....	....	....	....	.37	1.14	.18	.15	.29	.19	....
Chippewa River at Chippewa Falls, Wis	5,300	.26	.22	.24	1.48	2.87	1.51	.77	.68	.44	.55	1.83	1.29	1.01
Chippewa River near Eau Claire, Wis	6,740	.26	.22	.35	....	....	....	....	....	....	....	....	....	....
Black River at Neillsville, Wis	675	.14	.08	.21	....	....	....	....	....	....	....	....	....	....
Wisconsin River at Merrill, Wis	2,630	.57	.54	.50	1.72	2.72	1.34	.92	.70	.63	.54	1.62	.90	1.06
Wapsipinicon River at Stone City, Iowa	1,310	....	....	....	2.08	1.50	.92	.49	.44	.23	.11	.57	....	....
Cedar River at Cedar Rapids, Iowa	6,320	.26	.77	1.39	....	....	....	....	....	....	....	....	....	....
Des Moines River at Jackson, Minn	1,160	....	....	....	....	....	.95	1.14	.26	.07	.04	.08	....	....
Sangamon River at Monticello, Ill	550	.03	1.69	.82	2.20	1.34	1.01	1.74	.07	.03	.03	.20	.18	.78
Sangamon River at Riverton, Ill	2,560	.04	.84	.66	1.35	1.25	.91	1.62	.14	.07	.08	.28	.31	.63
Sangamon River near Oakford, Ill	5,000	....	....	....	....	....	....	....	....	....	....	.45	.36	....
South Fork of Sangamon River near Taylorville, Ill	427	.05	1.29	.45	1.75	1.09	.71	1.72	.06	.03	.08	.34	.28	.65
Salt Creek near Kenney, Ill	459	.05	1.35	.64	1.29	.87	.68	.87	.07	.03	.03	.38	.16	.54
Kaskaskia River near Arcola, Ill	390	(a)	1.94	1.31	3.64	1.81	1.05	2.22	.10	.04	.10	.50	.72	1.12
Kaskaskia River at Shelbyville, Ill	1,030	.04	1.60	1.06	4.12	1.88	1.69	2.13	.08	.02	.05	.36	.58	1.14
Kaskaskia River at Vandalia, Ill	1,980	.05	1.31	.93	2.51	1.21	1.27	1.47	.11	.06	.06	.53	.49	.83
Kaskaskia River at Carlyle, Ill	2,680	.03	.93	1.22	2.57	1.27	.98	1.21	.13	.08	.09	.61	.62	.81
Kaskaskia River at New Athens, Ill	5,220	.09	1.60	2.34	3.41	1.42	1.20	1.49	.17	.09	.20	.78	.60	1.12
Shoal Creek near Breese, Ill	760	....	....	....	....	....	....	....	....	....	....	....	.63	....
Silver Creek near Lebanon, Ill	335	....	1.84	1.27	2.35	.58	.85	1.53	.02	.05	.36	1.29	.46	....
Big Muddy River near Cambon, Ill	735	.02	2.61	3.35	3.14	.36	.52	1.67	.14	.08	.01	.18	.49	1.05
Beaucoup Creek near Pinckneyville, Ill	227	.02	1.63	1.56	2.33	.44	.13	1.18	.05	.07	.01	.02	.47	.68

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