Water-Supply and Irrigation Paper No. 207 Series P, Hydrographic Progress Reports, 61

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

SURFACE WATER SUPPLY
OF
UPPER MISSISSIPPI RIVER AND HUDSON BAY DRAINAGES

1906

A. H. HORTON AND ROBERT FOLLANSBEE
DISTRICT HYDROGRAPHERS

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CONTENTS.

ILLUSTRATIONS.

SURFACE WATER SUPPLY OF UPPER MISSISSIPPI AND HUDSON BAY DRAINAGES, 1906.[a]

A. H. HORTON and ROBERT FOLLANSBEE,
District Hydrographers.

INTRODUCTION.

SCOPE OF WORK.

The water supply of the United States is of more importance to the life and pursuits of the people than is any other natural resource. In the arid States the limit of agricultural development is determined by the amount of water available for irrigation; while in all parts of the country the increase in the population of cities and towns makes necessary additional water supplies for domestic and industrial uses, in procuring which both the quantity and the quality of the water that may be obtained must be considered. The location of manufacturing plants may depend largely on the water-power facilities and on the character of the water. The notable advances made in the electric transmission of power have led to the utilization of water powers for the operation of manufacturing establishments, railroads, and municipal lighting plants, many of which are at some distance from the places at which the power is developed.

The intelligent establishment and maintenance of enterprises or industries that depend on the use of water demands a thorough knowledge of the flow of the streams and an understanding of the conditions affecting that flow. This knowledge should be based on data showing both the total flow and the distribution of the flow throughout the year, in order that normal fluctuations may be provided for. As the flow of a stream is variable from year to year, estimates of future flow can be made only from a study of observations covering several years. The rapid increase in the development of the water resources of the United States has caused a great demand by engineers for information in regard to the flow of streams, as it is now

[a] This report contains information similar to that published in previous years under the title "Report of Progress of Stream Measurements."

generally realized that the failure of many large power, irrigation, and other projects has been due to the fact that the plans were made without sufficient trustworthy information in respect to the water supply.

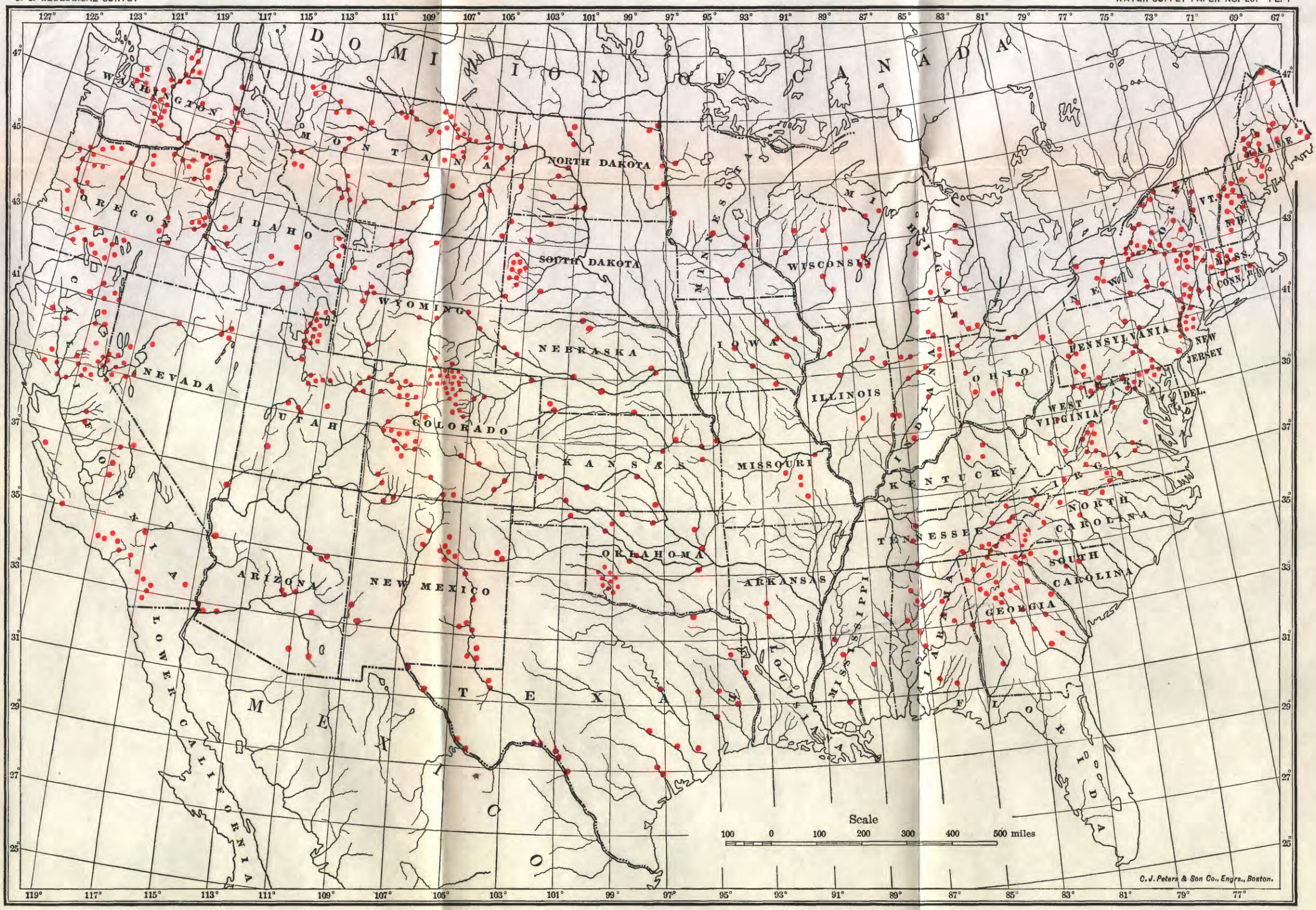
Owing to the broad scope of these hydrographic investigations and the length of time they should cover in order that the records may be of greatest value, it is in general impossible for private individuals to collect the necessary data, and as many of the streams traverse more than one State this work does not properly fall within the province of the State authorities. The United States Geological Survey has therefore, by means of specific appropriations by Congress, for several years systematically made records of stream flow, with the view of ultimately determining all the important features governing the flow of the principal streams of the country. In carrying out this plan stations are established on the streams and maintained for a period long enough to show their regimen or general behavior. When a record that is sufficient for this purpose has been obtained for any stream the work on that stream is discontinued. The order in which the streams are measured is determined by the degree of their importance.

During 1906 the regimen of flow was studied at about 700 stations distributed along the various rivers throughout the United States, as shown on Pl. I. In addition to these records data in regard to precipitation, evaporation, water power, and river profiles were obtained in many sections of the country.

These data have been assembled by drainage areas, and are published in a series of fourteen Water-Supply and Irrigation Papers Nos. 201 to 214, inclusive, each of which pertains to the surface water resources of a group of adjacent areas. In these papers are embodied not only the data collected in the field, but also the results of computations based on these data, and other information that has a direct bearing on the subject, such as descriptions of basins and the streams draining them, utility of the water resources, etc. The list follows:

Water-Supply and Irrigation Papers on Surface Water Supply, 1906.

201. Surface water supply of New England, 1906. (Atlantic Coast of New England drainage.)
202. Surface water supply of the Hudson, Passaic, Raritan, and Delaware river drainages, 1906.
203. Surface water supply of the Middle Atlantic States, 1906. (Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages.)
204. Surface water supply of the Southern Atlantic and Eastern Gulf States, 1906. (Santee, Savannah, Ogeechee, and Altamaha rivers and eastern Gulf of Mexico drainages.)
205. Surface water supply of the Ohio and lower eastern Mississippi river drainages, 1906.



MAP OF UNITED STATES SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1906.

206. Surface water supply of the Great Lakes and St. Lawrence River drainages, 1906.
207. Surface water supply of the upper Mississippi River and Hudson Bay drainage, 1906.
208. Surface water supply of the Missouri River drainage, 1906.
209. Surface water supply of the lower western Mississippi River drainage, 1906.
210. Surface water supply of the western Gulf of Mexico and Rio Grande drainages, 1906.
211. Surface water supply of the Colorado River drainage above Yuma, 1906.
212. Surface water supply of the Great Basin drainage, 1906.
213. Surface water supply of California, 1906. (The Great Basin and Pacific Ocean drainage in California, and Colorado River drainage below Yuma.)
214. Surface water supply of the North Pacific Coast drainages, 1906.

The records at most of the stations discussed in these reports extend over a series of years. An index of the reports containing such records up to and including 1903 has been published in Water-Supply Paper No. 119. The following table gives, by years and primary drainage basins, the numbers of the papers on the surface water supply, published from 1901 to 1906.

Numbers of water-supply papers containing results of stream measurements, 1901–1906.[a]

	1901.	1902.	1903.	1904.	1905.	1906.
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Atlantic Coast of New England drainage	65 75	82	97	124	165	201
Hudson, Passaic, Raritan, and Delaware river drainages	65 75	82	97	125	166	202
Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages	65 75	82 83	97 98	126	167	203
Santee, Savannah, Ogeechee, and Altamaha river and eastern Gulf of Mexico drainages	65 75	83	98	126	168	204
Ohio and lower eastern Mississippi river drainages	65 75	83	98	128	169	205
Great Lakes and St. Lawrence River drainages	65	83	97	129	170	206
Hudson Bay and upper eastern and western Mississippi River drainages	65 66 75	83 84 85	98 99 100	128 130	171	207
Missouri River drainage	66 75	84	99	130 131	172	208
Meramec, Arkansas, Red, and lower western Mississippi river drainages	66 75	84	99	131	173	209
Western Gulf of Mexico and Rio Grande drainages	66 75	84	99	132	174	210
Colorado River drainage above Yuma	66 75	85	100	133	175	211
The Great Basin drainage	66 75	85	100	133	176	212
The Great Basin and Pacific Ocean drainages in California, and Colorado River drainage below Yuma	66 75	85	100	134	177	213
North Pacific Coast drainages	66 75	85	100	135	178	214

DEFINITIONS.

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

[a] Reports containing data for years prior to 1901 are noted in the series list at the end of this paper.

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 quantity 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.

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

The "miner's inch" is the quantity of water that passes through an orifice 1 inch square under a head which varies locally. It has been 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. There is a convenient relation between the second-foot and the acre-foot: One second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, or approximately 2 acre-feet.

EXPLANATION AND USE OF TABLES.

For each regular gaging station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of monthly and yearly discharges and run-off.
6. Tables showing discharge and horsepower and the number of days during the year when the same are available.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and use the station, and they also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge

measurements made during the year, including the date, the name of the hydrographer, the width and area of cross section, the gage height, and the 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 heights taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The discharge measurements and gage heights are the base data from which the other tables are computed. In cases of extensive development, it is expected that engineers will use these original data in making their calculations, as the computations made by the Survey are based on the data available at the time they are made and should be reviewed and, if necessary, revised when additional data are available.

The rating table gives the discharge in second-feet, corresponding to various stages of the river, as given by the gage heights. It is published to enable engineers to determine the daily discharge in case this information is desired.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this 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 for each second during the month. Upon this the computations for the remaining columns, which are defined on page 4, are based.

The values in the table of monthly discharge are intended 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.

In most work where data in regard to flow are used the regimen of flow is of primary importance. Therefore for the principal stations tables have been prepared showing the horsepower that can be developed at various rates of flow and the length of time that these rates of flow and the corresponding horsepower are available. These tables have been prepared on a basis of 80 per cent efficiency on the turbines, and the horsepower per foot of fall is given in order that the reader can determine the horsepower for any fall.

In the computations sufficient significant figures have been used so that the percentage of error in the tables will not in general exceed 1 per cent. Therefore most of the values in the tables are given to

only three significant figures. In making the various computations Thatcher's slide rule, Crelle's tables, and computation machines have been generally used.

In order to give engineers an idea of the relative value of the various data, notes in regard to accuracy are given as far as possible. This accuracy depends on the general local conditions at the gaging stations and the amount of data collected. Every effort possible is made to so locate the stations that the data collected will give a high degree of accuracy. This is not always possible, but it is considered better to publish rough values with explanatory notes rather than no data.

In the accuracy notes the following terms have been used, indicating the probable accuracy in per cent of the mean monthly flow. As these values are mean values, the error in the value for the flow of any individual day may be much larger.

Excellent indicates that the mean monthly flow is probably accurate to within 5 per cent; good, to within 10 per cent; fair, to within 15 per cent; approximate, to within 25 per cent.

CONVENIENT EQUIVALENTS.

Following is a table 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 quals 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 equal 15.7 United States gallons per second
100 California miner's inches equal 96.0 Colorado miner's inches.
100 California miner's inches for one day equal 4.96 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gallons per second.
100 Colorado miner's inches equal 104 California miner's inches.
100 Colorado miner's inches for one day equal 5.17 acre-feet.

100 United States gallons per minute equal 0.223 second-foot.
100 United States gallons per minute for one day equal 0.442 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 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 equal 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.

FIELD METHODS OF MEASURING STREAM FLOW.

The methods used in collecting these data and in preparing them for publication are given in detail in Water-Supply Papers No. 94 (Hydrographic Manual, U. S. Geological Survey) and No. 95 (Accuracy of Stream Measurements). In order that those who use this report may readily become acquainted with the general methods employed, the following brief descriptions are given:

Streams may be divided, with respect to their physical conditions, into three classes—(1) those with permanent beds; (2) those with beds which change only during extreme low or high water; (3) those with constantly shifting beds. In determining the daily flow special methods are necessary for each class. The data upon which these determinations are based and the methods of collecting them are, however, in general the same.

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; (3) by measurements of the velocity of the current and the area of the cross section. The method chosen for any case depends upon 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 determining 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.

Weir methods.—When funds are available and the conditions are such that sharp-crested weirs can be erected, these offer the best facilities for determining the flow. If dams are suitably situated and constructed, they may be utilized for obtaining reliable measurements of flow. The conditions necessary to insure good results may be divided into two classes—(1) those relating to the physical characteristics of the dam itself and (2) those relating to the diversion and use of water around and through the dam.

The physical requirements are as follows: (*a*) Sufficient height of dam, so that backwater will not interfere with free fall over it; (*b*) absence of leaks of appreciable magnitude; (*c*) topography or abutments which confine the flow over the dam at high stages; (*d*) level crests, which are kept free from obstructions caused by floating logs or ice; (*e*) crests of a type for which the coefficients to be used in $Q = c\,b\,h^{\frac{3}{2}}$, or some similar standard weir formula are known (see Water-Supply Papers Nos. 180 and 200[a]); (*f*) either no flash boards or exceptional care in reducing leakage through them and in recording their condition.

Preferably there should be no diversion of water through or around the dam. Generally, however, the dam is built for purposes of power or navigation and part or all of the water flowing past it is diverted for such uses. This water is measured and added to that passing over the dam. To insure accuracy in such determinations of flow the amount of water diverted should be reasonably constant. Furthermore, it should be so diverted that it can be measured, either by a weir, a current meter, or a simple system of water wheels which are of standard make, or which have been rated as meters under working conditions, and so installed that the gate openings, the heads under which they work, and their angular velocities may be accurately observed.

The combination of physical conditions and uses of the water should be such that the determinations of flow will not involve, for a critical stage of considerable duration, the use of a head, on a broad-

[a] Water-Supply Paper No. 200 replaces No. 150, the edition of which has been exhausted.

crested dam, of less than 6 inches. Moreover, when all other conditions are good, the cooperation of the owners or operators of the plant is still essential if reliable results are to be obtained.

A gaging station at a weir or dam has the general advantage of continuity of record through the period of ice and floods and the disadvantages of uncertainty of coefficient to be used in the weir formula and of complications in the diversion and use of the water.

Velocity method.—The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a discharge measurement. This quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging section. The area depends upon the contour of the bed and the fluctuations of the water surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

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. Their essential requirements are practically the same whether the velocity is determined by meters or floats. They are located as far as possible where the channel is straight both above and below the gaging section; where there are no cross currents, backwater, or boils; where the bed of the stream is reasonably free from large projections of a permanent character; and where the banks are high and subject to overflow only at flood stages. The station must be so far removed from the effects of tributary streams and of dams or other artificial obstructions that the gage height shall be an index of the discharge.

Certain permanent or semipermanent structures usually referred to as equipment are generally pertinent to a gaging station. These are a gage for determining the fluctuations of the water surface, bench marks to which the datum of the gage is referred, permanent marks on a bridge or a tagged line indicating the points of measurement, and, where the current is swift, some appliance (generally a secondary cable) to hold the meter in position in the water. As a rule, the stations are located at bridges if the channel conditions are satisfactory, as from them the observations can more readily be made and the cost of the equipment is small.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In case of flood measurements, good results can be obtained by observing the velocity of floating cakes of ice or débris. In case of all surface-float measurements, coefficients must be used to reduce the observed velocity to the mean velocity.

The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run," a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined. This may be done by plotting the mean positions of the floats as indicated by the distances from the bank as ordinates and the corresponding times as abscissas. A curve through these points shows the mean time of run at any point across the stream, and the mean time for the whole stream is obtained by dividing the area bounded by this curve and its axis by the width. The length of the run divided by the mean time gives the mean velocity.

The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

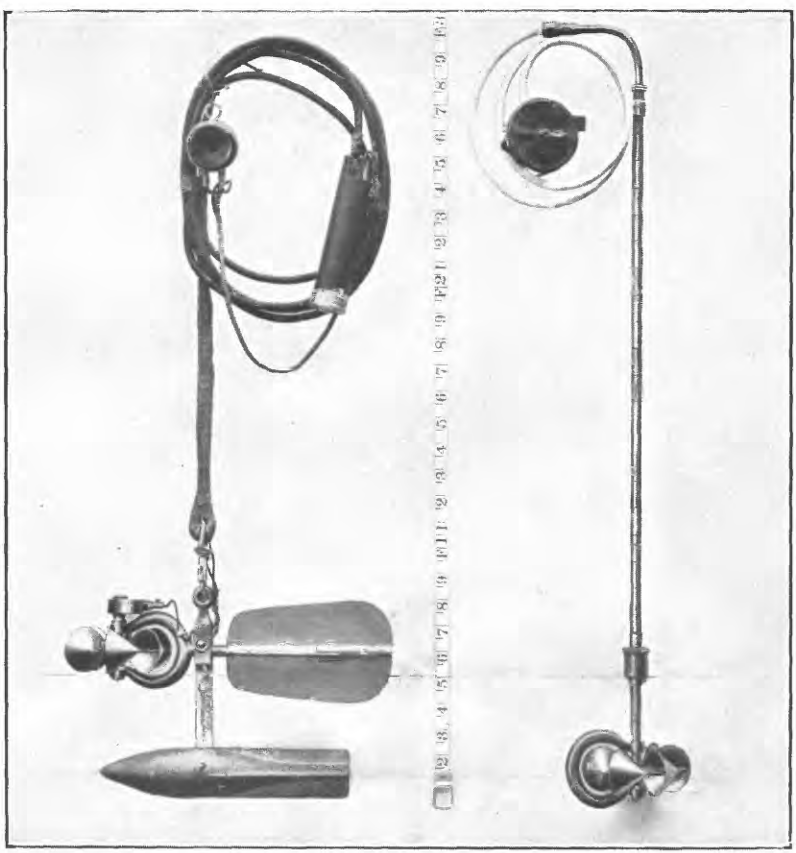
The essential parts of the current meters in use are a wheel of some type, so constructed that the impact of flowing water causes it to revolve, and a device for recording or indicating the number of revolutions. The relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter. This rating is done by drawing the meter 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 for any number of revolutions.

Many kinds of current meters have been constructed. They may, however, be classed in two general types: Those in which the wheel is made up of a series of cups, as the Price, and those having a screw propeller wheel, as the Haskell. Each meter has been developed for use under some special condition. In the case of the small Price meter, shown in Pl. II, *B*, which has been largely developed and has been extensively used by the United States Geological Survey, an attempt has been made to get an instrument which could be used under practically all conditions.

Current-meter measurements may be made from a bridge, a cable, a boat, or by wading, and gaging stations may be classified in accordance with such use. Fig. 1 shows a typical cable station.

In making the measurement an arbitrary number of points are laid off on a line perpendicular to the thread of the stream. The points at which the velocity and depth are observed are known as measuring points, and are usually fixed at regular intervals, varying from 2 to 20 feet, depending upon the size and condition of the stream. Perpendiculars dropped from the measuring points divide the gaging section into strips. For each strip or pair of strips the mean velocity,

A. CURRENT-METER RATING STATION AT LOS ANGELES, CAL.



B. PRICE CURRENT METERS.

area, and discharge are determined independently, so that conditions existing in one part of the stream may not be extended to parts where they do not apply.

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

The three principal multiple-point methods in general use are the vertical velocity-curve; 0.2 and 0.8 depth; and top, bottom, and mid-depth.

In the vertical velocity-curve method a series of velocity determinations are made in each vertical at regular intervals, usually from 0.5 to 1 foot 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. On account of the length

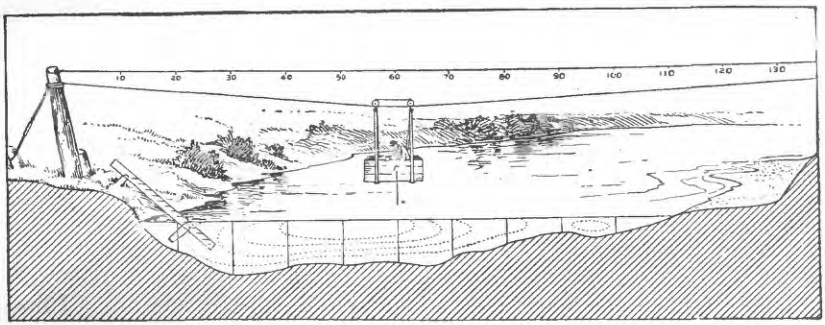


FIG. 1.—Cable station, showing section of river, car, gage, etc.

of time required to make a complete measurement by this method, its use is 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 of the depth, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity-curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 of the depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this second multiple-point method gives the mean velocity very closely for open-water conditions and, moreover, the indications are that it holds nearly as well for ice-covered rivers.

In the third multiple-point method the meter is held at mid-depth, at 0.5 foot below the surface, and at 0.5 foot above the bottom, and the mean velocity is determined by dividing by 6 the sum of the top

velocity, four times the mid-depth velocity, and the bottom velocity. This method may be modified by observing at 0.2, 0.6, and 0.8 depth.

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

Extensive experiments by vertical velocity-curves show that the thread of mean velocity generally occurs at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, at which point the meter is held in a majority of the measurements. 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.

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 from 0.85 to 0.95, depending upon 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 at 0.6 depth.

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.

The area, which is the other factor in the velocity method of determining the discharge of a stream, depends on the stage of the river, which is observed on the gage, and on the general contour of the bed of the stream, which is determined by soundings. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For streams with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also of value in obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at various points of measurement, the measuring section is divided into elementary strips, as shown in fig. 1, and the

mean velocity, area, and discharge are determined separately for either a single or a double strip. The total discharge and the area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

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 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, the thickness and character of the ice, etc. 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. For information in regard to flow under ice cover, see Water-Supply Paper No. 187.

OFFICE METHODS OF COMPUTING RUN-OFF.

There are two principal methods of determining run-off, depending upon whether or not the bed of the stream is permanent.

For stations on streams with permanent beds, the first step in computing the run-off is the construction of a rating table, which shows the discharge corresponding to any stage of the stream. This rating table is applied to the record of stage to determine the amount of water flowing. The construction of the rating table depends upon the method used in measuring flow.

For a station at a weir or dam, the basis for the rating table is some standard weir formula. The coefficients to be used in its application depend upon the type of dam and other conditions near its crest. After inserting in the weir formula the measured length of crest and assumed coefficient, the discharge is computed for various heads and the rating table constructed.

The data necessary for the construction of a rating table for a velocity-area station are the results of the discharge measurements, which include the record of stage of the river at the time of measurement, the area of the cross section, the mean velocity of the current, and the quantity of water flowing. A thorough knowledge of the conditions at and in the vicinity of the station is also necessary.

The construction of the rating table depends upon the following laws of flow for open, permanent channels: (1) The discharge will remain constant so long as conditions at or near the gaging station remain constant; (2) the discharge will be the same whenever the stream is at a given stage if the change of slope due to the rise and fall

of the stream be neglected; (3) the discharge is a function of and increases gradually with the stage.

The plotting of results of the various discharge measurements, using gage heights as ordinates, and discharge, mean velocity, and area as abscissas, will define curves which show the discharge, mean velocity, and area corresponding to any gage height. For the development of these curves there should be therefore a sufficient number of discharge measurements to cover the range of the stage of the stream. Fig. 2 shows a typical rating curve with its corresponding mean-velocity and area curves.

As the discharge is the product of two factors—the area and the mean velocity—any change in either factor will produce a corresponding change in the discharge. Their curves are therefore constructed in order to study each independently of the other.

The area curve can be definitely determined from accurate soundings extending to the limits of high water. It is always concave toward the horizontal axis or on a straight line, unless the banks of the stream are overhanging.

The form of the mean-velocity curve depends chiefly upon the surface slope, the roughness of the bed, and the cross section of the stream. Of these the slope is the principal factor. In accordance with the relative changes of these factors the curve may be either a straight line, convex or concave toward either axis, or a combination of the three. From a careful study of the conditions at any gaging station the form which the vertical velocity-curve will take can be predicted, and it may be extended with reasonable certainty to stages beyond the limits of actual measurements. Its principal use is in connection with the area curve in locating errors in discharge measurements and in constructing the rating table.

The discharge curve is defined primarily by the measurements of discharge, which are studied and weighted in accordance with the local conditions existing at the time of each measurement. The curve may, however, best be located between and beyond the measurements by means of curves of area and mean velocity. The discharge curve under normal conditions is concave toward the horizontal axis and is generally parabolic in form.

In the preparation of the rating table the discharge for each tenth or half tenth on the gage is taken from the curve. The differences between successive discharges are then taken and adjusted according to the law that they shall either be constant or increasing.

The determination of daily discharge of streams with changeable beds is a difficult problem. In case there is a weir or dam available, a condition which seldom exists on streams of this class, the discharge can be determined by its use. In case of velocity-area stations frequent discharge measurements must be made if the deter-

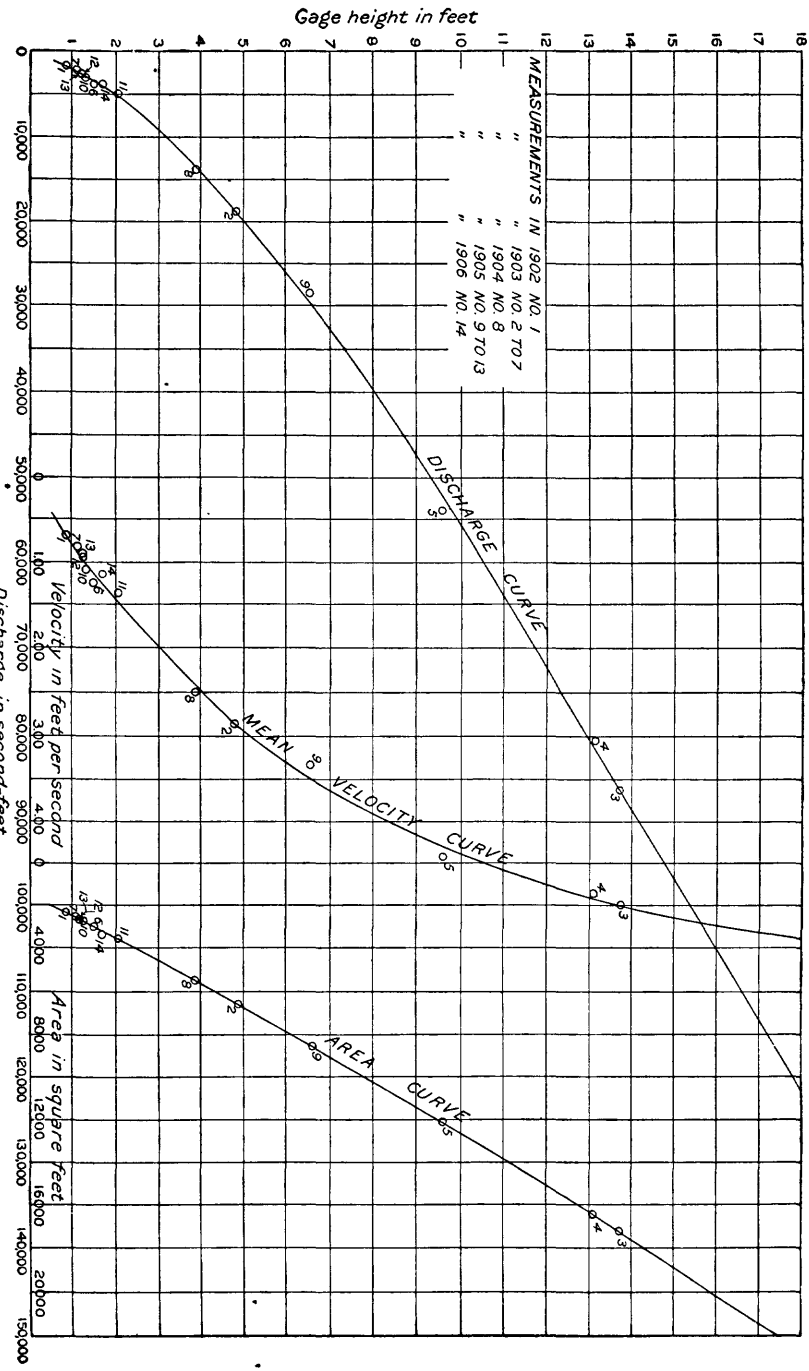


FIG. 2.—Discharge, area, and mean-velocity curves of Potomac River at Point of Rocks, Md.

minations of flow are to be other than rough approximations. For stations with beds which shift slowly or are materially changed only during floods, rating tables can be prepared for periods between such changes and satisfactory results obtained with a limited number of measurements, provided that some of them are taken soon after the change occurs. For streams with continually shifting beds, such as the Colorado and Rio Grande, discharge measurements should be made every two or three days and the discharge for intervening days obtained either by interpolation modified by gage height or by Professor Stout's method, which has been described in full in the Nineteenth Annual Report of the United States Geological Survey, Part IV, page 323, and in the Engineering News of April 21, 1904. This method, or a graphical application of it, is also much used in determining the flow at stations where the bed shifts but slowly.

COOPERATION AND ACKNOWLEDGMENTS.

Assistance has been rendered and records furnished by the following, to whom special acknowledgment is due: D. W. Mead, Madison, Wis.; officers and observers of the U. S. Weather Bureau; the Wisconsin Geological and Natural History Survey, E. A. Birge, director and superintendent.

HUDSON BAY DRAINAGE.

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 two principal tributaries of Lake Winnipeg, and thus, indirectly, of Nelson River, are the Saskatchewan and Red River. The Saskatchewan drains the major portions of the provinces of Alberta and Saskatchewan and the northwestern part of Assiniboia, 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. Both rivers are large and important.

ST. MARY RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

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 numerous 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 sources and flow into a lake hemmed in by high mountains, known as Upper St. Mary Lake. Below this lake, separated from it by a narrow strip of land, is Lower St. Mary Lake, the aggregate length of the two lakes being 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 a stream nearly if not quite as large as itself, known as Swiftcurrent Creek, which is fed by the waters of Grinnell Glacier and four smaller 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 canal has been constructed in Canada by the Canadian Northwest Irrigation Company to divert water from the right bank of St. Mary River, about 5 miles below the international boundary line.

The data collected in the basin are valuable for irrigation purposes.

ST. MARY RIVER NEAR BABB, MONT.[a]

This station was established April 9, 1902. It is located at Henry Henkel's ranch, about 1 mile east of his house and 35 miles northwest of Browning, Mont. It is also about 4,500 feet below the foot of Lower St. Mary Lake. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 17, where are given also references to publications that contain data for previous years.

Discharge measurements of St. Mary River near Babb, Mont., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 31	Freeman and Edson	50	50	1.40	66
May 11	W. B. Freeman	92	172	2.92	a 631
August 18	Morse and Hartman	90	161	2.82	629
September 14	Richards and Hartman	88	132	2.42	420

a Meter probably not in good order, causing results to be too low.

Daily gage height, in feet, of St. Mary River near Babb, Mont., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.9	1.9	1.4	1.5	2.8	3.3	3.7	3.0	2.8	2.2	3.0	2.7
2	1.9	1.9	1.4	1.5	2.8	3.3	3.7	3.0	2.8	2.1	3.1	2.6
3	1.9	1.9	1.4	1.5	2.9	3.5	3.7	2.9	2.8	2.2	3.1	2.6
4	1.9	1.9	1.4	1.5	2.9	3.6	3.7	2.9	2.8	2.1	3.1	2.5
5	1.9	1.9	1.4	1.6	2.9	3.7	3.8	2.9	2.7	2.2	3.0	2.5
6	1.9	1.9	1.5	1.6	2.9	3.8	3.8	2.9	2.7	2.1	2.9	2.4
7	1.9	1.9	1.5	1.6	2.9	3.8	3.9	2.8	2.7	2.2	2.8	2.4
8	1.9	1.9	1.5	1.6	2.9	3.9	3.9	2.8	2.7	2.1	2.9	2.4
9	1.9	1.9	1.5	1.6	2.9	3.9	4.0	2.8	2.7	2.3	2.7	2.3
10	1.9	1.9	1.5	1.6	3.0	3.9	4.0	2.8	2.6	2.2	2.2	2.7

a Formerly dam site.

Daily gage height, in feet, of St. Marg River near Babb, Mont., for 1906—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
11	1.9	1.9	1.7	1.6	3.0	3.9	4.1	2.7	2.6	2.3	2.8	2.0
12	1.9	1.9	1.7	1.6	3.0	3.9	4.1	2.7	2.5	2.2	2.8	2.0
13	1.9	1.9	1.7	1.7	3.1	4.0	4.2	2.7	2.5	2.3	2.9	2.0
14	1.9	1.9	1.7	1.7	3.3	4.1	4.1	2.7	2.4	2.2	2.9	2.0
15	1.9	1.9	1.7	1.7	3.4	4.2	4.1	2.7	2.4	2.4	3.0	2.0
16	1.9	1.9	1.7	1.7	3.6	4.3	4.0	2.7	2.4	2.3	3.0	2.0
17	1.9	1.9	1.7	1.7	3.5	4.0	3.9	2.8	2.4	2.4	3.1	2.0
18	1.9	1.9	1.5	1.7	3.5	4.0	3.8	2.8	2.3	2.4	3.0	1.9
19	1.9	1.9	1.5	1.8	3.4	4.0	3.7	2.8	2.3	2.5	3.0	1.9
20	1.9	1.4	1.6	1.8	3.4	3.9	3.6	2.9	2.3	2.4	3.0	1.9
21	1.9	1.4	1.6	1.9	3.3	3.9	3.5	2.9	2.2	2.6	2.9	1.9
22	1.9	1.4	1.6	2.0	3.3	3.8	3.5	3.0	2.2	2.5	2.9	1.9
23	1.9	1.4	1.6	2.1	3.3	3.7	3.4	3.0	2.2	2.6	2.9	1.9
24	1.9	1.4	1.6	2.2	3.2	3.7	3.4	3.0	2.2	2.6	2.9	1.8
25	1.9	1.4	1.6	2.3	3.2	3.6	3.3	3.1	2.2	2.7	2.8	1.8
26	1.9	1.4	1.5	2.5	3.3	3.6	3.2	3.0	2.2	2.6	2.8	1.8
27	1.9	1.4	1.5	2.6	3.3	3.5	3.2	3.0	2.1	2.7	2.8	1.8
28	1.9	1.4	1.4	2.7	3.3	3.6	3.1	3.0	2.1	2.7	2.7	1.8
29	1.9	.....	1.4	2.7	3.3	3.6	3.1	2.9	2.1	2.8	2.7	1.8
30	1.9	.....	1.4	2.7	3.3	3.7	3.3	2.9	2.1	2.8	2.7	1.8
31	1.9	.....	1.4	.....	3.3	.....	3.3	2.8	.....	3.0	.....	1.8

NOTE.—Ice conditions January 1 to February 19, March 11 to 26; gage heights to surface of ice. Practically open-channel condition during December.

Rating table for St. Mary River near Babb, Mont., for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.40	65	2.20	325	3.00	725	3.80	1,300
1.50	90	2.30	365	3.10	790	3.90	1,380
1.60	115	2.40	410	3.20	855	4.00	1,460
1.70	145	2.50	455	3.30	925	4.10	1,545
1.80	175	2.60	505	3.40	995	4.20	1,630
1.90	210	2.70	555	3.50	1,070	4.30	1,715
2.00	245	2.80	610	3.60	1,145		
2.10	285	2.90	665	3.70	1,220		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1905 and 1906. It is well defined between gage heights 1.4 and 4 feet.

Monthly discharge of St. Mary River near Babb, Mont., for 1906.

[Drainage area, 177 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
January	.....	.....	[a] 70	4,300	0.396	0.46
February	.....	.....	[a] 65	3,610	.367	.38
March [b]	90	65	82.7	5,080	.467	.54
April	555	90	218	13,000	1.23	1.37
May	1,140	610	841	51,700	4.75	5.48
June	1,720	925	1,300	77,400	7.34	8.19
July	1,630	790	1,220	75,000	6.89	7.94
August	790	555	649	39,900	3.67	4.23
September	610	285	432	25,700	2.44	2.72
October	725	285	421	25,900	2.38	2.74
November	790	555	666	39,600	3.76	4.20
December	555	175	283	17,400	1.60	1.84
The year	1,720	.....	521	379,000	2.94	40.09

[a] Discharge January 1 to February 19 estimated by C. C. Babb.
[b] Discharge estimated March 11 to 25.

NOTE.—Values are rated as follows: January and February, approximate; April to November, excellent: March, fair: December, good.

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. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 19, where are given also references to publications that contain data for previous years.

Discharge measurements of St. Mary River near Cardston, Alberta, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 1	Freeman and Edson	90	126	2.90	138
May 12	W. B. Freeman	108	341	5.10	[a] 1,350
August 20	do	105	249	4.29	746
September 13	Richards and Hartman	102	231	4.13	650

[a] Meter probably not in good order, causing result to be too low.

Daily gage height, in feet, of St. Mary River near Cardston, Alberta, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	3.5	4.25	3.75	.....	4.6	5.45	5.45	4.65	4.55	3.7	4.8	4.05
2	3.5	4.25	3.8	2.95	4.65	.....	5.4	4.5	4.55	3.75	.....	4.05
3	3.5	.....	4.1	2.95	4.7	5.6	5.4	4.5	4.45	3.85	4.6	4.0
4	3.75	4.45	4.2	3.0	.....	5.65	5.45	4.45	4.45	4.0	4.5	3.95
5	3.75	4.5	.....	3.05	4.7	5.75	5.5	4.4	4.4	4.1	4.5	3.9
6	3.75	4.6	3.85	3.1	4.7	5.75	5.5	4.3	4.35	4.15	4.45	3.9
7	3.75	4.6	3.7	3.15	4.65	5.7	5.5	4.25	4.3	4.15	.....	3.8
8	3.75	4.65	3.6	3.25	4.65	5.55	5.5	4.25	4.3	4.1	4.35	3.7
9	.....	4.65	3.6	3.3	4.7	5.55	5.6	4.2	4.3	4.05	4.3	3.75
10	3.75	4.65	3.5	3.3	4.75	5.55	5.6	4.2	4.25	4.1	4.3	3.7
11	3.75	4.7	.....	3.3	4.8	5.55	5.6	4.2	4.2	.....	4.3	3.6
12	3.75	4.7	.....	3.35	5.0	5.75	5.6	4.25	4.15	4.1	4.5	.....
13	3.75	4.7	4.4	3.35	5.1	.....	5.6	4.3	4.15	4.1	4.6	3.5
14	3.75	4.7	4.45	.....	5.25	5.7	5.4	4.35	4.05	4.1	4.7	3.4
15	3.75	4.7	4.5	3.35	5.35	5.6	5.35	4.4	4.0	4.1	5.05	3.35
16	3.75	4.7	4.55	3.4	5.3	5.6	5.3	4.4	3.95	4.1	.....	.....
17	3.75	4.7	.....	3.5	5.3	5.5	5.2	.....	3.9	4.1	.....	3.3
18	3.75	4.7	4.6	3.55	5.1	5.55	5.25	4.35	3.85	4.1	5.1	3.3
19	3.75	4.5	4.6	3.65	5.05	5.4	5.2	4.35	3.8	.....	5.1	3.3
20	3.75	4.5	4.6	3.75	5.05	5.35	5.15	4.3	3.8	4.2	4.9	3.35
21	3.75	4.5	4.6	3.8	5.0	5.25	5.05	4.35	.....	4.15	4.95	3.35
22	3.75	4.5	4.6	4.05	5.05	5.35	5.0	4.5	3.8	4.1	4.85	3.4
23	3.75	4.5	4.5	4.25	5.05	5.45	4.95	4.6	3.8	4.1	4.8	3.45
24	3.8	4.5	4.5	4.6	5.1	5.3	4.95	4.75	3.85	4.1	4.7	3.45
25	4.0	4.35	4.45	4.6	.....	5.25	4.9	4.95	3.85	4.1	4.55	3.5
26	.....	4.3	4.3	4.65	5.15	.....	4.85	.....	3.85	4.5	4.5	3.5
27	4.25	4.2	4.2	4.65	5.15	5.55	4.85	4.85	3.8	4.75	4.4	3.45
28	4.15	.....	3.3	4.65	5.2	5.65	4.75	4.8	3.7	5.0	4.35	3.4
29	4.2	.....	.....	.....	5.25	5.5	4.65	4.7	3.7	5.0	4.2	3.3
30	4.2	.....	.....	4.55	5.25	5.55	.....	4.65	3.65	4.95	4.15	.....
31	4.25	.....	2.90	.....	5.3	.....	4.65	4.6	.....	4.85	.....	.....

NOTE.—Ice conditions January 1 to March 31; river frozen to bottom during greater portion of ice period; gage heights are to ice surface, except for short periods when water overflowed ice. Ice conditions December 9 to 31; gage readings to water surface.

Rating table for St. Mary River near Cardston, Alberta, for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.90	153	3.70	410	4.50	960	5.30	1,900
3.00	174	3.80	460	4.60	1,055	5.40	2,055
3.10	198	3.90	515	4.70	1,155	5.50	2,215
3.20	225	4.00	575	4.80	1,260	5.60	2,385
3.30	255	4.10	640	4.90	1,370	5.70	2,565
3.40	288	4.20	710	5.00	1,490	5.80	2,755
3.50	325	4.30	785	5.10	1,620		
3.60	365	4.40	870	5.20	1,755		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 22 discharge measurements made during 1902–1906. It is well defined between gage heights 2.5 feet and 7 feet.

Monthly discharge of St. Mary River near Cardston, Alberta, for 1906.

[Drainage area, 452 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
January			[a] 100	6,150	0.221	0.25
February			[a] 95	5,280	.210	.22
March			[b] 125	7,690	.277	.32
April	1,100	160	481	28,600	1.06	1.18
May	1,990	1,060	1,500	92,200	3.32	3.83
June	2,660	1,830	2,280	136,000	5.04	5.62
July	2,380	1,100	1,830	113,000	4.05	4.67
August	1,430	710	946	58,200	2.09	2.41
September	1,010	385	628	37,400	1.39	1.55
October	1,490	410	756	46,500	1.67	1.92
November	1,620	675	1,100	65,500	2.43	2.71
December [c]	607	255	359	22,100	.794	.92
The year	2,660		850	619,000	1.88	25.60

[a] January and February estimated by C. C. Babb.
[b] Estimated from flow of St. Mary and Swiftcurrent near Babb, Mont.
[c] Flow only slightly affected by ice conditions.

NOTE.—Values are rated as follows: January and February, approximate; March, fair; April to November, excellent; December, good.

SWIFTCURRENT CREEK NEAR BABB, MONT.

This station was established April 8, 1902. It is located one-half mile northwest of Henkel's ranch and 36 miles northwest of Browning, Mont. The nearest post-office is at Babb, Mont., 2 miles below. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 21, where are given also references to publications that contain data for previous years. The length of the chain is now 15.90 feet.

Discharge measurements of Swiftcurrent Creek near Babb, Mont., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 31	Freeman and Edson	30	30	2.08	48
May 12	W. B. Freeman	55	108	3.60	[a] 501
August 18	Morse and Hartman	55	71	2.73	233
September 14	Richards and Hartman	50	53	2.38	146

[a] Meter probably out of order, causing result to be too low.

Daily gage height, in feet, of Swiftcurrent Creek near Babb, Mont., for 1906.

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

NOTE.—Ice conditions January 1 to February 20, March 11 to 25, readings are to top of ice. Practically open-channel conditions during December.

Rating table for Swiftcurrent Creek near Babb, Mont., for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.70	7	2.40	130	3.10	385	3.80	800
1.80	18	2.50	160	3.20	435	3.90	875
1.90	30	2.60	190	3.30	485	4.00	950
2.00	44	2.70	225	3.40	540	4.10	1,025
2.10	60	2.80	260	3.50	600	4.20	1,100
2.20	80	2.90	300	3.60	665	4.30	1,175
2.30	105	3.00	340	3.70	730		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1905 and 1906. It is well defined between gage heights 2.1 feet and 4.5 feet.

Monthly discharge of Swiftcurrent Creek near Babb, Mont., for 1906.

[Drainage area, 101 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
January			[a] 30	1,840	0.297	0.34
February			[a] 30	1,670	.297	.31
March	60	7	[b] 29.5	1,810	.292	.34
April	600	60	299	17,800	2.96	3.30
May	730	385	500	30,700	4.95	5.71
June	1,020	485	623	37,100	6.17	6.88
July	540	225	381	23,400	3.77	4.35
August	300	160	220	13,500	2.18	2.51
September	260	80	151	8,980	1.50	1.67
October	875	130	347	21,300	3.44	3.97
November	485	190	308	18,300	3.05	3.40
December	190	7	55.5	3,410	.550	.63
The year	1,020	7	248	180,000	2.45	33.41

[a] January and February estimated by C. C. Babb. [b] Discharge estimated March 11 to 25.

NOTE.—Values are rated as follows: January to March, approximate; April to November, excellent; December, good.

KENNEDY CREEK NEAR BABB, MONT.

This station was established October 17, 1903. It is located 50 feet above the ford on the road from Altyn, Mont., to Cardston, Alberta, and is 37 miles northwest of Browning, Mont., and about 4 miles north of Babb post-office. The station is situated where the creek emerges from the canyon, about 1½ miles above its confluence with St. Mary River. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 24, where are given also references to publications that contain data for previous years.

Discharge measurements of Kennedy Creek near Babb, Mont., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 31	Freeman and Edson	19	19	5.74	28.7
May 12	W. B. Freeman	57	72	6.38	[a] 17.2
August 18	Morse and Hartman	50	34	5.78	49.4
September 14	Richards and Hartman	51	43	5.91	66.4

[a] Meter probably out of order, causing result to be too low.

RED RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Red River rises in Lake Traverse, on the boundary line between South Dakota and Minnesota, and flows almost due north into Lake Winnipeg, its waters finally reaching Hudson Bay through Nelson River. It drains a large area in the United States, including portions of Minnesota and of South and North Dakota.

The basin is characterized by level topography, broken in places by moraines and other glacial deposits. The greater part of it is prairie land, and its eastern half comprises some woods and a great abundance of lakes. The main river has cut a deep channel in its broad, level valley, which includes about 9,000,000 acres of excellent agricultural land. The heavy spring rains cause sudden freshets, which frequently entail considerable loss of life and property. The principal tributaries of the stream from the United States are Sheyenne and Pembina rivers from the west and Ottertail and Red Lake rivers from the east. Mouse River drains into it through Assiniboine River. A number of water powers have been developed during recent years on tributaries from both sides.

The data collected in this basin are valuable for water power and drainage purposes.

RED RIVER AT FARGO, N. DAK.

This station was established May 27, 1901. It is located at the bridge connecting Front street, Fargo, N. Dak., with Main street, Moorhead, Minn. Gage heights are furnished by the United States Weather Bureau. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 27, where are given also references to publications that contain data for previous years.

Discharge measurements of Red River at Fargo, N. Dak., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 18..	R. Richards	108	410	8.84	760
1906.					
April 14.....	E. F. Chandler	90	690	13.69	[a]2,390
June 27.....	do	120	774	12.03	1,630
September 10..	do	110	533	10.04	971
October 27.....	do	112	567	10.20	987

[a] At Northern Pacific Railway bridge.

Daily gage height, in feet, of Red River at Fargo, N. Dak., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	8.6	8.6	9.8	12.6	10.9	12.7	12.2	10.9	11.1	10.5	10.6	11.0
2.....				13.2	11.0	12.5	12.2	11.1	10.9	10.4	10.6	.....
3.....				13.4	11.1	12.4	12.5	11.4	10.7	10.3	10.6	.....
4.....				13.5	11.2	12.2	12.6	11.3	10.6	10.2	10.5	.....
5.....				13.5	11.3	12.1	12.7	11.4	10.5	10.1	10.5	.....
6.....				13.7	11.4	12.0	12.7	11.5	10.4	10.0	10.4	.....
7.....				14.1	11.4	12.1	12.7	11.4	10.2	10.0	10.4	.....
8.....			10.2	14.9	11.4	12.1	12.6	11.3	10.0	9.9	10.3	.....
9.....			10.8	15.5	11.3	12.2	12.5	11.2	10.0	9.8	10.2	.....
10.....			11.2	14.9	11.2	12.2	12.3	11.1	10.0	9.6	10.1	.....
11.....				13.3	11.1	12.3	12.2	11.0	10.1	9.6	10.1	.....
12.....		8.6		12.3	11.2	12.2	12.0	10.9	10.0	9.6	10.1	.....
13.....				12.4	10.9	12.1	11.8	10.8	9.9	9.5	10.1	.....
14.....				13.5	10.8	12.0	11.8	10.7	9.9	9.5	10.0	.....
15.....				14.2	10.7	12.0	11.8	10.6	9.9	9.5	10.0	.....

Daily gage height, in feet, of Red River at Fargo, N. Dak., for 1906—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
16				14.5	12.5	12.0	11.6	10.5	9.9	9.3	9.4	
17				14.9	14.0	11.9	11.5	10.4	9.9	9.5	9.8	
18				15.0	13.8	12.0	11.5	10.6	9.9	9.5	9.6	
19				14.5	13.3	12.0	11.5	10.8	9.9	9.5	9.4	
20			10.0	13.7	12.7	12.0	11.4	10.8	10.0	9.3	9.2	
21				12.9	12.4	12.0	11.3	10.8	10.0	9.3		
22		9.8		11.0	12.2	11.9	11.2	10.9	10.2	9.3		
23				11.8	12.1	11.9	11.1	10.8	10.4	9.4		
24				11.5	12.0	11.8	11.1	10.8	10.5	9.5		10.5
25			10.0	11.2	11.9	11.8	11.0	10.9	10.8	9.6		
26			10.0	11.0	12.1	12.0	10.9	10.9	10.8	10.0		
27			10.0	10.9	12.8	12.0	10.9	10.9	10.8	10.2	9.6	
28			10.2	10.8	12.5	12.0	10.9	11.0	10.7	10.5	9.8	
29			10.5	10.8	12.7	12.2	10.9	11.1	10.6	10.6	10.4	
30			11.5	10.8	12.8	12.2	10.9	11.3	10.6	10.6	11.0	
31			12.1		12.9		10.9	11.3		10.6		

NOTE.—Ice conditions January 1 to April 6 and November 21 to December 31: ice 2 to 3 feet thick during first part of year and 0.5 to 1.5 feet during latter part of year.

Rating table for Red River at Fargo, N. Dak., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
8.80	653	10.10	1,008	11.40	1,429	13.40	2,185
8.90	678	10.20	1,038	11.50	1,464	13.60	2,266
9.00	703	10.30	1,069	11.60	1,499	13.80	2,348
9.10	729	10.40	1,100	11.70	1,535	14.00	2,430
9.20	755	10.50	1,131	11.80	1,571	14.20	2,512
9.30	781	10.60	1,163	11.90	1,607	14.40	2,594
9.40	808	10.70	1,195	12.00	1,644	14.60	2,676
9.50	835	10.80	1,227	12.20	1,718	14.80	2,758
9.60	863	10.90	1,260	12.40	1,793	15.00	2,840
9.70	891	11.00	1,293	12.60	1,869	16.00	3,260
9.80	920	11.10	1,326	12.80	1,947		
9.90	949	11.20	1,360	13.00	2,025		
10.00	978	11.30	1,394	13.20	2,105		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 4 discharge measurements made during 1906 and a number of older measurements. It is fairly well defined.

Monthly discharge of Red River at Fargo, N. Dak., for 1906.

[Drainage area, 6,020 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
April[a]	3,050	1,230	2,050	122,000	0.341	0.38
May	2,430	1,200	1,630	100,000	.271	.31
June	1,910	1,570	1,680	100,000	.279	.31
July	1,910	1,260	1,550	95,300	.257	.30
August	1,460	1,100	1,290	79,300	.214	.25
September	1,330	949	1,070	63,700	.178	.20
October	1,160	781	940	57,800	.156	.18
November[b]	1,160		942	56,100	.156	.17
The period				674,000		

[a] River not materially affected by ice conditions first week in April.
[b] Discharge estimated November 21 to 30.

NOTE.—Values are rated as follows: April, good; May to October, excellent; November, fair.

RED RIVER AT GRAND FORKS, N. DAK.

This station was established May 26, 1901. It is located at the Northern Pacific Railway bridge at Grand Forks, N. Dak. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 29, where are given also references to publications that contain data for previous years.

Discharge measurements of Red River at Grand Forks, N. Dak., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
December 22	E. F. Chandler	208	1,110	[a] 9.05	[b] 1,840
1906.					
January 29	Chandler and Richards	207	1,060	[c] 9.45	[b] 1,770
March 5	do	205	949	[d] 9.51	[b] 1,550
March 23	do	207	1,110	[e] 10.24	[b] 1,880
April 9	R. Richards	576	9,140	32.40	23,000
August 11	E. F. Chandler	161	1,510	10.27	3,710
November 5	do	160	1,140	8.21	2,410
December 21	do	198	1,070	[f] 8.59	[b] 1,700

[a] Gage height to under side of ice=8.02.
[b] Ice measurements; gage heights are to the water surface in a hole in the ice.
[c] Gage height to under side of ice=7.79.
[d] Gage height to under side of ice=7.01.
[e] Gage height to under side of ice=7.82.
[f] Gage height to under side of ice=7.71.

Daily gage height, in feet, of Red River at Grand Forks, N. Dak., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				17.8	18.5	16.4	13.1	9.6	8.7	8.4	7.9	8.8
2				21.9	17.8	16.3	13.2	9.9	9.1	8.5	8.35	.....
3		9.5	9.5	25.1	17.4	16.1	13.25	10.1	9.15	8.4	8.35	.....
4				27.9	17.25	15.8	13.8	10.4	9.2	8.25	8.3	.....
5			9.5	30.55	17.25	15.4	14.4	10.6	9.05	8.3	8.25	.....
6	9.35			32.5	17.25	15.25	14.65	10.25	8.9	8.4	8.4	.....
7				33.5	17.2	15.1	14.4	10.85	8.55	8.45	8.05	.....
8				33.3	17.1	14.75	14.15	10.8	8.4	8.3	8.1	8.9
9				32.25	16.9	14.5	13.85	10.6	8.3	8.1	8.2	.....
10		9.35	9.7	31.0	16.7	14.35	13.5	10.5	8.3	7.85	8.5	.....
11				30.1	16.35	14.2	13.0	10.25	8.3	8.0	8.25	.....
12				29.25	16.0	14.2	12.75	10.1	8.2	7.85	8.25	.....
13	9.2			28.9	15.65	14.0	12.35	9.85	8.25	7.8	8.1	.....
14				29.5	15.25	13.85	11.95	9.65	8.1	7.7	8.1	.....
15				31.1	15.5	13.65	11.65	9.55	7.9	7.8	8.1	8.4
16				34.0	16.15	13.3	11.3	9.4	7.8	7.7	7.6	.....
17		9.2	10.3	35.5	16.75	13.0	11.1	9.3	7.8	7.6	7.2	.....
18				36.0	16.75	12.85	10.85	9.2	7.9	7.7	7.15	.....
19				35.85	16.9	12.8	10.7	9.05	7.85	7.6	7.4	.....
20	9.4			35.15	17.2	13.1	10.5	9.0	8.0	7.55	.....	.....
21				34.2	17.1	13.35	10.45	9.0	7.95	7.55	7.5	.....
22				32.9	17.05	13.3	10.5	9.0	8.0	7.45	.....	8.4
23			10.2	31.2	16.85	13.1	10.25	8.95	8.1	7.4	.....	.....
24		9.15	10.1	29.4	16.7	13.0	10.15	9.0	8.1	7.35	7.6	.....
25				27.35	16.45	12.9	10.2	9.15	8.2	7.3	.....	.....
26				25.5	16.3	12.8	10.2	9.1	8.6	7.25	.....	.....
27	9.5			23.55	16.7	12.85	10.2	8.9	8.65	7.3	.....	.....
28				22.0	17.25	13.15	10.0	8.95	8.55	7.4	.....	.....
29	9.45			20.55	17.35	13.2	9.8	9.2	8.4	7.7	.....	8.4
30				19.4	17.05	13.2	9.8	9.15	8.5	8.4	.....	.....
31			14.0		16.8	.....	9.7	8.8	.....	7.6	.....	.....

NOTE.—Ice conditions January 1 to April 8; gage heights were to water surface; average ice thickness, 2 feet. Ice condition November 13 to December 31; average thickness 1.1 feet.

Rating table for Red River at Grand Forks, N. Dak., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
7.00	1,800	8.80	2,700	11.20	4,140	22.00	12,790
7.10	1,846	8.90	2,755	11.40	4,270	23.00	13,730
7.20	1,892	9.00	2,810	11.60	4,400	24.00	14,670
7.30	1,939	9.10	2,865	11.80	4,530	25.00	15,640
7.40	1,986	9.20	2,920	12.00	4,660	26.00	16,640
7.50	2,034	9.30	2,975	12.20	4,790	27.00	17,650
7.60	2,082	9.40	3,030	12.40	4,920	28.00	18,670
7.70	2,131	9.50	3,090	12.60	5,060	29.00	19,720
7.80	2,180	9.60	3,150	12.80	5,200	30.00	20,790
7.90	2,230	9.70	3,210	13.00	5,340	31.00	21,880
8.00	2,280	9.80	3,270	14.00	6,040	32.00	22,980
8.10	2,330	9.90	3,330	15.00	6,790	33.00	24,100
8.20	2,380	10.00	3,390	16.00	7,560	34.00	25,250
8.30	2,430	10.20	3,510	17.00	8,360	35.00	26,400
8.40	2,480	10.40	3,630	18.00	9,190	36.00	27,550
8.50	2,535	10.60	3,750	19.00	10,040		
8.60	2,590	10.80	3,880	20.00	10,940		
8.70	2,645	11.00	4,010	21.00	11,850		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1901–1906. It is well defined.

Monthly discharge of Red River at Grand Forks, N. Dak., for 1906.

[Drainage area, 25,000 square miles.[a]]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
January			[b]1,750	108,000	0.070	0.08
February			[b]1,590	88,300	.064	.07
March			[b]1,890	116,000	.076	.09
April	27,600	7,000	[c]19,800	1,180,000	.792	.88
May	9,620	6,980	8,220	505,000	.329	.38
June	7,880	5,200	6,060	361,000	.242	.27
July	6,530	3,210	4,560	280,000	.182	.21
August	3,910	2,700	3,180	196,000	.127	.15
September	2,920	2,180	2,470	147,000	.099	.11
October	2,540	1,920	2,200	135,000	.088	.10
November			[d]2,150	128,000	.086	.10
December			[b]1,630	100,000	.065	.07
The year			4,620	3,340,000	.185	2.51

[a] Revised since 1905 report.
[b] Estimated from gage heights and ice measurements.
[c] Discharge estimated April 1 to 8.
[d] Discharge November 20 to 30 estimated.

NOTE.—Values are rated as follows: January to March and December, fair; April and November, good; May to October, excellent.

OTTERTAIL RIVER NEAR FERGUS FALLS, MINN.

This station was established May 9, 1904. It is located at Three-mile Bridge, about 3½ miles northeast of Fergus Falls, Minn. The conditions at this station and the bench marks[a] are described in Water-Supply Paper No. 171, page 33, where are given also references to publications that contain data for previous years.

[a] During 1906 the gage was attached to the guard rail at station "20" on the lower side of the bridge. The bench mark is the center of the lowest bolt holding the vertical strap iron tie-rod against the face of the stone abutment on the right bank; it is about 3 feet above the lower angle of the abutment; elevation, 7.75 feet above gage datum.

Discharge measurements of Ottertail River near Fergus Falls, Minn., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 4	R. Richards	98	240	3.84	759
November 4	E. F. Chandler	98	202	3.49	539
1906.					
May 14	E. F. Chandler	93	225	3.89	786
June 25	do	92	264	4.30	1,010

Daily gage height, in feet, of Ottertail River near Fergus Falls, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				4.8	3.7	3.95	4.25	3.95	3.85	3.7	3.7	
2				4.6	3.75	4.0	4.25	3.95	3.85	3.7	3.7	
3				4.3	3.8	4.0	4.25	3.95	3.85	3.7	3.7	
4				4.0	3.8	4.0	4.25	3.95	3.85	3.7	3.7	
5				4.0	3.8	4.0	4.25	3.9	3.85	3.7	3.7	
6				3.5	3.8	4.1	4.25	3.9	3.85	3.7	3.65	
7				3.2	3.8	4.1	4.25	3.9	3.85	3.7	3.65	
8				3.2	3.8	4.15	4.25	3.85	3.85	3.7	3.65	
9				3.3	3.85	4.2	4.25	3.85	3.85	3.7	3.6	
10				3.3	3.85	4.2	4.2	3.8	3.85	3.7	3.6	
11	4.55			3.4	3.85	4.2	4.15	3.8	3.8	3.7	3.6	
12				3.4	3.85	4.2	4.15	3.8	3.8	3.7	3.6	
13				3.4	3.85	4.2	4.15	3.8	3.8	3.7	3.6	
14			4.7	3.4	3.9	4.2	4.15	3.8	3.8	3.7	3.6	
15				3.4	3.9	4.2	4.15	3.75	3.8	3.7	3.65	
16		4.6		3.4	3.9	4.2	4.15	3.75	3.8	3.7	3.65	
17				3.4	3.9	4.2	4.1	3.75	3.8	3.7	3.7	
18				3.4	3.9	4.2	4.1	3.75	3.8	3.7	3.9	
19				3.4	3.9	4.2	4.1	3.75	3.8	3.7	4.0	
20				3.4	3.9	4.2	4.0	3.7	3.8	3.7	4.5	
21				3.45	3.9	4.2	4.0	3.7	3.85	3.75	4.8	
22				3.45	3.9	4.2	4.0	3.7	3.8	3.8	4.8	4.65
23				3.45	3.9	4.2	4.0	3.75	3.8	3.8	4.8	
24				3.5	3.9	4.2	4.0	3.8	3.75	3.8	4.8	
25				3.5	3.95	4.25	4.0	3.85	3.75	3.75		
26	4.7			3.6	3.95	4.25	4.0	3.85	3.75	3.75		
27				3.65	3.95	4.25	4.0	3.85	3.75	3.7		
28				3.65	3.95	4.25	4.0	3.85	3.7	3.7		
29				3.65	3.95	4.25	4.0	3.85	3.7	3.7		
30				3.7	3.95	4.25	4.0	3.85	3.7	3.7		
31			4.8		3.95		3.95	3.85		3.7		

NOTE.—Ice conditions January 1 to April 6, also November 19 to December 31; gage heights were to water surface. The following comparative readings were made:

Comparative ice and water gage heights of Ottertail River near Fergus Falls, Minn.

Date.	Water surface.	Top of ice.	Thickness of ice.
January 11	4.55	4.65	1.3
January 26	4.7	4.8	1.6
February 16	4.6	4.7	1.7
March 14	4.7	4.8	1.6

3688—IRR 207—07——3

Rating table for Ottertail River near Fergus Falls, Minn., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
3.20	402	3.50	552	3.80	726	4.10	921
3.30	449	3.60	607	3.90	789	4.20	987
3.40	499	3.70	665	4.00	855		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 12 discharge measurements made during 1904–1906. It is well defined between gage heights 2.8 feet and 3.8 feet.

Monthly discharge of Ottertail River near Fergus Falls, Minn., for 1906.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
April	665	402	[a] 517	30,800	0.395	0.44
May	822	665	772	47,500	.589	.68
June	1,020	822	965	57,400	.737	.82
July	1,020	822	932	57,300	.711	.82
August	822	665	742	45,600	.566	.65
September	758	665	727	43,300	.555	.62
October	726	665	674	41,400	.515	.59
November (1–24)	855	607	[b] 686	32,600	.524	.47
The period				356,000		

[a] Discharge estimated April 1 to 6. [b] Discharge estimated November 20 to 24.

NOTE.—Values are rated as follows: April and November, good; May to October, excellent.

SHEYENNE RIVER NEAR HAGGART, N. DAK.

This station was established March 22, 1902. It is located near the station of Haggart, on the Northern Pacific Railway, 6 miles west of Fargo, N. Dak., at a private wagon bridge about one-fourth mile north of the railroad. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 35, where are given also references to publications that contain data for previous years.

Discharge measurements of Sheyenne River near Haggart, N. Dak., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 30	R. Richards	53	175	6.60	198
June 22	Chandler and Richards	46	154	4.70	173
July 11	R. Richards	47	147	4.60	156
July 29	Hanna and Chandler	44	134	4.42	146
August 22	R. Richards	54	216	6.01	288
November 18	E. F. Chandler	39	105	3.64	69
1906.					
April 14	E. F. Chandler	72	530	10.89	948
June 27	do	48	208	5.92	317
September 10	Grover and Chandler	39	105	3.45	68

Daily gage height, in feet, of Sheyenne River near Haggart, N. Dak., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				9.5	6.2	6.7	5.4	4.7	3.3	3.3	3.2	3.5
2				9.65	6.2	6.5	5.5	4.7	3.3	3.3	3.2	.....
3				8.7	6.2	6.4	5.5	4.6	3.3	3.3	3.2	.....
4				7.2	6.1	6.2	5.4	4.6	3.3	3.3	3.2	.....
5				7.1	6.1	6.2	5.3	4.5	3.2	3.2	3.2	.....
6	4.5			6.6	6.1	6.1	5.1	4.4	3.2	3.2	3.2	.....
7				6.7	6.0	6.1	5.0	4.4	3.2	3.2	3.2	.....
8				7.2	6.0	6.1	4.7	4.3	3.1	3.2	3.2	.....
9				7.5	5.7	6.0	4.7	4.3	3.1	3.2	3.3	.....
10				8.1	5.6	6.0	4.6	4.3	3.0	3.2	3.3	.....
11				9.1	5.4	6.0	4.6	4.2	3.0	3.2	3.3	3.9
12				9.7	5.3	5.7	4.6	4.2	3.0	3.2	3.3	.....
13				10.3	5.2	5.7	4.5	4.2	3.0	3.2	3.3	.....
14				10.6	5.0	5.6	4.5	4.1	3.0	3.2	3.3	.....
15				11.5	4.7	5.5	4.5	4.1	3.1	3.2	3.3	.....
16		5.6	5.6	11.7	5.1	5.5	4.5	4.0	3.1	3.2	3.4	.....
17				11.6	5.2	5.5	4.4	4.0	3.2	3.2	3.4	.....
18				11.2	5.5	5.6	4.3	3.7	3.2	3.2	3.4	.....
19				10.7	6.0	5.7	4.3	3.7	3.3	3.2	3.4	.....
20				10.5	6.2	5.7	4.2	3.6	3.3	3.2	3.4	.....
21				10.2	6.1	5.6	4.2	3.6	3.4	3.2	3.4	.....
22				9.7	5.7	5.5	4.2	3.6	3.4	3.2	3.4	.....
23				9.2	5.6	5.5	4.1	3.6	3.5	3.2	3.4	.....
24			8.6	8.4	5.5	5.5	4.1	3.5	3.5	3.2	3.5	.....
25			9.2	7.6	5.7	5.5	4.1	3.5	3.5	3.2	3.5	.....
26	4.6		8.7	7.2	6.0	5.6	4.1	3.5	3.4	3.2	3.5	.....
27			8.0	6.7	6.5	5.6	4.2	3.5	3.4	3.2	3.5	.....
28			7.6	6.6	7.2	5.5	4.4	3.4	3.4	3.2	3.5	.....
29			8.1	6.5	7.1	5.5	4.5	3.4	3.3	3.2	3.5	.....
30			8.4	6.2	7.1	5.4	4.6	3.4	3.3	3.2	3.5	.....
31			9.2	.....	7.0	.....	4.7	3.3	.....	3.2	.....	4.0

NOTE.—Ice conditions January 1 to April 3. Gage heights probably to water surface. Thickness of ice, 1.8 feet approximately. Ice conditions also November 20 to December 31.

Rating table for Sheyenne River near Haggart, N. Dak., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
3.00	32	4.30	131	5.60	269	7.80	554
3.10	38	4.40	140	5.70	281	8.00	580
3.20	44	4.50	149	5.80	294	8.20	606
3.30	51	4.60	159	5.90	307	8.40	632
3.40	58	4.70	169	6.00	320	8.60	658
3.50	65	4.80	179	6.20	346	8.80	684
3.60	72	4.90	189	6.40	372	9.00	710
3.70	80	5.00	200	6.60	398	10.00	840
3.80	88	5.10	211	6.80	424	11.00	970
3.90	96	5.20	222	7.00	450	12.00	1,100
4.00	104	5.30	233	7.20	476		
4.10	113	5.40	245	7.40	502		
4.20	122	5.50	257	7.60	528		

NOTE.—The above table is applicable only for open-channel conditions. It is based on the discharge measurements made during 1903–1906. It is fairly well defined.

Monthly discharge of Sheyenne River near Haggart, N. Dak., for 1905–6.

[Drainage area, 5,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
1905.[a]						
April (3–30)	385	113	201	11,200	0.037	0.04
May	814	96	326	20,000	.060	.07
June	333	169	206	12,300	.038	.04
July	398	88	177	10,900	.033	.04
August	684	104	303	18,600	.056	.06
September	159	80	120	7,140	.022	.02
October	104	65	79.7	4,900	.015	.02
November	96		[b] 76.5	4,550	.014	.02
The period				89,600		
1906.						
April	1,060	346	682	40,600	0.126	0.14
May	476	169	311	19,100	.058	.07
June	411	245	295	17,600	.055	.06
July	257	113	162	9,960	.030	.03
August	169	51	104	6,400	.019	.02
September	65	32	47.5	2,830	.0088	.01
October	51	44	44.9	2,760	.0083	.01
November	58	44	[c] 52.6	3,130	.0097	.01
The period				102,000		

[a] For 1905 gage heights see Water-Supply Paper No. 171.
[b] Discharge estimated November 1 to 17, 1905.
[c] Discharge estimated November 24 to 30, 1906.

NOTE.—Values are rated as follows: June and July, 1905, excellent; remainder of 1905, good. It is impossible to determine the accuracy of the 1906 values which are subject to large errors, probably being much too low. This is due to the appointment of a new observer for 1906, who recorded the gage height as 0.4 foot less than the hydrographer on the days when measurements were made.

RED LAKE RIVER AT CROOKSTON, MINN.

The gaging station was established May 19, 1901. It is located at the bridge connecting Robert and St. Paul streets, Crookston, known as the "Sampson Addition" bridge. It is about one-sixth mile west of the Great Northern Railway station. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 37, where are given also references to publications that contain data for previous years.

Discharge measurements of Red Lake River at Crookston, Minn., 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 20	E. F. Chandler	176	628	5.90	1,680
1906.					
February 12	Chandler and Richards	174	471	6.75	[a]984
April 16	E. F. Chandler	246	3,660	20.13	14,100
June 30	do	180	715	6.72	1,990
September 11	Grover and Chandler	173	405	4.80	968

[a] Ice measurement: gage height to undersurface of ice is 5.29 feet; ice thickness 0.7 foot to 2.7 feet. The discharge was about 45 per cent of the open-channel rating for gage height 6.75 feet.

Daily gage height, in feet, of Red Lake River at Crookston, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.8	7.0	7.0	12.4	10.4	8.05	6.7	5.7	5.4	5.0	5.2	5.0
2	6.7	.....	.....	14.05	10.0	8.15	6.5	5.9	5.4	5.0	5.0	5.2
3	6.6	.....	.....	14.46	9.6	7.92	6.65	5.8	5.85	(5.25)	5.0	5.1
4	6.7	.....	6.85	15.77	9.5	7.8	6.45	5.5	5.55	5.5	4.5	5.3
5	6.7	.....	.....	15.3	9.5	(7.75)	6.55	5.6	5.3	5.25	4.2	5.0
6	6.8	7.1	7.0	12.39	9.6	7.72	6.5	5.65	5.2	5.2	4.4	5.4
7	6.8	.....	6.75	12.5	9.45	7.45	6.4	5.8	5.5	5.5	4.5	5.5
8	6.7	.....	6.8	10.3	9.25	7.4	6.2	5.35	5.25	5.05	4.5	5.6
9	6.8	.....	.....	11.15	9.1	7.4	6.15	5.6	5.5	4.9	4.6	5.5
10	6.9	7.2	.....	11.67	8.95	7.45	6.05	5.7	4.85	4.8	4.2	5.6
11	6.8	.....	7.1	12.1	8.9	7.55	6.2	5.65	5.05	5.15	4.3	5.6
12	6.7	.....	.....	13.18	8.8	7.3	6.15	5.5	5.1	4.75	4.3	5.6
13	6.7	.....	.....	14.41	8.7	7.2	6.1	5.55	5.35	5.0	4.2	5.5
14	6.7	.....	.....	16.78	8.6	7.08	6.05	5.7	4.85	4.6	4.1	5.4
15	.....	.....	6.9	20.97	8.7	7.0	6.0	5.9	5.05	5.1	4.5	5.6
16	.....	.....	.....	19.81	8.6	6.8	6.0	6.6	5.35	5.05	4.2	5.5
17	.....	6.5	.....	18.45	8.55	6.6	5.9	6.0	5.5	4.95	4.2	5.6
18	.....	.....	6.8	16.92	8.9	6.45	5.9	6.15	4.5	4.6	4.2	5.6
19	.....	.....	.....	15.6	8.7	6.85	5.9	5.9	5.0	4.15	4.2	5.6
20	6.55	7.25	14.6	8.5	6.65	5.9	5.8	5.4	4.5	4.2	5.6	
21	.....	.....	.....	13.75	8.25	6.4	6.0	6.0	5.25	4.7	4.9	5.5
22	.....	.....	7.05	13.0	8.05	6.65	6.0	5.7	5.05	4.4	4.7	5.6
23	.....	.....	7.15	12.4	7.85	6.65	5.9	5.25	4.9	4.5	4.3	5.6
24	6.5	7.2	12.1	7.75	6.65	5.85	5.55	5.35	4.5	4.3	5.6	
25	7.1	.....	6.95	11.9	7.85	6.6	5.9	5.55	5.5	4.6	4.7	5.6
26	.....	.....	7.05	11.5	7.72	6.55	5.9	5.5	5.55	4.3	4.3	5.6
27	.....	6.8	7.1	11.2	7.55	6.68	5.8	5.6	5.5	4.2	4.9	5.6
28	7.2	.....	7.15	11.0	7.5	6.6	5.75	5.75	5.25	4.4	5.0	5.6
29	.....	.....	9.62	10.9	7.7	6.65	5.8	5.4	5.0	4.4	4.9	5.6
30	.....	.....	11.1	.....	7.7	6.62	5.8	5.3	5.35	4.5	5.0	5.6
31	7.4	.....	11.45	.....	7.8	.....	5.65	5.5	...	4.7	.....	5.6

NOTE.—Ice conditions January 1 to April 4, there being a narrow, open channel from January 1 to 24. Gage readings to water surface January 1 to 14, and to top of ice during remainder of ice period. Ice condition also during December, except for narrow channel during part of the month.

Rating table for Red Lake River at Crookston, Minn., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
4.10	615	5.20	1,220	6.30	1,950	7.80	3,095
4.20	660	5.30	1,280	6.40	2,020	8.00	3,255
4.30	710	5.40	1,340	6.50	2,095	8.20	3,415
4.40	760	5.50	1,400	6.60	2,170	8.40	3,575
4.50	815	5.60	1,465	6.70	2,245	8.60	3,735
4.60	870	5.70	1,530	6.80	2,325	8.80	3,895
4.70	925	5.80	1,600	6.90	2,395	9.00	4,055
4.80	980	5.90	1,670	7.00	2,470	9.20	4,225
4.90	1,040	6.00	1,740	7.20	2,620	9.40	4,395
5.00	1,100	6.10	1,810	7.40	2,775		
5.10	1,160	6.20	1,880	7.60	2,935		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 24 discharge measurements made during 1902–1906. It is well defined. Above gage height 9 feet the rating curve is a tangent, the difference being 85 per tenth.

Monthly discharge of Red Lake River at Crookston, Minn., for 1906.

[Drainage area, 5,520 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
January[a]			1,500	92,200	0.272	0.31
February[a]			1,020	56,600	.185	.19
March[a]			1,500	92,200	.272	.31
April[b]	14,200	5,880	8,090	481,000	1.47	1.64
May	5,240	2,860	3,780	232,000	.685	.79
June	3,380	2,020	2,540	151,000	.460	.51
July	2,240	1,500	1,800	111,000	.326	.38
August	1,840	1,250	1,520	93,500	.275	.32
September	1,640	815	1,260	75,000	.228	.25
October	1,400	638	983	60,400	.178	.21
November	1,220	660	836	49,700	.151	.17
The period				1,490,000		

[a] Estimated from gage heights and one ice measurement.
[b] Discharge, April 1 to 4, estimated.

NOTE.—Values are rated as follows: January and March, approximate; February, fair; April to October, excellent; November good.

PEMBINA RIVER NEAR NECHE, N. DAK.

The gaging station was established April 29, 1903. It is located at the Great Northern Railway bridge, two-thirds of a mile north of the railroad station at Neche, N. Dak. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 40, where are given also references to publications that contain data for previous years.

Discharge measurements of Pembina River near Neche, N. Dak., in 1904 and 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1904.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 18	R. Richards	85	634	11.85	[a] 1,230
April 26	do	92	1,490	18.12	3,200
May 23	do	96	909	13.28	2,230
June 8	E. C. Murphy	86	837	12.04	1,780
July 9	R. Richards	79	488	8.51	971
August 16	do	72	299	5.70	363
October 17	L. L. Wilcox	70	274	5.22	249
1906.					
April 23	R. Richards	70	220	4.47	288
June 11	E. F. Chandler	70	246	4.88	372
August 15	do	66	157	3.67	140
October 22	do	66	178	3.67	132

[a] Discharge affected by ice jam below station.

Daily gage height, in feet, of Pembina River near Neche, N. Dak., for 1906.[a]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.0	4.2	4.1	4.4	3.5	3.65	3.7	3.65
2	7.5	4.15	4.3	4.3	3.5	3.7	3.7	3.65
3	8.5	4.15	4.35	4.2	3.5	3.7	3.7	3.65
4	9.0	4.15	4.35	4.1	3.5	3.7	3.75	3.65
5	8.5	4.1	4.3	4.2	3.5	3.65	3.75	3.65
6	8.0	4.1	4.3	4.3	3.5	3.65	3.75	3.6
7	7.5	4.1	4.3	4.4	3.5	3.65	3.75	3.5
8	6.5	4.05	4.4	4.35	3.5	3.65	3.75	3.5
9	6.0	4.05	4.45	4.3	3.5	3.65	3.75	3.5
10	5.5	4.0	4.6	4.2	3.6	3.65	3.75	3.5

[a] 1904 gage heights published in Water-Supply Paper No. 130.

Daily gage height, in feet, of Pembina River near Neche, N. Dak., for 1906—Continued.

Days.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.
11	5.0	3.95	4.65	4.15	3.7	3.65	3.7	3.3
12	4.9	3.95	4.6	4.1	3.7	3.65	3.7	3.05
13	4.8	3.9	4.5	3.9	3.7	3.65	3.7	3.05
14	4.8	3.9	4.4	3.8	3.7	3.8	3.75	3.1
15	4.85	3.9	4.3	3.8	3.65	3.8	3.75	3.1
16	4.8	3.9	4.2	.....	3.65	3.75	3.7	3.2
17	4.8	3.9	4.1	3.7	3.65	3.75	3.7	3.25
18	4.75	3.9	4.1	3.7	3.65	3.75	3.7	3.35
19	4.7	3.95	4.45	3.65	3.65	3.7	3.7	3.35
20	4.6	3.95	4.45	3.6	3.6	3.7	3.7	.....
21	4.55	4.1	4.75	3.6	3.6	3.7	3.7	.....
22	4.5	4.0	4.75	3.6	3.6	3.7	3.7	.....
23	4.45	4.0	4.6	3.55	3.6	3.8	3.7	.....
24	4.4	4.0	4.5	3.5	3.6	3.85	3.7	.....
25	4.4	3.95	4.0	3.55	3.65	3.85	3.7	.....
26	4.35	3.95	4.0	3.5	3.65	3.85	3.7	.....
27	4.3	3.9	4.5	3.5	3.65	3.85	3.65	.....
28	4.25	3.9	4.5	3.5	3.65	3.8	3.65	.....
29	4.2	3.9	4.75	3.55	3.65	3.8	3.65	.....
30	4.2	3.9	4.6	3.5	3.65	3.75	3.65	.....
31	.....	4.0	.....	3.5	3.65	.....	3.65	...

NOTE.—Ice conditions January 1 to April 7; also November 18 to December 31.

Rating table for Pembina River near Neche, N. Dak.

JANUARY 1 TO DECEMBER 31, 1904.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
4.50	131	6.10	442	7.70	794	10.60	1,448
4.60	147	6.20	464	7.80	816	10.80	1,494
4.70	164	6.30	486	7.90	838	11.00	1,540
4.80	181	4.40	508	8.00	860	12.00	1,770
4.90	199	6.50	530	8.20	904	13.00	2,000
5.00	217	6.60	552	8.40	948	14.00	2,230
5.10	236	7.70	574	8.60	992	15.00	2,460
5.20	255	6.80	596	8.80	1,036	16.00	2,690
5.30	275	6.90	618	9.00	1,080	17.00	2,930
5.40	295	7.00	640	9.20	1,126	18.00	3,170
5.50	315	7.10	662	9.40	1,172	19.00	3,410
5.60	336	7.20	684	9.60	1,218	20.00	3,650
5.70	357	7.30	706	9.80	1,264	21.00	3,890
5.80	378	7.40	728	10.00	1,310		
5.90	399	7.50	750	10.20	1,356		
6.00	420	7.60	772	10.40	1,402		

JANUARY 1 TO DECEMBER 31, 1906.[b]

3.00	79	4.20	231	5.40	470	7.00	800
3.10	85	4.30	250	5.50	490	7.20	842
3.20	92	4.40	270	5.60	510	7.40	884
3.30	100	4.50	290	5.70	530	7.60	926
3.40	109	4.60	310	5.80	550	7.80	968
3.50	119	4.70	330	5.90	570	8.00	1,010
3.60	130	4.80	350	6.00	590	8.20	1,052
3.70	143	4.90	370	6.20	632	8.40	1,094
3.80	158	5.00	390	6.40	674	8.60	1,136
3.90	175	5.10	410	6.60	716	8.80	1,178
4.00	193	5.20	430	6.80	758	9.00	1,220
4.10	212	5.30	450				

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904. It is well defined between gage heights 5.0 feet and 18.0 feet.

[b] This table is applicable only for open-channel conditions. It is based on 9 discharge measurements made during 1905–6. It is well defined between gage heights 3.2 feet and 6.0 feet.

Monthly discharge of Pembina River near Neche, N. Dak., for 1904–1906.[a]

[Drainage area, 2,940 square miles.[b]]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
1904.[c]						
April (8–30)[d]	3,580	217	1,920	87,600	0.653	0.56
May	3,870	1,420	2,640	162,000	.898	1.04
June	2,530	926	1,690	101,000	.575	.64
July	2,690	399	839	51,600	.285	.33
August	420	315	385	23,700	.131	.15
September	315	236	302	18,000	.103	.11
October	275	217	235	14,400	.080	.09
November (1–26)	217	131	183	9,440	.062	.06
The period				468,000		
1906.[e]						
April[f]	1,220	193	479	28,500	.163	.18
May	231	175	193	11,900	.066	.08
June	340	193	271	16,100	.092	.10
July	270	119	175	10,800	.060	.07
August	143	119	131	8,060	.045	.05
September	166	136	147	8,750	.050	.06
October	150	136	144	8,850	.049	.06
November (1–19)	136	82	111	4,180	.038	.03
The period				97,100		

[a] Monthly discharge values for 1905 published in Water-Supply Paper No. 171. Some are subject to considerable error, owing to doubtful gage heights.
[b] Revised since 1905 report.
[c] Values for 1904 are rated as follows: April, fair; May to August, excellent; September to November, good. Gage heights for September and October are doubtful; otherwise values for these months could be classed as excellent.
[d] Discharge estimated for ice period April 8 to 20.
[e] Values for 1906 are probably good. Some months might be classed as excellent, but the observer's records for June at least do not appear to be good.
[f] Discharge not corrected for ice conditions April 1 to 7.

MISCELLANEOUS MEASUREMENTS IN RED RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in 1906 at the mouth of Red Lake River at East Grand Forks, Minn:

March 23: Area of section, 627 square feet; discharge, 853 second-feet; ice 2 feet thick.

August 11: Area of section, 1,000 square feet; discharge, 1,150 second-feet.

MOUSE RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

The Mouse (or Souris) River rises in the southeastern part of the Province of Assiniboia, Canada, and flows southeastward to the western part of McHenry County, N. Dak., thence northeastward for about 30 miles to Towner, N. Dak., where it makes another turn to the north and northwest, which carries it back into Canada, to empty into Assiniboine River, a tributary of Red River. Its drainage basin, which is limited on the southwest by the Missouri Coteau and on the northeast by the Turtle Mountains, is relatively large, but its flow is small. The region through which it flows is generally gently rolling,

except in the immediate vicinity of the stream, where the hills are steep and high. The chief tributary of the Mouse above Minot is Des Lacs River.

The data collected in this basin are valuable for irrigation purposes.

MOUSE RIVER NEAR FOXHOLM, N. DAK.

This station was established June 22, 1904, and was discontinued July 31, 1906. It is located at the highway bridge 3½ miles northeast of Foxholm, N. Dak., a station on the Minneapolis, St. Paul and Sault Ste. Marie Railway. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 42, where are given also references to publications that contain data for previous years.

Discharge measurements of Mouse River near Foxholm, N. Dak., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 16	E. F. Chandler	31	7.4	1.50	[a] 4.9
1906.					
April 24	E. F. Chandler	61	203	2.92	215
June 28	do	65	241	3.40	310

[a] Wading section

Daily gage height, in feet, of Mouse River near Foxholm, N. Dak., for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Day.	Mar.	Apr.	May.	June.	July.
1		3.4	2.5	2.7	3.3	17		3.9	2.3	4.3	2.7
2		4.0	2.5	2.7	3.3	18		3.5	2.2	4.2	2.7
3		5.0	2.5	2.6	3.3	19		3.4	2.1	4.0	2.6
4		6.1	2.5	2.5	3.2	20		3.0	2.2	3.9	2.5
5		7.8	2.4	2.5	3.3	21		3.2	2.2	3.9	2.5
6		8.0	2.4	2.8	3.4	22		3.0	2.2	3.9	2.5
7		8.6	2.4	3.0	3.45	23		3.0	2.2	3.9	2.4
8		8.9	2.4	3.0	3.4	24		2.9	2.2	3.9	2.4
9		8.0	2.5	3.0	3.3	25		3.0	2.2	3.8	2.3
10		7.8	2.5	3.3	3.3	26	3.1	2.9	2.2	3.7	2.3
11		6.8	2.4	3.6	3.2	27		2.8	2.2	3.5	2.2
12		6.5	2.4	3.9	3.1	28		2.7	2.2	3.4	2.2
13		5.6	2.4	4.7	2.9	29		2.6	2.2	3.3	2.1
14		4.8	2.4	5.0	2.9	30		2.6	2.3	3.2	2.1
15		4.0	2.5	5.0	2.8	31	3.9		2.5		2.0
16		3.9	2.3	4.7	2.7						

NOTE.—Ice conditions January 1 to March 31.

MOUSE RIVER AT MINOT, N. DAK.

This station was established May 5, 1903. It is located at the footbridge 150 feet northwest of the Great Northern Railway roundhouse at Minot, N. Dak. The gage was read during 1906 by James

Cavanaugh. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 45, where are given also references to publications that contain data for previous years.

Discharge measurements of Mouse River at Minot, N. Dak., in 1904–1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1904.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 22	E. F. Chandler	88	400	6.69	698
June 24	....do	87	373	6.32	577
July 13	R. Richards	83	291	5.16	279
July 14	.....do	83	299	5.29	312
August 12	.....do	77	220	4.40	102
September 18	E. F. Chandler	74	220	4.30	88
1905.					
March 27	Chandler and Richards	76	227	4.40	114
April 27	E. F. Chandler	70	195	4.03	44
May 24	.....do	77	223	4.56	139
May 24	.....do	54	89	4.45	[a] 122
August 18	R. Richards	48	58	4.01	[a] 36
September 17	E. F. Chandler	40	23	3.86	[a] 14
1906.					
April 23	E. F. Chandler	80	279	5.19	300
May 29	.....do	76	218	4.42	112
June 29	.....do	82	297	5.33	343
September 6	.....do	50	57	4.00	[a] 30
September 6	.....do	38	39	4.00	[a] 31

[a] Wading section.

Daily gage height, in feet, of Mouse River at Minot, N. Dak., for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		5.0	4.9	5.4	5.2	4.5	4.0	3.8	3.9
2		5.2	4.9	5.5	5.2	4.4	4.0	3.8	3.9
3		5.4	4.8	5.5	5.2	4.4	4.0	3.8	3.9
4		5.0	4.8	5.3	5.2	4.4	4.0	3.8	3.9
5		5.2	4.8	5.2	5.1	4.4	4.0	3.8	3.9
6		5.4	4.8	5.9	5.1	4.4	4.0	3.8	3.9
7		5.7	4.8	5.9	5.1	4.3	4.0	3.9	3.9
8		6.5	4.8	5.8	5.1	4.3	4.0	3.9	3.9
9		8.0	4.7	5.8	5.1	4.3	4.0	3.9	3.9
10		9.4	4.7	5.8	5.0	4.3	4.0	3.9	3.9
11		9.2	4.7	5.8	5.0	4.3	4.0	3.9	3.9
12		8.4	4.7	5.9	5.0	4.2	4.0	3.9	3.9
13		7.3	4.7	5.9	5.0	4.2	4.0	3.9	3.9
14		5.7	4.6	6.0	5.0	4.2	4.0	3.9	3.9
15		5.7	4.6	6.1	5.0	4.1	4.0	3.9	3.9
16		5.7	4.6	6.1	4.9	4.1	4.0	3.9	3.9
17		5.7	4.6	6.0	4.9	4.1	4.0	3.9	3.9
18		5.6	4.6	5.9	4.8	4.1	4.0	3.9	3.9
19		5.6	4.6	5.8	4.7	4.1	4.0	3.9	.....
20		5.4	4.6	5.8	4.7	4.1	3.9	3.9	.....
21		5.4	4.5	5.8	4.6	4.0	3.9	3.9	.....
22		5.4	4.5	5.7	4.8	4.0	3.9	3.9	.....
23		5.3	4.5	5.6	4.8	4.0	3.9	3.9	.....
24		5.2	4.4	5.6	4.7	4.0	3.9	3.9	.....
25		5.2	4.4	5.5	4.7	4.0	3.9	3.9	.....
26		5.1	4.4	5.5	4.6	4.0	3.9	3.9	.....
27		5.1	4.4	5.4	4.6	4.0	3.9	3.9	.....
28		5.0	4.4	5.4	4.6	4.0	3.9	3.9	.....
29	4.0	5.0	4.4	5.4	4.6	4.0	3.9	3.9	.....
30	4.4	5.0	4.6	5.4	4.5	4.0	3.9	3.9	.....
31	4.8	.....	4.8	.....	4.5	4.0	.....	3.9	.....

NOTE.—Ice conditions January 1 to April 5; also November 18 to December 31.

Rating tables for Mouse River at Minot, N. Dak.

JANUARY 1, 1904, TO DECEMBER 31, 1905.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
3.80	10	4.00	33	4.20	68	4.40	108
3.90	20	4.10	50	4.30	87	4.50	130

JANUARY 1 TO DECEMBER 31, 1906.[b]

3.90	18	5.00	240	6.10	499	7.40	820
4.00	31	5.10	263	6.20	523	7.60	870
4.10	46	5.20	286	6.30	547	7.80	920
4.20	66	5.30	309	6.40	571	8.00	970
4.30	87	5.40	332	6.50	595	8.20	1,020
4.40	108	5.50	355	6.60	620	8.40	1,070
4.50	130	5.60	379	6.70	645	8.60	1,120
4.60	152	5.70	403	6.80	670	8.80	1,170
4.70	174	5.80	427	6.90	695	9.00	1,220
4.80	196	5.90	451	7.00	720	9.20	1,270
4.90	218	6.00	475	7.20	770	9.40	1,320

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904 and 1905. Prior to about June 20, 1904, the conditions of flow were not the same as they were after that date and any rating would be very uncertain. It is well defined between gage heights 3.85 feet and 6 feet. Above gage height 4.5 feet the table for 1906 should be used.

[b] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906. It is not well defined above 6 feet, but is well defined below this point.

Monthly discharge of Mouse River at Minot, N. Dak., for 1904 to 1906.

[Drainage area, 8,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
1904.[a]						
July	427	152	258	15,900	0.031	0.04
August	152	108	114	7,010	.014	.02
September	108	68	81.7	4,860	.0097	.01
October	87	68	71.8	4,410	.0085	.01
November 1–25	87	50	64.3	3,190	.0077	.01
The period				35,400		
1905.[b]						
March 5–31	108	78	97.6	5,230	0.012	0.01
April	78	33	61.2	3,640	.0073	.01
May	130	33	64.1	3,940	.0076	.01
June	119	68	98.6	5,870	.012	.01
July	108	59	81.3	5,000	.0097	.01
August	108	33	68.4	4,210	.0081	.01
September	87	10	30.3	1,800	.0036	.004
October	20	10	15.5	953	.0018	.002
November 1–28	33	20	24.6	1,370	.0029	.003
The period				32,000		
1906.[c]						
April	1,320	240	454	27,000	0.054	0.06
May	218	108	159	9,780	.019	.02
June	499	286	401	23,900	.048	.05
July	286	130	214	13,200	.025	.03
August	130	31	61.9	3,810	.0074	.01
September	31	18	26.2	1,560	.0031	.003
October	18	8	16.1	990	.0019	.002
November 1–18	18	18	18.0	643	.0021	.001
The period				80,900		

[a] Gage heights for 1904 have been published in Water-Supply Paper No. 130. Discharge values for 1904 are excellent. During the spring flood the maximum discharge was estimated to be 12,000 second-feet. Discharge values for stages greater than about 10 feet are very uncertain, owing to the collection of débris below the section causing back water.

[b] Estimates of monthly discharge for 1905 have been revised; gage heights for 1905 are published in Water-Supply Paper No. 171. Discharge values for 1905 are rated as follows: March to August, excellent; September to November, fair.

[c] Discharge values for 1906 are rated as follows: April and September, good; May to August, excellent; October and November, fair.

DES LACS RIVER AT FOXHOLM, N. DAK.

This station was established June 23, 1904, and was discontinued July 31, 1906. It is located at the highway bridge at Foxholm, N. Dak., a station of the Minneapolis, St. Paul and Sault Ste. Marie Railway. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 47, where are given also references to publications that contain data for previous years.

Discharge measurements of Des Lacs River at Foxholm, N. Dak., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 16	E. F. Chandler		3	1.96	[a] 1.6
1906.					
April 24	E. F. Chandler	17	8.3	2.36	[a] 6.6
Do	do	17	22	2.36	6.6
June 28	do	16	6.9	2.31	[a] 5.9

[a] Wading section.

Daily gage height, in feet, of Des Lacs River at Foxholm, N. Dak., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	2.0			8.4	2.35	3.4	2.0
2				8.0	2.35	3.0	2.0
3		2.0	2.4	7.9	2.3	3.0	1.9
4				7.6	2.3	3.0	1.9
5				5.0	2.3	3.7	1.9
6				4.7	2.3	3.8	1.9
7				3.7	2.25	3.8	1.9
8				3.7	2.25	3.8	1.9
9				3.6	2.0	3.7	1.8
10			3.0	3.55	2.0	3.7	1.8
11				3.4	2.0	3.65	1.8
12				3.2	2.0	3.5	1.8
13				3.0	2.0	3.3	1.8
14				2.8	2.1	3.0	1.8
15				2.7	2.2	2.8	1.8
16				2.65	2.2	2.8	1.8
17				2.6	2.25	2.8	1.8
18				2.6	2.25	2.8	1.8
19				2.5	2.25	2.7	1.8
20				2.45	2.25	2.7	1.8
21				2.45	2.3	2.6	1.8
22				2.4	3.0	2.6	1.8
23				2.4	3.2	2.6	1.8
24		2.0		2.4	3.3	2.5	1.8
25			3.0	2.35	3.5	2.4	1.8
26			3.0	2.35	3.6	2.4	1.8
27	2.0		4.0	2.35	3.6	2.3	1.8
28			5.3	2.4	3.7	2.0	1.8
29			6.0	2.4	3.7	2.0	1.8
30			7.0	2.35	3.7	2.0	1.8
31			7.5		3.5		1.8

NOTE.—Ice conditions January 1 to March 24; gage heights were probably to water surface in hole in ice; average thickness of ice, 1.1 feet.

Rating table for Des Lacs River at Foxholm, N. Dak., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.80	0.9	2.60	11	3.40	29	5.00	92
1.90	1.5	2.70	13	3.50	32	5.50	119
2.00	2.4	2.80	15	3.60	35	6.00	149
2.10	3.6	2.90	17	3.70	38	6.50	183
2.20	4.9	3.00	19	3.80	41	7.00	222
2.30	6.3	3.10	21	3.90	44	7.50	265
2.40	7.8	3.20	23	4.00	47	8.00	313
2.50	9.3	3.30	26	4.50	68		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906. It is fairly well defined up to gage height 4 feet; above that point the table is not well defined.

Monthly discharge of Des Lacs River at Foxholm, N. Dak., for 1906.

[Drainage area 615 square miles.]

Month	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.
March (25–31)	265	19	118	1,640	0.192	0.05
April	355	7.0	59.6	3,550	.097	.11
May	38	2.4	13.6	836	.022	.03
June	41	2.4	19.8	1,180	.032	.04
July	2.4	0.9	1.1	68	.0018	.002
The period				7,270		

NOTE.—Values are rated as follows: March and July, fair; April to June, good.

UPPER MISSISSIPPI RIVER DRAINAGE.

GENERAL FEATURES.

The sources of Mississippi River proper lie between latitudes 47° and 48° north, almost exactly in the center of the continent on an east-west line; its mouth is in latitude 29° north.

The basin, which is very irregular in outline, can best be 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, while on the east there is a large protuberance from the general outline extending to the Allegheny Mountains. The eastern outline conforms roughly to that of the Atlantic coast, the mean distance between them being about 250 miles; the eastern and western outlines are determined by the two great mountain systems of the continent, the Appalachian and the Cordilleran. The total area drained is 1,240,000 square miles. It includes wholly or in part thirty States, besides a small area in the Dominion of Canada.

Topographically the country included within the Mississippi basin presents all varieties of form—mountain, prairie, arid plain, and alluvial bottom land teeming with vegetation, all are represented.

The drainage system may be divided into four grand sections, in the following order of size: (1) The Missouri basin, (2) the basins of Arkansas and Red rivers, (3) the Ohio basin, and (4) the basin of the upper Mississippi. The area last named, which is considered in this report, extends from the source of the river to the mouth of the Missouri; below that the stream is called the lower Mississippi.

In the northern part of Minnesota, 2,555 miles from the Gulf of Mexico, is a low plain consisting of sandy ridges of glacial origin, known as the Hauteur des Terres. It is a region of innumerable lakes, from one of the smallest of which, Lake Hernando de Soto, springs the great river. Lake Hernando de Soto is drained by a small stream flowing into Itasca Lake, which was for many years considered the source of the river. The length of Itasca Lake is about 4 miles and its breadth nowhere exceeds one-half mile. Its outlet is from 10 to 12 feet wide and from 12 to 18 inches deep.

From its utmost source to the falls of Pokegama the river flows through a drift-covered region in 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 lakes are the most important. The total fall from the head of the stream to the mouth of Leech Lake River, which is nearly as large as the main stream, is about 420 feet. 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. The mouth of Crow Wing River is only 75 miles in a straight line from Lake Itasca, but the distance along the river course is 450 miles.

Below the mouth of the Crow Wing the river flows in a general southerly 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 rapid amounting to 75 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 bluffs are not vertical, bare surfaces of rock, but are composed of easily eroded stone and drift, which form well-wooded or grassy slopes.

Minnesota River, formerly called St. Peters River, enters the Mississippi about 10 miles below St. Anthony Falls, and below its mouth the breadth of the main stream averages 1,000 feet. From this point to the mouth of the Missouri the general characteristics of the river are the same—a broad placid stream with innumerable islands, the entire width of the valley averaging 1 mile. In many places, especially where tributaries enter, there are fertile flats 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 20.4 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 21.85 feet.

The large tributaries below the Minnesota are the St. Croix, Chippewa, Wisconsin, Rock, and Illinois from the east and the Iowa and Des Moines from the west.

MISSISSIPPI RIVER PROPER.

MISSISSIPPI RIVER NEAR SAUK RAPIDS, MINN.

This station was established April 23, 1903, and was discontinued March 31, 1906, owing to the construction of a dam 2 miles below. It is located about 1½ miles south of Watab station, on the Northern Pacific Railway, about 5 miles north of Sauk Rapids and 7 miles north of St. Cloud. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 51, where are given also references to publications that contain data for previous years.

Discharge measurements of Mississippi River near Sauk Rapids, Minn., in 1903–1905.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 4	W. R. Hoag	580	4,080	13.22	7,910
September 9	E. C. Murphy	615	3,350	11.85	5,020
Do	Murphy and Stockman	615	3,340	11.85	5,040
October 17	L. R. Stockman	631	5,680	15.60	17,400
1904.					
January 5	E. Johnson jr	515	2,200	[a] 11.55	2,470
April 20	E. F. Chandler	585	4,170	14.26	12,300
July 1	do	577	3,790	13.31	8,020
July 25	R. Richards	557	2,680	11.38	4,740
August 22	do	572	3,400	12.76	[b] 4,340
September 8	do	561	2,860	11.77	[c] 4,800
October 15	E. F. Chandler	578	3,820	13.75	9,350
1905.					
January 3	R. Richards	560	1,810	[d] 11.29	2,620
April 5	do	582	3,890	13.60	8,520
December 26	do	580	3,690	12.88	6,800

[a] Ice 1.7 feet thick, and anchor ice. Gage height to bottom of ice, 10.20 feet.
[b] Log jam 600 feet below.
[c] Partial log jam 600 feet below.
[d] Ice 1.5 feet thick. Gage height to bottom of ice, 9.9 feet.

Daily gage height, in feet, of Mississippi River near Sauk Rapids, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
3		12.95	13.25	20	12.95		
8	12.9			24		13.35	12.75
10		12.95	13.15	25		13.35	
14	12.95			27	12.95		
17		13.0	12.85	31			13.5
18		13.0					

NOTE.—No ice notes given by observer; ice conditions not known. The river, however, was known to be open December 26, 1905.

Rating table for Mississippi River near Sauk Rapids, Minn., for 1903–1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
10.80	3,480	12.10	5,450	13.40	8,310	15.40	16,370
10.90	3,610	12.20	5,640	13.50	8,590	15.60	17,440
11.00	3,740	12.30	5,830	13.60	8,880	15.80	18,550
11.10	3,880	12.40	6,020	13.70	9,180	16.00	19,700
11.20	4,020	12.50	6,220	13.80	9,490	16.20	20,890
11.30	4,160	12.60	6,420	13.90	9,810	16.40	22,120
11.40	4,300	12.70	6,630	14.00	10,150	16.60	23,390
11.50	4,450	12.80	6,840	14.20	10,870	16.80	24,700
11.60	4,600	12.90	7,060	14.40	11,660	17.00	26,050
11.70	4,760	13.00	7,290	14.60	12,510	18.00	33,200
11.80	4,920	13.10	7,530	14.80	13,400	19.00	40,990
11.90	5,090	13.20	7,780	15.00	14,350	20.00	49,290
12.00	5,270	13.30	8,040	15.20	15,340		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1905. It is well defined between gage heights 11.5 feet and 16.0 feet.

Monthly discharge of Mississippi River near Sauk Rapids, Minn., for 1903–1905.[a]

[Drainage area, 12,400 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
1903.[b]					
May 3–31	21,200	10,200	13,600	1.10	1.19
June	9,650	4,300	5,750	.464	.52
July	8,450	4,230	6,090	.491	.57
August	7,830	4,450	6,000	.484	.56
September	18,300	4,520	10,300	.831	.93
October	27,100	7,290	16,000	1.29	1.49
November 1–14; 27–30[c]	9,840	5,360	6,720	.542	.36
December			3,740	.302	.35
1904.[d]					
January			2,340	.189	.22
February			2,070	.167	.18
March			2,620	.211	.24
April 11–30[e]	19,100	10,300	12,600	1.02	.76
May	12,500	7,660	10,400	.839	.97
June	13,200	5,540	8,700	.702	.78
July	8,040	3,950	5,910	.477	.55

[a] It is possible that log jams below this station may have affected results over relatively short periods. Ice estimates are based on the observer's notes on ice statements and on two measurements made under ice conditions.

[b] Gage heights for 1903 have been published in Water-Supply Paper No. 98. Discharge values are rated as follows: May to July, good; August to November, excellent; remainder of the year, approximate. Ice conditions December 1 to 31.

[c] No gage-height records November 15 to 26.

[d] Gage heights for 1904 have been published in Water-Supply Paper No. 128. Discharge values for 1904 are rated as follows: April to November, excellent; remainder of the year, approximate. Ice conditions as follows: January 1 to April 10, December 1 to December 31.

[e] Ice gorge April 1 to 10.

Monthly discharge of Mississippi River near Sauk Rapids, Minn., for 1903—Cont'd.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. miles.	Depth in inches.
1904.					
August[a]	5,000	3,680	4,240	0.342	0.39
September[a]	5,640	4,020	4,570	.369	.41
October	10,300	5,270	8,280	.668	.77
November	7,290	3,740	5,400	.435	.49
December			3,050	.246	.28
1905.[b]					
January			2,620	.211	.24
February			2,500	.202	.21
March	4,680		3,180	.256	.30
April	11,300	4,020	6,570	.530	.59
May	22,800	4,380	14,000	1.13	1.30
June	35,500	7,530	21,000	1.69	1.89
July	51,000	10,900	28,700	2.31	2.66
August	15,800	9,980	12,900	1.04	1.20
September	10,900	7,000	9,320	.752	.84
October	7,600	5,270	6,700	.540	.62
November	7,290	5,270	6,000	.484	.54
December			7,190	.580	.67
The year	51,000		10,100	.810	11.06

[a] Log jam August 20 to September 3; discharge values corrected.
[b] Gage heights for 1905 have been published in Water-Supply Paper No. 171. Discharge values are rated as follows: May to November, excellent; April, fair; remainder of the year, approximate. Ice conditions as follows: January 1 to March 29, December 1 to 31.

MISSISSIPPI RIVER AT ANOKA, MINN.

This station was established May 8, 1905. It is located at a highway bridge three-fourths mile southwest of Anoka. The station was temporarily discontinued from July 20, 1906, to August 10, 1906. The bench mark is a chiseled cross on the face of the stone in the lower wing wall of the left abutment of the bridge, the second stone of the bottom course. The mark is about 5 feet from the lower end of the wing wall; elevation, 11.19 feet above the gage datum. The conditions at this station are described in Water-Supply Paper No. 171, page 52.

Discharge measurements of Mississippi River at Anoka, Minn., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 16	R. Richards	764	4,600	2.36	12,200
November 3	E. F. Chandler	756	4,070	1.77	9,650
December 27	R. Richards	755	3,700	2.86	[a] 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

[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.

Daily gage height, in feet, of Mississippi River at Anoka, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				2.3	4.25	6.0	4.8		2.8	3.5		6.3
2				2.4	4.25	5.8	4.85		2.8	3.35		9.4
3			2.0	3.4	4.25	5.6	5.05		2.8	3.35		10.4
4		2.3		5.4	4.25	6.0	5.0		2.8	3.2		10.0
5	2.3			5.5	3.8	6.0	5.05		2.7	3.0		9.5
6				4.5	3.8	6.45	4.9		2.65	3.0		9.5
7				5.6	3.8	6.8	4.85		2.65	2.8	2.8	9.3
8				6.0	3.8	7.0	5.0		2.6	2.8	2.8	9.3
9				5.5	3.8	7.2	5.0		2.3	2.6	2.75	
10		2.5		5.4	4.0	7.35	4.8	1.5	2.0	2.3	2.7	
11			2.4	5.5	4.2	7.25	4.8	1.5	1.5	2.3	2.7	
12				5.3	4.25	7.2	4.25	1.5	1.5	2.2	2.7	
13	2.1			5.3	4.2	6.8	4.2	1.55	1.5	2.2	2.6	
14				5.4	4.2	6.5	4.0	1.65	1.5	2.2	2.5	
15				5.8	3.8	6.1	3.8	1.8	1.8	1.8	2.4	6.8
16				5.97	3.4	5.6	3.55	1.8	1.8	1.8	2.4	
17				5.97	3.4	5.15	3.5	1.8	1.8	1.8	2.35	
18			2.75	5.85	3.25	4.9	3.0	1.8	1.8	1.95	2.1	
19		2.3		5.8	3.2	4.85	2.8	1.8	1.85	2.0	1.9	
20				5.6	3.4	4.85	2.55	1.85	1.85	2.0	2.8	
21				5.4	3.5	4.5		1.85	1.9	2.05	3.8	
22	2.2			5.4	3.55	4.5		1.85	2.0	1.9	6.1	6.2
23				5.1		4.8		1.85	2.0	1.8	6.9	
24		2.3	2.7	4.8		4.8		1.85	2.35	1.8	7.6	
25				4.25	4.5	4.7		1.85	2.5	1.8	8.8	
26				4.25		4.55		2.0	2.8	2.3	5.3	
27	2.2			4.25	4.5	4.55		2.1	2.85	2.5	3.3	
28				4.3	5.4	4.8		2.5	3.0	2.8	2.8	
29				4.8	6.0	4.85		2.6	3.0	3.0	2.8	5.4
30				4.25	6.0	4.85		2.8	3.0		3.5	
31					6.0			2.8				

NOTE.—The river was frozen from January 1 to March 31; gage heights are to water surface in a hole in the ice, except during February, when the river at the gage was frozen to the bottom, and gage heights are to top of ice. The following comparative readings were taken:

Comparative ice and water gage heights of Mississippi River at Anoka, Minn.

Date.	Water surface.	Top of ice.	Thickness of ice at gage.
January 5	2.3	2.5	1.2
January 13	2.1	2.3	1.2
January 22	2.2	2.3	1.4
January 27	2.2	2.3	1.5
March 3	2.0	2.0	1.65
March 11	2.4	2.5	1.65
March 18	2.75	2.85	1.3
March 24	2.7	2.85	1.2

Ice conditions caused backwater November 20 to 26; also during the first part of December. River frozen entirely across December 15.

MISCELLANEOUS MEASUREMENT OF MISSISSIPPI RIVER.

The following miscellaneous measurement was made of the Mississippi River from the Chicago Great Western Railroad bridge at St. Paul, Minn.:

October 31, 1905: Width, 894 feet; area, 7,640 square feet; gage height, 5.54 feet; discharge, 16,100 second-feet.

CROW RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Crow River is formed by the junction of North and South forks. Below the junction the river is only 18 miles in length, while North and South forks are 96 and 80 miles long, respectively. With the exception of the Crow Wing this river is the largest tributary of the Mississippi above the Minnesota.

The basin of the Crow lies wholly within the State of Minnesota. It consists, principally, of rolling prairie, interspersed with groves of hard-wood timber, and is largely cultivated. The numerous lakes within its limits, some of which are 4 or 5 square miles in area, help to make the flow of the river uniform.

The stream is of value for water power, especially North Fork and the main stream below the junction.

CROW RIVER NEAR DAYTON, MINN.

This station was established April 13, 1906, and was discontinued July 21, 1906. It is located at the highway bridge at Berning's mill, about 13½ miles by road from Anoka, Minn., and about 7 miles up the valley from Dayton, at the mouth of the river.

The channel is straight for about 200 feet above and below the station. Berning's mill and dam are about 200 feet above the bridge. The mill uses only a small amount of the total flow. Water flows over the dam at all times. There is one channel at all stages. Both banks are of medium height and are but rarely or never overflowed. The bed of the stream is of coarse gravel and is permanent. The current is swift.

Discharge measurements are made from the lower side of the single-span highway bridge. The initial point for soundings is the inner face of the left cylinder pier.

The gage, which was read during 1906 by Joseph Berning, is a vertical staff attached to a pile near the left end of the bridge on the upstream side. The bench mark is a point between two chisel drafts on top of the casing of the upstream pier at the left end of the bridge. An arrow chiseled on the upstream side of the pier points toward the mark; elevation, 15.66 feet above the gage datum.

The high water of 1890, the highest for fifty years, corresponded to a gage height of 15.5 feet.

Discharge measurements of Crow River near Dayton, Minn., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
1905.					
November 2	E. F. Chandler	160	509	3.79	570
1906.					
April 13	Horton and Brennan	168	907	6.53	2,010
May 26	M. S. Brennan	215	2,030	12.00	8,050

Daily gage height, in feet, of Crow River near Dayton, Minn., for 1906.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1		5.4	13.8	8.0	17	7.5	6.0	9.4	6.2
2		5.6	13.3	8.0	18	7.2	6.1	9.0	6.1
3		5.8	12.8	7.9	19	7.0	6.1	8.7	6.0
4		5.9	12.9	7.9	20	6.8	6.0	8.7	5.9
5		5.8	12.5	7.9	21	6.6	6.9	8.8	5.7
6		5.7	12.6	7.8	22	6.3	9.7	8.9	
7		5.5	12.8	7.6	23	6.1	10.7	8.9	
8		5.4	12.7	7.4	24	5.9	11.6	8.7	
9		5.3	12.5	7.3	25	5.7	11.9	8.6	
10		5.2	12.3	7.1	26	5.5	12.1	8.5	
11		5.1	11.9	6.9	27	5.4	12.9	8.3	
12		5.0	11.4	6.7	28	5.3	13.3	8.3	
13	6.5	5.4	10.9	6.5	29	5.3	13.6	8.3	
14	7.1	5.6	10.6	6.4	30	5.3	13.8	8.1	
15	7.7	5.8	10.1	6.3	31		13.9		
16	7.7	5.9	9.8	6.3					

Rating table for Crow River near Dayton, Minn., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
5.00	1,080	6.30	1,855	7.60	2,845	9.80	5,110
5.10	1,130	6.40	1,925	7.70	2,930	10.00	5,350
5.20	1,185	6.50	1,995	7.80	3,020	10.20	5,600
5.30	1,240	6.60	2,065	7.90	3,110	10.40	5,855
5.40	1,295	6.70	2,135	8.00	3,200	10.60	6,115
5.50	1,350	6.80	2,210	8.20	3,390	10.80	6,380
5.60	1,410	6.90	2,285	8.40	3,585	11.00	6,650
5.70	1,470	7.00	2,360	8.60	3,785	12.00	8,050
5.80	1,530	7.10	2,435	8.80	3,990	13.00	9,550
5.90	1,595	7.20	2,515	9.00	4,200	14.00	11,140
6.00	1,660	7.30	2,595	9.20	4,420		
6.10	1,725	7.40	2,675	9.40	4,645		
6.20	1,790	7.50	2,760	9.60	4,875		

NOTE.—The above table is based on three discharge measurements made during 1905-6. Its accuracy is wholly dependent on the accuracy of the three measurements which define it; an error in any one would involve a corresponding error in the rating at the stage of the measurement in question. The general form of the curve, however, appears to be very good.

Monthly discharge of Crow River near Dayton, Minn., for 1906.

[Drainage area, 2,540 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
April 13-30	2,930	1,240	1,960	0.772	0.52
May	11,000	1,080	3,790	1.49	1.72
June	10,800	3,300	6,170	2.43	2.71
July 1-21	3,200	1,470	2,360	.929	.73

NOTE.—Values for 1906 are probably excellent. See rating table footnote.

RUM RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Rum River, so named on account of the color of its water, starts from the southwestern part of Mille Lacs, in east-central Minnesota, flows southward, and enters the east side of the Mississippi at Anoka,

7½ miles below the mouth of Crow River. Its basin is about 80 miles long and averages not over 19 miles in width. The large body of water at its head serves an important part in maintaining the flow during low water. The stream flows between banks of clay or mud, and where it crosses the ridge of granite which produces Sauk Rapids on the Mississippi there is a slight fall over rock in place.

Rum River has been largely used for lumbering, and its small tributaries have many dams, built for holding and flushing logs into the main river. The data collected in this basin are valuable for water-power purposes.

RUM RIVER NEAR ANOKA, MINN.

This station was established May 8, 1905, and was discontinued July 21, 1906. It is located at the highway bridge 6½ miles due north of Anoka, the distance by road being 7½ miles. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 54.

Discharge measurements of Rum River near Anoka, Minn., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 16	R. Richards	148	877	12.65	987
November 2	E. F. Chandler	149	939	13.16	1,190
December 28	R. Richards	145	488	13.26	[a] 765
1906.					
April 12	Horton and Brennan	200	1,950	17.66	4,480
May 26	M. S. Brennan	191	1,290	14.18	1,810

[a] Ice measurement; gage height to under side of ice 12.26 feet; ice about 1 foot thick. The discharge was about 60 per cent of the open-channel rating for gage height 13.26 feet.

Daily gage height, in feet, of Rum River near Anoka, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1				15.2	13.8	16.2	13.9
2				15.3	13.6	16.45	14.0
3		13.25	13.85	15.4	13.4	16.3	13.9
4				15.6	13.65	15.95	13.8
5				15.9	13.8	15.9	13.65
6	13.1			16.6	13.8	15.6	13.5
7				17.55	13.7	15.7	13.0
8				18.0	13.85	16.15	13.0
9				18.45	13.75	16.95	12.9
10		13.15	13.75	18.55	13.7	18.98	12.8
11				18.2	13.45	20.45	12.75
12				17.9	13.4	21.3	12.75
13	13.25			17.5	13.7	21.15	12.7
14				17.6	14.0	20.15	12.7
15				17.6	13.9	19.0	12.65
16				17.5	13.7	18.25	12.6
17		13.25	13.65	17.4	13.65	16.85	12.65
18				17.35	13.6	16.25	12.6
19				17.45	13.45	15.5	12.5
20	13.1			17.4	13.4	14.6	12.45
21				17.1	13.5	13.85	12.4
22				16.8	13.8	13.7	.....
23				16.2	13.8	13.8	.....
24		13.45	13.4	15.5	13.8	13.75	.....
25				15.1	14.0	13.8	.....

Daily gage height, in feet, of Rum River near Anoka, Minn., for 1906—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
26				14.5	14.2	13.95	
27	13.35			14.4	15.0	14.3	
28				14.15	15.45	14.5	
29				13.95	15.4	14.35	
30				13.9	15.6	13.85	
31			15.1		16.0		

NOTE.—The river was frozen January 1 to March 31; gage heights were to the water surface in a hole in the ice. The following comparative readings were taken:

Comparative water and ice gage heights on Rum River near Anoka, Minn.

Date.	Water surface.	Top of ice.	Thickness of ice.
January 6	13.1	13.15	1.1
January 13	13.25	13.35	1.2
January 20	13.1	13.2	1.2
January 27	13.35	13.4	1.4
February 3	13.25	13.3	1.4
February 10	13.15	13.2	1.5
February 17	13.25	13.3	1.6
February 24	13.45	13.5	1.5
March 3	13.85	13.9	1.5
March 10	13.75	13.8	1.4
March 17	13.65	13.7	1.5
March 24	13.4	13.5	1.6

Rating table for Rum River near Anoka, Minn., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
11.00	470	12.30	830	13.60	1,450	15.80	3,000
11.10	490	12.40	870	13.70	1,510	16.00	3,150
11.20	510	12.50	910	13.80	1,570	16.20	3,300
11.30	535	12.60	950	13.90	1,630	16.40	3,460
11.40	560	12.70	990	14.00	1,690	16.60	3,620
11.50	585	12.80	1,030	14.20	1,830	16.80	3,780
11.60	610	12.90	1,070	14.40	1,970	17.00	3,940
11.70	640	13.00	1,120	14.60	2,110	18.00	4,750
11.80	670	13.10	1,170	14.80	2,250	19.00	5,600
11.90	700	13.20	1,220	15.00	2,400	20.00	6,450
12.00	730	13.30	1,270	15.20	2,550	21.00	7,300
12.10	760	13.40	1,330	15.40	2,700	22.00	8,150
12.20	795	13.50	1,390	15.60	2,850		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905-6. It is well defined between gage heights 11.7 feet and 14.5 feet. The table has been extended beyond these limits, being based on one measurement at gage height 17.66 feet.

Monthly discharge of Rum River near Anoka, Minn., for 1906.

[Drainage area, 1,430 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
January			672	0.470	0.54
February			612	.428	.45
March			786	.550	.63
April	5,210	1,630	3,550	2.48	2.77
May	3,150	1,330	1,720	1.20	1.38
June	7,550	1,510	3,430	2.40	2.68
July 1-21	1,690	870	1,150	.804	.63

NOTE.—Values are rated as follows: January to March, approximate; April to July, excellent. Flow under ice cover estimated.

MINNESOTA RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Minnesota River rises in Bigstone Lake, which forms part of the boundary between South Dakota and Minnesota, flows southeastward to the city of Mankato, in the northern part of Blue Earth County, where it makes an abrupt turn to the north, and continues in a northerly and northeasterly direction until it enters the Mississippi at a point midway between Minneapolis and St. Paul. The course of this river is generally marked by wide bottom lands. It has a sluggish current, affording few opportunities for the development of water power.

MINNESOTA RIVER NEAR MANKATO, MINN.

This station was established May 20, 1903, and was discontinued July 21, 1906. It is located at Sibley Park, 1 mile below the highway and railroad bridges across Blue Earth River and 1½ miles above the city bridge in Mankato. Blue Earth River joins the Minnesota about 500 feet above the station. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 56, where are given also references to publications that contain data for previous years.

Discharge measurements of Minnesota River near Mankato, Minn., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
November 1	E. F. Chandler	298	815	2.69	1,240
December 29	R. Richards	297	811	3.70	[a] 1,070
1906.					
April 11	Horton and Brennan	310	1,890	7.59	6,020
May 24	M. S. Brennan	308	1,730	5.81	4,300

[a] Ice measurement; gage height to under side of ice, 3 feet; ice thickness, about 0.8 foot. The discharge was about 55 per cent of the discharge as given by the open-channel rating for gage height 3.70 feet.

Daily gage height, in feet, of Minnesota River near Mankato, Minn., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	3.5	3.2	4.8	7.1	6.3	8.2	7.55
2	3.5	3.3	4.8	7.6	6.45	8.3	7.4
3	3.5	3.3	4.95	8.1	6.55	8.3	7.45
4	3.5	3.0	4.85	7.6	6.6	8.3	7.4
5	3.5	3.2	4.8	7.4	6.55	8.5	7.3
6	3.5	3.1	4.9	7.1	6.45	8.7	7.2
7	3.45	3.1	4.8	7.0	6.3	8.8	7.1
8	3.45	3.05	4.9	6.8	6.25	8.95	7.0
9	3.45	3.0	5.4	7.1	6.15	9.1	6.85
10	3.45	3.0	5.4	7.4	6.0	9.2	6.75
11	3.4	2.95	5.2	8.0	5.85	9.2	6.6
12	3.4	2.9	4.9	7.45	5.75	9.15	6.4
13	3.4	2.9	4.7	7.8	5.65	9.05	6.45
14	3.4	2.9	4.5	8.85	5.55	8.95	6.0
15	3.35	2.9	4.4	8.9	5.4	8.9	5.85

Daily gage height, in feet, of Minnesota River near Mankato, Minn., for 1906—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
16	3.4	2.9	4.15	9.2	5.3	8.8	5.6
17	3.4	2.9	3.95	9.3	5.3	8.7	5.4
18	3.4	2.9	3.6	9.25	5.5	8.55	5.3
19	3.35	2.9	3.6	9.1	5.55	8.65	5.15
20	3.35	3.1	3.6	8.85	5.55	8.6	5.0
21	3.35	3.2	3.3	8.6	5.35	8.45	4.8
22	3.35	3.4	3.3	8.3	5.75	8.4	.....
23	3.3	4.0	3.4	7.9	5.55	8.4	.....
24	3.25	4.45	3.1	7.5	5.7	8.3	.....
25	3.2	4.4	3.1	7.3	5.75	8.2	.....
26	3.05	4.4	3.25	7.05	5.8	8.1	.....
27	3.0	4.5	4.3	6.8	6.15	8.1	.....
28	3.0	4.6	4.25	6.55	6.55	8.1	.....
29	3.05	.....	4.65	6.45	7.0	8.1	.....
30	3.2	.....	5.1	6.3	7.6	8.1	.....
31	3.2	.....	5.45	.....	8.0	.....	.....

NOTE.—Ice conditions January 1 to April 2.

Rating table for Minnesota River near Mankato, Minn., for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
4.80	3,090	5.80	4,270	6.80	5,610	7.80	7,010
4.90	3,200	5.90	4,400	6.90	5,750	7.90	7,150
5.00	3,310	6.00	4,530	7.00	5,890	8.00	7,300
5.10	3,430	6.10	4,660	7.10	6,030	8.20	7,600
5.20	3,550	6.20	4,790	7.20	6,170	8.40	7,900
5.30	3,670	6.30	4,920	7.30	6,310	8.60	8,200
5.40	3,790	6.40	5,050	7.40	6,450	8.80	8,500
5.50	3,910	6.50	5,190	7.50	6,590	9.00	8,800
5.60	4,030	6.60	5,330	7.60	6,730	9.20	9,100
5.70	4,150	6.70	5,470	7.70	6,870		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1905 and 1906. It is well defined between gage heights 2.8 feet and 8.6 feet. On account of changes at gaging section, measurements of previous years were not applicable. For low stages this table gives over 25 per cent increase over the 1903 table.

Monthly discharge of Minnesota River near Mankato, Minn, for 1906.

[Drainage area, 13,400 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
April	9,250	4,920	6,900	0.521	0.58
May	7,300	3,670	4,650	.347	.40
June	9,100	7,450	8,160	.609	.68
July 1-21	6,660	3,090	5,120	.382	.30

NOTE.—Values for 1906 are excellent.

CHIPPEWA RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Chippewa River rises in the southeastern part of Ashland County, Wis., flows southwestward, and unites with the Mississippi near Wabash, Minn. Its principal tributary is Flambeau River, which enters from the east, in Gates County.

A. BRUNETT FALLS, CHIPPEWA RIVER, WISCONSIN.

B. LOWER PITCH OF BIG FALLS, FLAMBEAU RIVER, WISCONSIN.

The Chippewa is one of the most important power streams in Wisconsin. There are some 33 feet of fall at Chippewa Falls. Between the falls and the mouth of the Flambeau, 43 miles, there is a fall of 244 feet, 116 feet of this being concentrated in five falls and rapids. The large flow of the Chippewa and the use of storage reservoirs to maintain the summer flow gives the stream unusual value as a source of power.

One of the best powers on Chippewa River, and one most cheaply developed, is found at Brunett Falls (Pl. III, *A*), in sec. 18, T. 31 N., R. 6 W. It belongs to Cornell University, which also owns the adjacent land as well as the water rights. The best location for the dam would be about 650 feet above the foot of the rapids, where a 35-foot dam would create a large reservoir, backing the water up to the rapids at Holcombe, 5½ miles above. The river at the dam site is narrow (70 or 80 feet), while the banks are high granite ledges; the plans are said to contemplate a dam 200 feet long. A steel wagon bridge has recently been built across the river immediately below.

CHIPPEWA RIVER AT CHIPPEWA FALLS, WIS.

The United States Weather Bureau has maintained a station at this point since 1900. June 1, 1906, the Geological Survey began making discharge measurements at the highway bridge; 2,500 feet below the dam at Chippewa Falls.

The channel is straight for 500 feet above the station and for a considerable distance below. The left bank is low and liable to overflow; the right bank is formed by a railroad embankment, which is under water in high floods. The bed of the stream is gravel and sand and is probably permanent. The current is swift.

Discharge measurements are made from the lower side of the steel highway bridge. The initial point for soundings is the inner face of the right abutment at the downstream side.

The gage is an iron staff attached to the downstream face of the first pier from the right bank. The gage readings for 1906 were furnished by N. O. Swift, the United States Weather Bureau observer at Chippewa Falls.

The river stage during the "sawing season" fluctuates very rapidly at times, due to the storage of water at Holcombe by the lumber company. This reservoir is opened two or three times a week to flood logs to the sawmill.

A measurement was made at this station on June 1, 1906, by M. S. Brennan, giving the following results:

Width, 721 feet; area, 4,700 square feet; gage height, 6.70 feet; discharge, 18.000 second-feet.

Daily gage height, in feet, of Chippewa River at Chippewa Falls, Wis., for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		5.0	4.0	8.2	2.0	1.7	2.3	1.5	3.9	3.0
2		4.3	4.0	2.3	1.8	1.5	1.4	1.8	3.6	2.7
3		5.5	4.2	5.0	2.4	1.0	1.5	3.0	3.4	2.4
4		6.3	4.4	4.0	2.3	1.4	4.6	1.8	3.2	2.2
5		8.0	5.0	3.1	2.0	1.3	1.8	1.5	3.1	2.0
6		7.9	5.1	3.6	2.4	1.5	1.5	1.3	3.0	1.9
7		7.8	5.4	3.1	2.3	3.0	1.8	1.2	3.0	1.8
8		8.0	4.5	5.1	1.0	1.9	1.5	1.0	3.0	1.8
9		9.0	2.5	6.0	1.5	2.3	1.4	1.2	3.8	1.8
10		9.8	2.3	5.6	2.0	2.4	2.4	1.2	3.8	1.8
11		9.9	2.0	5.1	2.3	1.5	1.5	3.3	3.6	1.8
12		9.5	1.8	5.0	1.5	1.3	1.6	1.3	3.4	1.9
13		9.6	2.3	4.0	1.6	1.9	1.7	1.3	3.3	2.0
14		10.0	2.9	3.9	1.5	1.2	1.8	1.4	3.2	2.0
15		11.5	5.8	3.5	2.0	1.7	3.0	1.5	2.7	2.0
16		11.4	5.0	3.3	2.4	1.4	3.2	1.7	2.6	2.0
17		10.5	2.3	2.3	2.7	1.3	6.5	1.8	2.5	2.0
18		9.3	4.3	3.5	1.8	1.4	3.6	1.8	2.8	2.0
19		8.8	4.4	1.8	2.0	1.3	2.6	1.5	3.3	2.0
20		7.4	2.9	1.5	1.9	1.2	2.8	1.5	3.0	2.0
21		8.0	3.0	1.9	1.7	1.5	2.5	1.7	2.8	2.0
22		7.8	1.8	2.0	1.1	1.8	2.8	2.0	2.7	2.0
23		7.4	4.0	2.4	1.3	4.0	3.0	2.3	2.5	2.0
24		7.0	5.7	1.0	1.0	1.8	6.8	2.4	2.2	2.0
25		7.3	2.4	1.5	1.8	4.5	3.8	3.0	2.0	2.0
26		6.3	3.8	2.5	1.5	2.8	3.5	5.1	2.2	2.0
27		5.6	5.5	2.7	1.6	4.2	2.5	5.0	2.5	2.0
28		5.0	6.6	2.8	1.5	1.8	2.3	5.0	3.0	2.0
29		4.4	6.8	3.3	1.2	2.7	2.5	4.9	3.3	2.0
30		4.2	5.9	1.0	1.0	1.5	2.4	4.6	3.4	2.0
31	3.6	.....	5.7	.....	1.5	1.3	.....	3.8	.....	2.0

NOTE.—There were ice conditions January 1 to March 31; also December 13 to 31.

CHIPPEWA RIVER NEAR EAU CLAIRE, WIS.

This station was established November 13, 1902. It is located 2 miles below Eau Claire, at a suburb known as Shawtown. The river stage during the "sawing season" fluctuates very rapidly at times, owing to the lumber company at Chippewa Falls storing water about 30 miles above the falls in a reservoir which is opened two or three times a week to flood logs to the sawmill. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 59, where are given also references to publications that contain data for previous years.

Discharge measurements of Chippewa River near Eau Claire, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 25	M. S. Brennan	332	2,770	4.82	[a] 2,760
April 25	do	425	4,870	9.45	17,100
June 2	do	355	3,650	6.52	7,980

[a] Ice measurement; river partly open. Gage height to bottom of ice, 3.92 feet; ice 1 to 1.2 feet thick. Discharge was about 75 per cent of the open-channel rating for gage height, 4.82 feet.

Daily gage height, in feet, of Chippewa River near Eau Claire, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.62	4.91	5.73	8.28	7.66	10.30	5.88	5.72	8.95	5.32	7.29	6.91
2				9.57	7.58	6.22	8.44	5.06	4.76	5.28	7.04	6.36
3				10.90	7.79	9.00	6.64	4.70	5.23	6.60	7.19	5.81
4				12.27	8.30	7.13	6.12	4.34	9.55	5.40	6.99	6.02
5		4.95	5.45	13.48	8.76	6.20	5.42	3.52	5.82	5.18	6.74	6.04
6				12.46	8.52	7.18	5.76	4.29	4.83	4.85	6.57	5.56
7				12.25	9.00	6.80	7.52	7.92	5.36	4.26	6.55	5.25
8			5.15	12.25	9.00	9.65	4.25	5.51	4.98	4.24	6.76	5.08
9		5.05		12.90	6.78	9.82	5.20	5.27	4.48	4.52	6.78	5.07
10				13.55	7.16	9.24	5.22	7.87	6.25	4.36	7.20	4.86
11				13.50	7.44	8.00	6.18	5.52	5.35	6.40	6.80	5.28
12		5.19	5.21	12.99	6.86	8.92	5.32	3.68	4.79	5.34	6.92	5.34
13				12.95	6.60	7.58	4.98	6.62	4.82	5.04	6.65	5.56
14	4.25			13.73	10.06	7.50	5.13	5.05	5.04	3.55	6.54	5.46
15		5.00	4.96	14.86	10.26	6.84	5.25	4.62	6.12	4.82	5.95	5.75
16				14.71	8.77	6.74	5.58	4.51	6.50	4.90	6.55	5.12
17				13.55	7.39	6.42	6.29	4.52	7.78	4.64	6.20	5.65
18				12.62	7.95	7.20	5.28	6.81	6.84	5.12	6.40	5.42
19		5.24	4.95	12.08	8.26	5.22	5.60	5.08	6.59	4.45	6.76	5.48
20	4.21			11.60	6.60	4.90	5.72	4.03	6.33	5.39	6.54	5.06
21				11.36	7.66	5.02	5.78	4.56	5.66	4.84	6.68	5.04
22		5.09		11.20	6.08	5.60	4.20	4.77	6.25	5.59	5.76	5.14
23				10.41	6.82	8.51	4.22	8.73	6.45	5.88	6.10	4.76
24	5.13			10.02	10.06	5.26	5.04	5.28	7.68	7.02	5.98	5.41
25	4.82		5.42	9.62	6.75	5.04	6.69	10.20	6.70	6.28	5.22	4.56
26		5.23	4.88	9.28	8.16	6.11	5.32	5.32	6.24	8.51	6.15	4.58
27			5.32	8.76	9.82	6.41	4.77	8.33	5.95	9.10	6.57	4.89
28			5.42	8.45	10.94	6.86	4.88	5.54	5.62	8.54	7.18	4.81
29	4.65		5.28	8.07	11.05	8.87	3.56	9.33	6.22	8.32	7.43	4.82
30			5.50	7.36	9.82	5.54	4.72	5.59	5.38	7.84	7.34	4.38
31			7.47		9.45		4.52	5.50		7.60		4.82

NOTE.—River frozen January 1 to March 30. From January 1 to about February 20 and March 25 to 30 there was an open channel west of the gage which varied in width during this period from 50 to 180 feet. The river was open about 150 feet below the gage January 1 to February 15 and about 50 feet above the gage throughout the ice period. Fluctuations of daily gage heights during the open period are due almost wholly to "flooding for logs" by lumbermen. The following comparative readings were taken:

Comparative water and ice gage readings of Chippewa River near Eau Claire, Wis.

Date.	Water surface.	Top of of ice.	Thickness of ice.
January 20	4.2	4.8	1.0
January 24			1.1
January 29	4.65	4.95	1.1
February 1	4.9	5.0	1.1
February 5	4.95	5.15	1.2
February 9	5.05	5.25	1.4
February 12	5.2	5.4	1.6
February 15	5.0	5.05	1.7
February 19	5.25	5.35	1.9
February 22	5.1	5.2	1.5
February 26	5.25	5.45	1.3
March 1	5.75	5.8	.9
March 5	5.45	5.5	1.0
March 8	5.15	5.25	.8
March 12			1.5
March 15	4.95	5.05	.9
March 19	4.95	5.05	.9

Rating table for Chippewa River near Eau Claire, Wis., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
3.50	1,040	4.90	3,820	6.30	7,360	8.40	13,000
3.60	1,210	5.00	4,050	6.40	7,640	8.60	14,240
3.70	1,390	5.10	4,280	6.50	7,920	8.80	14,890
3.80	1,570	5.20	4,520	6.60	8,200	9.00	15,550
3.90	1,760	5.30	4,760	6.70	8,480	9.20	16,210
4.00	1,950	5.40	5,000	6.80	8,770	9.40	16,890
4.10	2,140	5.50	5,250	6.90	9,060	9.60	17,570
4.20	2,340	5.60	5,500	7.00	9,350	9.80	18,250
4.30	2,540	5.70	5,760	7.20	9,930	10.00	18,950
4.40	2,740	5.80	6,020	7.40	10,530	11.00	22,550
4.50	2,950	5.90	6,280	7.60	11,130	12.00	26,350
4.60	3,160	6.00	6,550	7.80	11,730	13.00	30,350
4.70	3,380	6.10	6,820	8.00	12,350	14.00	34,500
4.80	3,600	6.20	7,090	8.20	12,970	15.00	38,750

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1902–1906. It is well defined between gage heights 4 feet and 15 feet.

Monthly discharge of Chippewa River near Eau Claire, Wis., for 1906.

[Drainage area, 6,740 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft per sq. mile.	Depth in inches.
April	38,100	10,400	24,900	3.69	4.12
May	22,700	6,770	13,500	2.00	2.31
June	20,000	3,820	10,000	1.48	1.65
July	13,700	1,140	5,350	.794	.92
August	19,600	1,330	6,220	.923	1.06
September	17,400	2,910	6,970	1.03	1.15
October	15,900	1,120	6,270	.930	1.07
November	10,600	4,570	8,310	1.23	1.37
December	9,090	2,700	4,810	.714	.82

NOTE.—Values for 1906 are excellent. During January, February, and March the flow probably seldom exceeded 3,000 second-feet and may have attained a minimum of 1,500 second-feet, or less.

FLAMBEAU RIVER NEAR LADYSMITH, WIS.

This station was established February 13, 1903. It is located three-fourths mile south of the Minneapolis, St. Paul and Sault Ste. Marie Railway station, three-fourths mile south of Ladysmith, and one-half mile below the dam of the Menasha Pulp Company. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 62, where are given also references to publications that contain data for previous years.

No powers have been developed on Flambeau River for 70 miles above Ladysmith, but a fall of 353 feet in this distance insures many opportunities for development. At two localities—Little Falls and Big Falls—the power possibilities are of special importance. The first is in the NW. ¼ sec. 21, T. 35 N., R. 5 W., and is owned by A. J. McGilvary and B. D. Viles, of Chippewa Falls. A 15-foot dam at the head of the first rapids would give a head of about 25 feet at the foot of the rapids a short distance below. Big Falls, owned by

the John Heim Company, of Tony, Wis., is 6 miles above Little Falls, in sec. 35, T. 36 N., R. 5 W. There is a descent of 25 feet here in a short distance, concentrated in three pitches, a view of one of which is shown in Pl. III, B.

Discharge measurements of Flambeau River near Ladysmith, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 26	M. S. Brennan	344	501	16.13	[a]632
April 16	Horton and Brennan	380	2,630	20.74	10,800

[a] Entirely frozen over. Gage height to bottom of ice, 15.33 feet; thickness of ice varied from 0.8 to 2 feet; water surface 0.3 to 0.5 foot below ice surface. The discharge was about 40 per cent of the open-channel rating at gage height 16.13 feet.

Daily gage height, in feet, of Flambeau River near Ladysmith, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	16.72	..	..	16.92	17.82	17.35	16.80	15.20	16.15	16.15	20.25	19.55
2	16.90	..	..	16.92	18.05	17.30	16.92	15.75	16.25	15.70	20.25	19.00
3	16.85	..	..	17.00	17.65	17.15	17.10	16.20	16.12	15.80	20.30	..
4	17.35	16.80	17.10	17.85	18.30	16.90	16.80	15.25	16.10	15.40	20.50	..
5	16.65	..	..	18.15	18.60	16.82	16.82	15.70	16.05	16.00	20.10	..
6	17.10	..	..	18.20	18.55	17.15	16.20	17.15	16.10	15.20	20.55	..
7	..	..	..	18.05	18.20	17.78	16.35	17.30	16.35	15.80	20.05	..
8	..	..	..	17.45	17.78	18.25	16.10	16.95	15.50	14.90	19.55	..
9	..	..	..	18.15	17.52	17.90	16.35	16.30	15.55	15.75	19.40	..
10	..	..	..	18.38	17.40	18.20	16.38	16.20	15.70	15.85	19.90	..
11	..	17.10	15.60	18.30	17.18	17.72	16.40	16.35	15.60	15.72	19.85	..
12	..	..	..	19.05	17.10	17.45	16.52	16.20	15.65	15.70	17.05	..
13	..	..	..	19.65	17.10	17.40	16.60	16.15	16.65	15.70	16.45	..
14	16.70	..	..	20.50	17.02	16.85	16.35	16.00	17.12	15.65	16.35	..
15	..	..	..	20.72	17.25	16.80	16.20	16.00	17.15	15.00	16.50	..
16	..	..	..	20.65	17.00	16.65	16.40	15.80	17.08	15.75	16.70	..
17	..	..	17.10	20.48	17.50	16.55	16.30	15.90	17.10	15.65	16.75	..
18	..	..	..	20.35	16.68	16.30	16.20	15.70	17.12	17.05	16.70	..
19	..	17.00	..	20.40	16.68	16.10	16.10	15.35	17.10	[a]18.50	17.00	..
20	..	..	..	20.40	16.85	16.10	15.95	15.60	16.78	19.75	16.60	..
21	16.30	..	..	20.40	16.65	16.32	16.60	16.45	16.28	19.65	16.30	..
22	..	..	..	20.10	16.90	16.60	15.88	16.75	17.02	19.70	16.55	..
23	..	..	..	19.75	16.95	16.50	15.75	16.80	17.08	19.5	18.05	..
24	..	..	..	19.45	17.32	16.75	15.68	17.00	16.15	19.75	19.30	..
25	..	17.4	16.60	19.00	17.32	16.58	16.00	16.65	16.65	20.20	19.35	..
26	..	..	..	18.70	17.50	16.60	15.55	17.05	16.58	24.40	19.30	..
27	..	..	..	18.45	17.80	16.62	15.70	16.55	16.25	20.50	19.45	..
28	16.70	..	..	18.05	17.70	16.50	15.65	16.45	16.40	20.45	19.45	..
29	..	..	..	18.05	17.38	16.82	15.75	16.35	16.20	20.20	19.50	..
30	..	..	..	17.90	17.80	17.40	15.55	16.20	16.55	20.50	19.55	..
31	..	..	..	..	17.50	..	15.00	16.50	..	20.40	..	..

[a] October 18 a dam below the station was closed, raising the water at the section.

NOTE.—River frozen January 6 to April 4, approximately; also December 3 to 31. During January the average ice thickness was about 1 foot, while during February and March it was 1.6 feet.

Rating table for Flambeau River near Ladysmith, Wis., from January 1, 1906, to October 17, 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
14.90	535	16.20	1,735	17.50	3,700	19.40	7,710
15.00	600	16.30	1,855	17.60	3,890	19.60	8,170
15.10	670	16.40	1,980	17.70	4,090	19.80	8,630
15.20	745	16.50	2,110	17.80	4,300	20.00	9,090
15.30	825	16.60	2,245	17.90	4,510	20.20	9,550
15.40	910	16.70	2,385	18.00	4,720	20.40	10,030
15.50	1,000	16.80	2,530	18.20	5,140	20.60	10,510
15.60	1,090	16.90	2,680	18.40	5,560	20.80	11,000
15.70	1,185	17.00	2,835	18.60	5,980	21.00	11,500
15.80	1,285	17.10	2,995	18.80	6,400	22.00	14,100
15.90	1,390	17.20	3,160	19.00	6,820	23.00	16,800
16.00	1,500	17.30	3,330	19.20	7,260	24.00	19,600
16.10	1,615	17.40	3,510				

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906. It is well defined between gage heights 15.5 feet and 21 feet. Owing to the closure of a dam below the section the table is not applicable after October 17, 1906.

Monthly discharge of Flambeau River near Ladysmith, Wis., for 1906.

[Drainage area, 2,120 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
April (5–30)	10,800	3,600	7,310	3.45	3.34
May	5,980	2,320	3,680	1.74	2.01
June	5,240	1,620	2,900	1.37	1.53
July	3,000	600	1,770	.835	.96
August	3,330	745	1,860	.877	1.01
September	3,080	1,000	2,730	1.29	1.44
October (1–17)	1,340	910	1,170	.552	.35

NOTE.—Values for 1906 are probably excellent. During the frozen period the discharge probably seldom exceeded 1,500 second-feet and may have declined to a minimum of 500 or less. See ice measurement.

FLAMBEAU RIVER SURVEY.

In order to point out the power possibilities along the 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 the Director of the Geological Survey.

BLACK RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Black River rises in the southeastern part of Taylor County, Wis., at an elevation between 1,300 and 1,400 feet above tide, flows in a general southwesterly direction for a distance of 128 miles, and joins

the Mississippi about 10 miles above the town of La Crosse. Its basin, wedged in between that of the Wisconsin on the east and the Chippewa on the west, is long and narrow, being at one point scarcely more than 3 miles wide. The total area drained is 2,272 square miles.

The surface of the basin is gently rolling or level, and the country about the lower part of the river is well settled and under cultivation. The southern portion of the pine region crosses the basin between 60 and 80 miles from the mouth of the river, and all of the upper half of the area is forested. There are a few lakes at the upper waters, but the basin is not well supplied with natural reservoirs.

The river has a total fall of about 750 feet between source and mouth, or over 4.5 feet a mile. At Black River Falls there are very heavy rapids for a short distance, over hard granite rock. The tributaries, which are characterized by many rapids and moderate falls, are all small streams of little importance, though they furnish power for a few small mills.

BLACK RIVER SURVEY.

In order to point out the power possibilities along Black River 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 upon application to the Director of the Geological Survey.

BLACK RIVER AT NEILLSVILLE, WIS.

This station was established April 7, 1905. It is located at the lower highway bridge at Neillsville, Wis., about 40 rods below the Chicago, St. Paul, Minneapolis and Omaha Railway bridge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 65.

Discharge measurements of Black River at Neillsville, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 25	M. S. Brennan	147	198	4.30	[a] 152
April 24	do	165	484	4.75	819
June 3	do	160	436	4.46	752

[a] Entirely frozen over; gage height given to water surface; ice 1.3 feet thick. The discharge was 22 per cent of the open-channel rating for gage height 4.30 feet.

Daily gage height, in feet, of Black River at Neillsville, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.5	4.1	5.1	9.4	4.2	5.1	3.7	3.2	3.2	2.7	4.2	5.5
2	3.3	4.1	5.0	11.8	4.6	4.8	3.5	3.0	4.5	2.9	3.9	5.2
3	3.4	4.1	5.2	12.0	5.0	4.3	3.9	2.8	4.5	2.7	3.8	4.9
4	3.5	4.1	5.0	11.6	5.2	4.0	4.2	2.6	4.7	2.7	3.9	4.5
5	3.4	4.0	4.9	11.3	5.1	4.2	4.0	2.8	4.5	2.7	3.8	4.2
6	3.4	4.0	4.9	11.0	4.7	6.3	3.6	3.0	3.0	2.5	3.7	3.8
7	3.5	4.0	4.8	10.6	4.4	6.9	3.3	2.9	3.8	2.5	3.7	4.2
8	3.5	3.9	4.8	11.4	4.2	6.6	3.1	2.8	3.4	2.5	3.7	4.5
9	3.4	3.9	5.3	10.7	4.3	5.9	3.0	2.4	2.9	2.5	3.6	4.7
10	3.5	3.8	5.1	10.0	4.3	5.4	3.1	2.4	3.0	2.5	3.7	4.8
11	3.5	3.8	4.9	8.9	4.1	4.6	3.0	2.4	3.0	2.7	3.6	4.8
12	3.5	3.8	4.9	8.7	3.9	4.1	3.0	2.5	3.0	2.4	3.6	4.8
13	3.5	4.0	4.8	8.5	6.9	3.8	2.8	2.4	3.0	2.4	3.3	4.6
14	3.5	3.9	4.7	8.8	7.3	3.5	2.8	2.4	2.9	2.4	3.2	4.3
15	3.6	3.9	4.6	8.5	6.6	3.3	2.8	2.3	2.9	2.4	3.3	4.3
16	3.6	3.9	4.5	7.6	5.9	3.2	2.7	2.3	3.3	2.5	3.2	4.5
17	3.7	3.8	4.5	6.7	5.4	3.1	2.7	2.4	3.3	2.5	4.1	4.6
18	3.8	3.9	4.4	6.2	4.9	3.0	2.6	2.4	3.4	2.7	5.1	4.6
19	3.8	3.9	4.3	6.0	4.5	2.9	2.7	2.3	3.3	2.7	4.8	4.5
20	3.8	4.1	4.3	6.0	4.1	3.0	2.7	2.3	3.2	3.0	4.6	.....
21	4.0	4.2	4.4	5.8	4.0	3.1	2.6	2.2	3.2	3.5	4.4	.....
22	4.0	4.3	4.3	5.4	4.0	3.6	2.6	2.6	3.1	3.4	3.7	.....
23	4.0	4.4	4.2	4.9	4.1	3.9	2.2	3.0	3.0	3.4	3.8	.....
24	4.0	4.6	4.1	4.8	4.2	4.1	2.1	3.8	3.2	3.7	3.6	.....
25	4.0	4.8	4.2	4.4	6.0	3.9	2.1	4.1	3.2	4.2	3.8	.....
26	4.0	4.9	5.1	4.4	5.9	3.7	2.4	4.4	3.1	5.2	5.5	.....
27	4.1	5.1	6.0	4.3	9.3	3.9	2.4	4.3	3.0	5.2	6.7	.....
28	4.1	5.1	6.6	4.2	8.3	4.1	2.5	4.1	3.0	4.9	6.6	.....
29	4.1	.....	7.2	4.1	7.2	4.2	2.4	3.9	2.9	4.7	6.3	.....
30	4.1	.....	[a] 11.5	4.2	6.5	3.9	4.0	3.7	2.8	4.5	6.2	.....
31	4.1	.....	8.5	.....	5.8	.....	3.7	3.4	.....	4.2	.....	.....

[a] Ice jam.

NOTE.—Ice conditions January 1 to March 30 and December 20 to 31.

Rating table for Black River at Neillsville, Wis., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.10	20	3.60	338	5.10	1,185	7.20	2,850
2.20	26	3.70	379	5.20	1,250	7.40	3,050
2.30	34	3.80	424	5.30	1,315	7.60	3,250
2.40	44	3.90	473	5.40	1,385	7.80	3,460
2.50	56	4.00	525	5.50	1,455	8.00	3,680
2.60	70	4.10	579	5.60	1,525	8.20	3,900
2.70	86	4.20	635	5.70	1,600	8.40	4,120
2.80	105	4.30	692	5.80	1,675	8.60	4,340
2.90	126	4.40	750	5.90	1,750	8.80	4,580
3.00	150	4.50	810	6.00	1,825	9.00	4,820
3.10	177	4.60	870	6.20	1,985	10.00	6,020
3.20	205	4.70	930	6.40	2,145	11.00	7,300
3.30	235	4.80	990	6.60	2,310	12.00	8,700
3.40	267	4.90	1,055	6.80	2,480		
3.50	301	5.00	1,120	7.00	2,660		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1905 and 1906. It is well defined between gage heights 3.3 feet and 7.7 feet. Beyond these limits the discharge is only approximate.

Monthly discharge of Black River at Neillsville, Wis., for 1906.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
April	8,700	579	3,860
May	5,180	473	1,450
June	2,570	126	730
July	635	20	184
August	750	26	188
September	930	105	274
October	1,250	44	298
November	2,400	205	733
December (1-19)	1,460	424	874

NOTE.—Values for 1906 are good, except July and August, which are fair. During the frozen period the discharge probably seldom exceeded 500 second-feet and attained a minimum of at least 150, and probably much less.

WISCONSIN RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Wisconsin River, the largest stream in the State of Wisconsin, rises in Lac Vieux Desert, a sheet of water about 10 square miles in area which lies directly on the line separating the upper peninsula of Michigan from Wisconsin, and enters the Mississippi just below Prairie du Chien. The river flows southward for 300 miles to the city of Portage; it then turns sharply and flows west and southwest for the remainder of the distance to its mouth. Its drainage basin, 12,280 square miles in extent, has an average width of about 50 miles and is 225 miles long. From source to mouth the distance by water is approximately 400 miles. The stream lies for the most part in the eastern half of the basin, and below the bend at Portage it flows within about 10 miles of its southern edge.

The country drained is rolling, and in places decided ridges break the surface. In the headwater region are many lakes and tamarack swamps, and all the way down to Portage there is more or less swamp land between the ridges. The wooded (pine) country extends from the Michigan boundary line down to within 40 miles, by river, of the city of Portage. Below that point the pine disappears, and a semi-prairie region gradually takes the place of the woods. In the southern part of the basin the Baraboo ranges of quartzite pass east and west from 400 to 700 feet above the surrounding country, and the bluffs along the lower river, especially on the south side, form prominent ramparts to the valley. Back from these the land is level or undulating.

Owing to the form of the basin and the position of the river in it there are no very large tributaries. The wooded character of all the upper portion of the drainage area aids in maintaining the flow of the stream during the dry and cold seasons and makes the Wisconsin one of the most uniform in flow of all the large tributaries of the Mississippi.

The elevation of the headwaters is 1,532 feet above the sea, and that of the mouth about 600 feet. Hence in a course estimated to be 407 miles the river falls 932 feet, or about 2.29 feet per mile. The most rapid part is in the upper portion of the stream, and here are the available water powers. At the rapids the river flows over a rocky bed, but at intermediate places the bed is largely made up of sand, gravel, and bowlders.

In the 53 miles between the foot of the upper dam at Merrill and the foot of the Rhinelander dam the river has a natural descent of 277 feet, an average of 5.2 feet per mile. In this stretch, besides several other fine powers, are included Grandfather Rapids, the largest water power on the river, developed or undeveloped. These rapids begin in the NE. ¼ sec. 30, T. 33 N., R. 6 E., and extend to the SW. ¼ sec. 31, a distance of 1½ miles, and are the most noted rapids on the river. A view of them is shown in Pl. IV, *A*. The descent in this distance is 89½ feet. The high bank and the bed of the river are in hard rock. For nearly thirty years the Wisconsin River Logging Association has maintained three logging dams on these rapids. It is probable that the cheapest method of developing this power would be to construct three dams of 30 feet head each, and that the power could be best employed by paper mills. The site is about midway in the 20-mile stretch from Merrill to Tomahawk.

About 1.5 miles above Grandfather Rapids are some small rapids where an 8.9-foot dam would back the water to the foot of Grandmother Rapids.

WISCONSIN RIVER SURVEY.

In order to point out the power possibilities along the 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 had upon application to the Director of the Geological Survey.

EAU CLAIRE RIVER SURVEY.

In order to point out the power possibilities along the Eau Claire River, a survey was made during 1906 from the mouth 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 had upon application to the Director of the Geological Survey.

WISCONSIN RIVER NEAR RHINELANDER, WIS.

This station was established December 1, 1905. It is located about 8 miles southwest of Rhinelander, Wis., at the highway bridge about 400 feet below Forbes and Wixson's dam and power station.

A. GRANDFATHER RAPIDS, WISCONSIN RIVER, WISCONSIN.

B. EVAPORATION STATION, MADISON, WIS.

The channel is straight for 400 feet above and below the bridge. The banks are of medium height, but do not overflow. The bed of the river is rocky and is permanent; the current is swift.

Discharge measurements are made from the lower side of the two-span highway bridge; the initial point for soundings is the right end of the downstream railing of the bridge.

A standard chain gage, which was read during 1906 by E. H. Miller and Charles Hagen, is attached to the upstream side of the bridge. Length of chain, 18.97 feet. The bench mark is the head of the right bolt on the upstream side of the top of the right upstream cylinder pier. It is marked with white paint and the letters "B. M."; elevation, 13.96 feet above the gage datum. The reference point is the center of pulley of gage; elevation, 17.12 feet above the gage datum.

Discharge measurements of Wisconsin River near Rhinelander in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 27	M. S. Brennan	209	473	2.71	[a] 1,040
April 17	Horton and Brennan	215	822	4.25	2,580
June 12	M. S. Brennan	216	656	3.60	2,050

[a] Narrow strip of ice along shore.

Daily gage height, in feet, of Wisconsin River near Rhinelander, Wis., for 1905–6.

Day.	1905.	1906.										
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.5	3.0	2.6	2.8	2.8	3.4	3.1	4.1	2.8	3.1	2.4	2.95	3.1
2	2.4	3.0	2.6	2.5	3.0	3.3	3.2	3.1	2.7	2.4	2.5	3.1	2.65
3	2.25	2.75	3.0	2.95	3.0	3.3	2.8	4.0	3.1	3.0	2.5	3.0	3.0
4	2.4	2.9	2.7	2.95	2.95	3.9	3.1	3.6	3.15	2.9	2.5	2.1	3.1
5	3.0	2.75	2.8	2.4	3.0	3.9	3.2	2.1	1.4	3.3	2.8	2.9	2.8
6	3.1	2.75	2.9	2.9	2.8	4.2	3.6	3.1	3.1	2.6	2.8	3.1	2.3
7	3.05	2.6	3.1	2.8	3.0	3.4	4.3	3.3	2.9	2.5	1.8	2.9	3.0
8	3.1	3.0	2.9	2.4	3.3	3.5	3.9	2.5	3.0	2.8	2.9	2.9	2.65
9	3.2	2.8	2.9	2.7	3.1	3.6	4.3	2.7	3.0	1.7	3.0	2.8	2.9
10	3.0	2.7	2.55	2.8	3.2	3.4	4.4	2.8	2.8	2.1	3.0	2.5	2.7
11	3.0	2.9	2.6	2.6	3.9	3.5	3.5	3.0	2.5	2.5	2.8	2.1	2.9
12	3.2	2.8	2.1	2.6	4.3	3.6	3.6	3.15	2.7	2.7	2.9	2.4	2.7
13	3.1	2.7	2.8	3.0	4.0	3.3	3.5	2.5	2.9	2.6	2.9	2.9	2.85
14	3.2	2.5	2.7	2.95	4.2	3.2	3.4	2.8	2.9	2.4	2.2	2.4	2.8
15	3.0	2.7	2.6	3.0	4.3	2.6	3.2	2.6	2.9	2.8	2.5	2.6	2.8
16	3.05	2.7	2.65	2.7	3.8	3.1	3.2	2.85	2.8	2.0	2.8	2.45	2.6
17	2.85	2.9	2.7	2.75	4.4	3.2	2.8	2.8	2.8	2.4	3.15	2.5	2.7
18	2.9	2.7	2.7	2.5	4.1	3.3	2.4	2.8	2.7	2.5	3.0	1.8	2.3
19	3.1	2.8	2.4	2.7	4.5	3.3	3.0	2.85	1.8	2.5	3.0	2.4	2.9
20	3.1	2.75	2.4	2.8	4.6	3.1	3.1	2.8	2.7	2.5	3.1	2.8	2.5
21	2.7	2.8	2.45	2.8	4.4	3.2	3.2	2.3	2.7	2.7	2.9	2.3	2.7
22	2.95	2.75	2.5	2.7	4.7	3.1	3.5	2.0	2.9	2.6	2.6	2.2	2.7
23	3.3	2.75	2.4	2.5	4.0	3.1	3.3	2.2	3.0	1.8	3.0	2.1	2.5
24	2.9	2.9	3.2	2.7	3.9	3.0	2.5	2.9	3.6	2.3	2.9	2.2	2.5
25	3.0	2.8	2.7	2.9	3.6	2.95	3.1	3.0	3.1	2.4	3.0	1.4	2.9
26	2.7	2.8	2.9	3.0	3.5	3.2	3.2	3.1	2.5	2.45	3.1	2.4	2.6
27	2.9	2.75	2.9	2.95	3.5	1.8	3.7	2.9	2.8	2.4	3.1	2.8	2.3
28	2.7	2.6	3.0	2.8	3.4	3.1	3.1	3.0	3.2	2.4	3.1	3.0	2.8
29	2.6	2.9	.....	2.5	3.9	3.05	3.7	2.0	3.25	2.6	3.1	3.2	2.8
30	2.8	3.0	.....	2.3	3.6	3.6	3.7	2.9	3.0	2.6	3.1	3.1	2.2
31	2.6	2.7	.....	2.7	.....	3.7	.....	2.6	2.9	.....	3.0	.....	2.7

NOTE.—No ice record.

WISCONSIN RIVER AT MERRILL, WIS.

This station was established November 17, 1902. It is located on the highway bridge in the city of Merrill, three blocks from the Lincoln County court-house, one-half mile from the Chicago, Milwaukee and St. Paul Railway station, and 1,000 feet below the dam of the electric-power house. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 68, where are given also references to publications that contain data for previous years.

Discharge measurements of Wisconsin River at Merrill, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 24[a]	M. S. Brennan	331	1,090	5.92	1,980
April 23[b]	do	334	2,300	8.26	10,000

[a] Partly frozen; discharge about 50 per cent of open channel rating. [b] Logs running.

Daily gage height, in feet, of Wisconsin River, at Merrill, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.6	5.5	5.75	5.65	7.35	6.55	6.65	4.45	5.85	3.5	6.05	5.9
2	5.75	5.9	5.7	5.7	7.65	6.65	6.45	4.6	6.45	4.5	5.7	5.8
3	6.45	5.5	5.45	6.15	7.8	6.45	7.0	5.2	6.4	4.8	6.0	5.6
4	6.3	5.9	5.2	6.7	7.6	5.85	7.2	5.3	6.35	5.0	5.95	5.5
5	6.85	5.6	5.75	7.65	7.75	7.35	6.85	5.45	6.15	4.75	5.0	5.7
6	5.95	5.65	6.0	7.45	7.75	8.15	6.55	5.05	5.9	5.05	5.75	5.6
7	5.8	5.5	5.65	7.6	7.3	8.25	6.95	5.05	5.6	4.85	5.45	5.45
8	5.7	5.8	5.9	7.5	6.8	7.95	7.5	5.1	5.3	4.45	5.85	5.3
9	5.5	5.6	5.8	8.0	6.45	8.1	5.7	5.15	5.0	4.75	5.65	5.3
10	5.55	5.9	5.4	9.75	6.75	7.75	5.75	5.6	5.0	4.15	5.25	4.8
11	6.05	5.8	4.95	9.8	6.95	7.5	5.7	5.5	4.8	5.3	5.35	5.5
12	5.95	5.65	6.0	9.75	7.0	7.5	5.8	5.9	4.7	5.25	4.9	5.4
13	5.75	5.65	5.6	10.0	6.6	6.7	5.65	4.8	5.55	5.3	5.2	5.7
14	5.8	5.55	6.15	10.05	6.65	6.4	5.8	5.2	5.6	5.0	5.0	5.0
15	5.65	5.7	5.8	9.95	6.65	6.1	5.5	5.05	5.65	4.35	5.65	5.45
16	5.95	5.25	5.9	9.45	6.7	6.1	4.55	5.6	5.7	4.85	5.3	5.45
17	6.35	5.05	6.05	9.2	6.95	5.7	5.6	5.15	3.75	5.15	5.45	5.4
18	6.15	5.1	5.75	9.25	6.4	5.55	5.25	5.2	5.05	5.3	5.15	5.55
19	5.65	5.2	5.6	9.5	6.55	5.85	5.25	5.05	5.45	5.95	5.45	5.5
20	5.65	5.3	5.6	9.55	6.8	6.4	5.15	3.3	5.4	5.1	5.55	5.1
21	5.9	5.75	5.9	9.4	7.2	6.65	5.05	5.6	5.4	5.9	5.75	5.4
22	5.75	5.85	5.75	9.15	6.95	5.8	4.15	6.55	5.75	5.6	5.7	4.95
23	6.0	5.8	5.8	8.85	6.6	5.75	3.5	7.55	5.5	5.6	5.25	5.0
24	5.6	5.65	5.85	8.25	6.55	6.15	5.5	7.15	4.45	5.85	5.1	4.85
25	5.2	5.95	5.6	8.25	6.95	6.7	5.55	6.8	5.55	6.95	5.45	5.35
26	5.5	5.7	5.95	8.0	7.05	6.2	5.15	8.45	5.1	6.65	5.4	5.4
27	5.9	5.5	6.15	7.55	6.4	6.1	4.35	7.75	5.35	6.5	5.5	5.6
28	5.6	5.95	5.7	7.3	6.8	6.05	4.95	7.25	5.0	6.15	6.1	5.7
29	5.7	.....	5.35	6.95	6.55	5.9	5.15	7.1	5.15	6.0	6.3	5.5
30	5.55	.....	5.8	7.4	7.2	6.45	3.8	5.95	4.7	6.1	6.3	5.65
31	5.85	.....	5.65	.....	6.95	.....	5.0	5.45	.....	6.1	.....	4.8

NOTE.—No ice record by observer. Probably ice conditions during January to March and December.

Rating table for Wisconsin River at Merrill, Wis., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
3.50	790	4.80	1,950	6.10	4,210	7.80	8,480
3.60	840	4.90	2,090	6.20	4,420	8.00	9,070
3.70	895	5.00	2,230	6.30	4,640	8.20	9,680
3.80	955	5.10	2,380	6.40	4,860	8.40	10,310
3.90	1,020	5.20	2,540	6.50	5,090	8.60	10,960
4.00	1,090	5.30	2,700	6.60	5,320	8.80	11,620
4.10	1,170	5.40	2,870	6.70	5,560	9.00	12,300
4.20	1,260	5.50	3,040	6.80	5,800	9.20	12,980
4.30	1,360	5.60	3,220	6.90	6,050	9.40	13,680
4.40	1,460	5.70	3,410	7.00	6,300	9.60	14,380
4.50	1,570	5.80	3,600	7.20	6,820	9.80	15,080
4.60	1,690	5.90	3,800	7.40	7,360	10.00	15,800
4.70	1,820	6.00	4,000	7.60	7,910		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906. It is fairly well defined between gage heights 5 feet and 8.5 feet. Below gage height 4.5 feet it is only approximate.

Monthly discharge of Wisconsin River at Merrill, Wis., for 1905–6.

[Drainage area, 2,630 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
1905.					
April	13,000	2,960	7,170	2.73	3.05
May	8,480	2,460	5,640	2.14	2.47
June	18,000	3,040	9,920	3.77	4.21
July	9,680	1,360	5,290	2.01	2.32
August	5,920	1,950	4,090	1.56	1.80
September	7,220	3,900	5,010	1.91	2.13
October	5,920	1,360	4,410	1.68	1.94
November	4,640	1,950	3,150	1.20	1.34
1906.					
April	16,000	3,320	10,400	3.95	4.41
May	8,480	4,860	6,230	2.37	2.73
June	9,840	3,130	5,510	2.09	2.33
July	7,630	790	3,450	1.31	1.51
August	10,500	706	3,770	1.43	1.65
September	4,980	925	2,950	1.12	1.25
October	6,180	790	2,900	1.10	1.27
November	4,640	2,090	3,170	1.21	1.35

NOTE.—Gage heights for 1905 are published in Water-Supply Paper No. 171. Discharge values for 1905 and 1906 are excellent, although logging may affect the results to a slight degree. Ice conditions assumed January, February, March, and December. Discharge as given by the measurements on January 24, 1906, is about 50 per cent of the open-channel rating.

WISCONSIN RIVER NEAR NECEDAH, WIS.

This station was established December 2, 1902. It is located on the highway toll bridge 3 miles east of Necedah, Wis., and 3 miles from the Chicago, Milwaukee and St. Paul and the Chicago and Northwestern railway stations. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 70, where are given also references to publications that contain data for previous years.

Daily gage height, in feet, of Wisconsin River near Necedah, Wis., for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.5	7.6	8.0	8.2	4.8	6.7	4.8	6.65	8.5
2	.....	9.85	7.7	7.8	7.65	4.8	6.8	5.2	6.4	7.9
3	.....	9.5	7.65	7.5	7.4	4.8	5.9	4.8	6.7	7.0
4	.....	9.8	7.5	7.4	7.85	4.9	6.0	4.6	6.7	7.1
5	6.5	10.2	7.6	7.2	8.0	4.9	6.2	4.8	6.2	7.1
6	6.7	10.4	7.7	6.4	7.8	4.7	6.45	4.9	6.1	6.6
7	6.5	11.6	7.7	6.0	7.2	5.3	6.25	4.85	6.0	6.5
8	6.5	13.0	7.85	7.4	6.75	4.9	6.1	4.4	5.55	6.5
9	6.5	13.0	7.5	8.45	6.4	5.05	5.9	4.85	5.4	6.5
10	6.5	12.9	7.35	8.75	6.35	4.8	5.3	4.9	5.1	6.1
11	6.4	13.0	7.1	8.6	6.3	4.95	5.8	4.75	5.75	6.6
12	6.4	13.2	7.0	8.4	6.0	5.0	5.2	4.8	5.9	6.7
13	6.4	13.0	6.9	7.8	6.0	5.0	4.9	4.6	5.9	6.2
14	6.4	12.85	6.75	7.4	5.8	5.3	4.9	5.1	5.3	5.9
15	6.4	13.0	7.5	6.9	5.6	5.0	4.95	4.75	5.3	5.85
16	6.4	13.3	8.1	6.8	5.5	4.95	4.9	5.15	5.3	6.0
17	6.4	13.3	7.85	6.7	5.1	5.0	5.15	5.0	5.2	6.4
18	6.4	12.9	7.8	6.3	5.3	5.05	5.7	4.8	5.2	7.6
19	6.3	12.1	7.25	6.4	5.3	4.8	5.2	4.65	5.7	7.6
20	6.3	11.3	7.2	5.9	5.3	4.7	4.9	4.8	6.4	.....
21	6.4	11.0	6.85	6.3	5.35	5.1	5.0	5.1	6.35	.....
22	6.4	10.8	6.7	6.8	5.35	4.8	5.25	5.55	6.35	.....
23	5.7	10.6	6.6	8.1	5.2	4.9	5.3	6.0	5.7	.....
24	5.7	10.1	6.2	8.3	5.05	5.95	5.2	5.75	5.4	.....
25	6.2	9.6	6.4	7.7	5.1	6.7	5.6	5.75	5.6	.....
26	6.5	9.15	6.4	7.3	5.05	6.9	5.45	6.0	5.6	.....
27	6.7	8.75	6.4	7.7	5.0	6.7	5.3	7.0	6.5	.....
28	7.1	8.4	7.2	8.3	5.2	7.3	5.15	7.1	7.1	.....
29	7.1	8.2	8.75	8.4	4.5	7.9	5.2	6.9	8.0	.....
30	7.9	7.9	8.7	8.6	5.1	7.5	5.15	7.0	8.9	.....
31	7.9	.....	8.5	.....	4.6	7.15	.....	6.6	.....	.....

NOTE.—Ice conditions January 1 to April 2, approximately. During March ice 1.6 feet thick. Ice conditions from about December 17 to 31.

Rating table for Wisconsin River near Necedah, Wis., for 1904–1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
4.50	2,810	5.60	5,380	6.60	8,200	8.20	13,000
4.60	3,020	5.70	5,640	6.70	8,500	8.40	13,600
4.70	3,240	5.80	5,900	6.80	8,800	8.60	14,200
4.80	3,460	5.90	6,170	6.90	9,100	8.80	14,800
4.90	3,690	6.00	6,440	7.00	9,400	9.00	15,400
5.00	3,920	6.10	6,720	7.20	10,000	9.20	16,000
5.10	4,150	6.20	7,010	7.40	10,600	9.40	16,600
5.20	4,390	6.30	7,300	7.60	11,200	9.60	17,200
5.30	4,630	6.40	7,600	7.80	11,800	9.80	17,800
5.40	4,880	6.50	7,900	8.00	12,400	10.00	18,400
5.50	5,130						

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904 and 1905. It is well defined between gage heights 4.5 feet and 10.5 feet. From gage height 6.3 feet to 11 feet the rating curve is a tangent, the difference being 300 per tenth. Above 11 feet the bank overflows, causing the discharge to increase at a greater rate per foot rise of gage.

Monthly discharge of Wisconsin River near Necedah, Wis., for 1906.

[Drainage area, 5,800 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
April	35,400	12,100	22,600	3.90	4.35
May	14,600	7,010	10,500	1.81	2.09
June	14,600	6,170	10,800	1.86	2.08
July	13,000	2,810	6,570	1.13	1.30
August	12,100	3,240	5,240	.903	1.04
September	8,800	3,690	5,140	.886	.99
October	9,700	2,600	4,840	.834	.96
November	15,100	4,150	6,760	1.17	1.30
December (1–19)[a]	13,900	6,040	8,160	1.41	1.00

[a] Discharge values December 17 to 19 corrected for ice conditions.

NOTE.—Values for 1906 good.

WAPSIPINICON RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Wapsipinicon River rises in Mower County, Minn., and flows southeastward, entering the Mississippi near Shafton, Scott County, Iowa. Its total drainage area is 2,300 square miles.

The river is generally fairly constant in flow, though its headwaters are sometimes low. As a rule, its banks are moderately high and the stream is well confined. There are numerous small power sites on this stream at Toronto, Oxford Mills, Newport, Anamosa, Central City, Troy Mills, Quasqueton, Independence, and Littleton. At several of these points, notably at Anamosa, there are good opportunities for building dams.

WAPSIPINICON RIVER AT STONE CITY, IOWA.

This station was established August 19, 1903. It is located in Stone City at the highway bridge, just above the Chicago, Milwaukee and St. Paul Railway bridge, and near the Dearborn stone quarry. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 73, where are given also references to publications that contain data for previous years.

Discharge measurements of Wapsipinicon River at Stone City, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 12	M. S. Brennan	125	173	2.68	[a] 95
March 7	A. H. Horton	186	1,490	10.26	4,750
March 31	M. S. Brennan	189	2 200	13.64	9,340
April 2	do	181	1,430	9.88	4,580

[a] Stream frozen entirely across; thickness of ice, 0.9 foot. The discharge was about 60 per cent of the open-channel rating for gage height, 2.68 feet.

Daily gage height, in feet, of Wapsipinicon River at Stone City, Iowa, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	9.42	12.45	3.62	3.95	2.95	2.90	2.72	3.08	2.68
2	.....	.....	10.02	10.00	3.60	4.32	2.92	2.90	2.68	3.02	2.80
3	2.76	.....	11.60	8.70	3.56	5.02	3.02	2.82	2.65	3.00	2.78
4	.....	.....	11.92	7.75	3.55	5.44	3.12	2.85	2.61	2.92	2.80
5	.....	.....	10.80	7.42	3.55	5.30	3.35	2.82	2.60	2.85	2.78
6	.....	.....	10.10	6.98	3.52	4.80	3.42	3.12	2.64	2.84	2.80
7	.....	3.04	9.30	6.85	3.50	4.35	3.40	3.04	2.62	2.80	2.76
8	.....	.....	8.80	6.70	3.48	3.92	3.30	3.00	2.62	2.78	2.74
9	2.68	.....	8.50	7.45	3.58	3.73	3.22	3.26	2.62	2.74	2.72
10	.....	.....	8.15	7.92	3.60	3.50	3.15	3.26	2.63	2.72	2.70
11	.....	.....	7.50	8.20	3.58	3.48	3.12	3.40	2.62	2.68	2.68
12	2.68	.....	7.10	8.20	3.52	3.34	3.10	3.68	2.72	2.66	2.66
13	.....	.....	6.35	7.88	3.48	3.25	3.35	3.68	2.82	2.68	2.65
14	.....	3.26	5.45	7.20	3.44	3.25	3.08	3.56	2.72	2.64	2.65
15	.....	.....	5.50	6.54	3.40	3.28	3.00	3.42	2.71	2.64	2.74
16	.....	.....	5.60	6.40	3.36	3.40	2.94	3.40	2.70	2.62	2.74
17	.....	3.02	5.45	6.23	3.38	3.35	2.90	3.35	2.75	2.62	2.75
18	.....	.....	4.95	5.90	3.52	3.24	2.85	3.22	2.76	2.62	2.72
19	.....	3.35	4.72	5.62	3.35	.....	2.82	3.12	2.85	2.62	2.70
20	.....	3.80	4.64	5.38	3.32	3.10	2.74	3.05	2.96	2.58	2.68
21	.....	5.05	4.30	5.05	3.25	3.10	2.80	3.00	2.95	2.56	2.70
22	.....	6.12	4.16	4.78	3.30	3.10	2.90	2.94	3.15	2.61	2.62
23	3.75	7.44	3.92	4.55	3.60	3.06	2.88	2.91	3.32	2.60	2.54
24	.....	7.95	3.80	4.38	4.02	3.02	2.81	2.85	3.52	2.64	2.52
25	.....	8.40	3.84	4.12	4.30	3.04	2.80	2.90	3.55	2.62	2.68
26	.....	8.55	4.45	3.96	4.30	2.92	2.72	2.96	3.54	2.60	2.96
27	.....	8.95	6.09	3.85	4.02	2.98	2.76	2.92	3.42	2.62	2.92
28	.....	9.55	7.42	3.72	3.95	2.96	2.78	2.88	3.30	2.64	3.12
29	.....	.....	8.90	3.65	4.02	2.94	2.88	2.84	3.22	2.64	3.08
30	.....	.....	10.82	3.60	3.84	2.98	2.96	2.80	3.15	2.65	3.08
31	.....	3.16	.....	13.66	.....	3.75	.....	2.92	2.79	.....	2.66	.....

NOTE.—River frozen January 1 to March 2; thickness of ice increasd from 0.5 foot January 3 to 1.3 feet February 14. River also frozen November 23 to 27 and December 7 to 31. During December the thickness of the ice was about 0.3 foot.

Rating table for Wapsipinicon River at Stone City, Iowa, for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.50	115	3.70	570	4.90	1,185	7.20	2,580
2.60	137	3.80	620	5.00	1,240	7.40	2,710
2.70	162	3.90	670	5.20	1,350	7.60	2,840
2.80	189	4.00	720	5.40	1,460	7.80	2,980
2.90	218	4.10	770	5.60	1,580	8.00	3,120
3.00	250	4.20	820	5.80	1,700	9.00	3,850
3.10	286	4.30	870	6.00	1,820	10.00	4,640
3.20	326	4.40	920	6.20	1,940	11.00	5,520
3.30	370	4.50	970	6.40	2,060	12.00	6,560
3.40	420	4.60	1,020	6.60	2,190	13.00	7,770
3.50	470	4.70	1,075	6.80	2,320	14.00	9,160
3.60	520	4.80	1,130	7.00	2,450		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906. It is well defined above gage height 2.7 feet.

Monthly discharge of Wapsipinicon River at Stone City, Iowa, for 1906.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
March	8,690	620	2,890	2.21	2.55
April	7,100	520	2,170	1.66	1.85
May	870	348	531	.405	.47
June	1,480	224	523	.399	.45
July	430	167	258	.197	.23
August	560	186	293	.224	.26
September	495	137	236	.180	.20
October	279	128	166	.127	.15
November	294	119	180	.137	.15

NOTE.—Values for 1906 are excellent. During the winter period the minimum flow was probably at least as low as 40 second-feet.

ROCK RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Rock River rises in the southeastern part of Wisconsin, flows south and southwest, and enters the Mississippi just below Rock Island, Ill. Its length is 286 miles. Of the total drainage area (11,000 square miles), 5,650 square miles are in Wisconsin and 5,350 in Illinois. The length of the basin is 175 miles; its greatest width is near the Wisconsin-Illinois State line, where for 20 miles or more it averages about 80 miles; above the boundary it averages 40 or 50 miles in width, while below, in Illinois, it narrows rapidly.

In the upper part of its course the river flows rather toward the eastern side of the basin, but near the State line it approaches the center, and finally flows decidedly near the western boundary of its drainage area. The total fall of the stream, distributed with comparative uniformity throughout its length, is 340 feet, an average of 1.2 feet per mile.

The country drained is undulating and comprises large expanses of unbroken prairie, groves, and extensive bodies of timber, swamp, and lake.

The data collected in this basin are valuable for water-power purposes.

ROCK RIVER AT ROCKTON, ILL.

This station was established May 13, 1903. It is located at the Rockton highway bridge, one-half mile from the Chicago, Milwaukee and St. Paul Railway station, 1 mile below the dam, and three-fourths mile below the junction of Pecatonica River with Rock River. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 76, where are given also references to publications that contain data for previous years.

Discharge measurements of Rock River at Rockton, Ill., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 31	M. S. Brennan	503	2,390	5.79	8,240
February 24	do	510	4,300	9.85	16,000
February 25	do	510	4,740	10.55	18,600
February 27	do	510	4,130	9.36	15,400
February 27	do	510	4,180	9.45	16,500
February 28	do	510	4,000	9.13	14,900
May 3	do	494	1,420	4.10	4,570

NOTE.—Measurements January 31 to February 28, inclusive, were slightly affected by ice conditions below the gaging section.

Daily gage height, in feet, of Rock River at Rockton, Ill., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Oct.	Nov.	Dec.
1	3.3	5.45	8.8	8.7	4.15	3.15	3.3	1.1	1.5	3.25
2	2.95	5.0	8.8	8.45	4.15	3.0	3.2	1.4	1.6	3.0
3	2.85	5.72	11.15	7.95	4.1	2.8	3.15	1.3	1.4	2.85
4	3.9	5.45	10.8	7.0	4.1	2.45	3.05	1.2	1.5	2.7
5	4.57	6.75	10.0	6.25	4.0	2.8	3.0	1.1	1.45	2.6
6	4.9	6.9	10.25	6.15	3.9	2.8	2.9	1.05	1.55	2.9
7	4.9	5.75	9.85	6.1	3.95	2.8	2.85	1.4	1.55	2.65
8	5.6	7.15	9.45	6.15	3.85	2.8	2.7	1.15	1.5	2.25
9	6.25	6.5	9.25	6.65	3.8	2.6	2.7	1.1	1.4	2.4
10	6.0	5.45	8.75	7.0	3.7	2.6	2.6	1.0	1.4	2.4
11	4.85	5.75	8.4	7.0	3.6	2.55	2.6	1.1	1.4	2.35
12	4.0	5.7	6.8	6.45	3.6	2.7	2.5	1.1	1.35	2.35
13	3.5	4.7	6.05	6.8	3.4	2.6	2.4	1.1	1.45	2.3
14	3.1	4.7	6.2	6.4	3.5	2.5	2.45	1.1	1.4	2.3
15	3.4	5.88	6.2	6.15	3.5	2.5	2.5	1.0	1.4	2.3
16	8.4	5.7	6.0	6.25	3.45	2.5	2.45	.95	1.3	2.0
17	7.25	5.45	6.25	6.05	3.2	2.3	2.5	1.0	1.15	2.0
18	7.1	5.1	5.61	5.9	3.15	2.3	2.4	1.0	1.3	2.0
19	7.3	4.3	5.31	5.75	3.0	2.45	2.3	.95	1.1	2.15
20	7.3	5.0	5.0	5.6	2.95	2.35	2.4	1.0	1.3	2.2
21	9.62	9.4	4.75	5.4	3.05	2.7	.....	1.25	1.3	2.0
22	9.5	9.1	4.3	5.35	2.9	2.6	.....	1.25	1.75	2.0
23	7.85	8.83	4.5	5.25	2.9	2.7	.....	1.3	1.95	2.0
24	8.7	9.25	4.4	5.0	2.9	2.65	.....	1.25	1.75	2.0
25	9.3	10.7	4.4	4.8	2.85	2.6	.....	1.3	1.8	1.5
26	9.5	9.85	4.65	4.7	2.9	2.75	.....	1.35	2.4	2.5
27	9.15	9.4	8.21	4.55	3.1	2.6	.....	1.4	3.4	1.5
28	8.3	9.25	8.3	4.53	3.4	2.5	.....	1.5	3.9	1.5
29	7.8	.....	8.7	4.5	3.2	3.1	.....	1.6	3.85	1.65
30	7.1	.....	8.8	4.21	3.6	3.3	.....	1.6	3.65	1.45
31	6.05	.....	8.75	.....	3.5	.....	.....	1.7	.....	3.01

NOTE.—Ice conditions January 5 to 10 and February 8 to 20; slight ice conditions during December. Gage heights are to water surface. This station was temporarily discontinued from July 21 to September 30.

Rating table for Rock River at Rockton, Ill., for 1904–1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.00	500	2.10	1,470	3.20	3,105	4.60	5,760
1.10	560	2.20	1,600	3.30	3,280	4.80	6,180
1.20	624	2.30	1,740	3.40	3,455	5.00	6,620
1.30	692	2.40	1,880	3.50	3,635	5.20	7,070
1.40	764	2.50	2,025	3.60	3,815	5.40	7,540
1.50	840	2.60	2,170	3.70	3,995	5.60	8,020
1.60	925	2.70	2,320	3.80	4,180	5.80	8,520
1.70	1,020	2.80	2,470	3.90	4,365	6.00	9,020
1.80	1,122	2.90	2,620	4.00	4,555	7.00	11,520
1.90	1,234	3.00	2,775	4.20	4,940	9.00	16,520
2.00	1,350	3.10	2,935	4.40	5,345	11.00	21,520

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906. It is well defined between gage heights 2.4 feet and 6 feet. The table has been extended beyond these limits, being based on one measurement at 13.32 feet. Above gage height 5.6 feet the rating curve is a tangent, the difference being 250 per tenth. Below gage height 2 feet the rating is approximate.

Monthly discharge of Rock River at Rockton, Ill., for 1906.

[Drainage area, 6,150 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
January	18,100	2,540	9,620	1.56	1.80
February	19,000	4,000	9,760	1.59	1.66
March	20,300	5,140	11,800	1.92	2.21
April	15,800	4,960	9,160	1.49	1.66
May	4,840	2,540	3,590	.584	.67
June	3,280	1,740	2,280	.371	.41
July 1–20	3,280	1,740	2,330	.379	.28
October	1,020	472	641	.104	.12
November	4,360	560	1,280	.208	.23
December	3,190	802	1,740	.283	.33

NOTE.—Values are rated as follows: January and March, good; February and October, approximate; April to July, excellent; November and December, fair. Discharge for ice periods corrected.

ROCK RIVER NEAR NELSON, ILL.

This station was established June 8 and was discontinued July 21, 1906. It is located about 1¼ miles west of Nelson, Ill., at the Chicago and Northwestern Railway bridge.

The channel is straight for 1,000 feet above and below the station. The right bank is high and does not overflow; the left bank is low and overflows. All of the discharge passes the section. The bed of the river is rocky and permanent, and the current is of moderate swiftness. The remains of old piers and an island above the station may affect the flow.

Discharge measurements were made from the downstream side of the five-span railway bridge to which the gage is attached. The initial point for soundings is the center of the right floor beam, which rests upon the right abutment.

The standard chain gage, which was read once each day by John McGlaughlin, is located on the lower side of the bridge about the center of the second span from the left side. Length of chain, 31.28 feet.

The bench mark is the top of the downstream end of the floor beam 363 feet from the right end of bridge; elevation, 30 feet above the gage datum.

Discharge measurements of Rock River near Nelson, Ill., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
May 4	M. S. Brennan	621	3,020	6.19	5,380
June 5	A. H. Horton	602	2,260	5.02	2,720
June 30	do	615	2,920	6.12	5,190

Daily gage height, in feet, of Rock River near Nelson, Ill., for 1906.

Day.	June.	July.	Day.	June.	July.
1		6.2	16	4.7	4.7
2		5.6	17	4.65	4.6
3		5.6	18	4.55	4.7
4		5.5	19	4.35	4.5
5		5.6	20	4.85	4.5
6		5.3	21	5.0	4.6
7		5.2	22	5.0	
8	5.2	5.1	23	4.8	
9	5.05	5.0	24	4.85	
10	5.0	4.8	25	4.7	
11	4.75	4.9	26	4.8	
12	4.65	4.9	27	4.85	
13	4.85	4.7	28	8.0	
14	4.9	4.7	29	6.4	
15	4.8	4.7	30	6.15	

ROCK RIVER AT STERLING, ILL.

This station was established January 5, 1905, and was discontinued March 3, 1906, on account of an ice gorge destroying the bridge. It was located on the new highway bridge in Sterling, Ill., about one-half mile below the dam of the Sterling Manufacturing Company. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 78, where are given also references to publications that contain data for previous years.

Discharge measurements of Rock River at Sterling, Ill., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 16[a]	M. S. Brennan	553	1,780	7.40	[c]3.370
January 16[b]	do	282	1,220	8.20	[c]2.300

[a] North channel. [b] South channel. [c] Ice conditions.

Daily gage height, in feet, of Rock River, at Sterling, Ill., for 1906.

Day.	North channel.		South channel.		Day.	North channel.		South channel.	
	Jan.	Feb.	Jan.	Feb.		Jan.	Feb.	Jan.	Feb.
1	6.04	14.71	5.88	15.72	17	7.00	13.10	7.04	14.90
2	6.06	14.64	5.90	15.64	18	6.98		7.02	
3	6.12	14.65	5.95	15.64	19	6.98		7.06	
4	6.12		5.98		20	7.00		7.10	
5	6.12		6.00		21	9.20		9.32	
6	6.16		6.06		22	[a]11.84		[a]11.94	
7	6.38		6.22		23	13.26		13.52	
8	6.46		6.29		24	14.38		14.78	
9	6.52		6.36		25	15.2		16.30	
10	6.58	13.00	6.40	14.10	26	15.45		16.50	
11	6.63		6.46		27	15.52		16.50	
12	6.77		6.66		28	15.3		16.52	
13	6.82		6.70		29	15.19		16.26	
14	6.88		6.77		30	14.78		15.66	
15	6.98		7.04		31	14.98		15.69	
16	6.98		7.04						

[a] Ice conditions January and February; both channels gorged with ice January 22 to February 26; South Channel bridge carried away February 22; North Channel bridge carried away February 25.

IOWA RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Iowa River rises in north-central Iowa, flows in a southeasterly direction, and joins the Mississippi about 30 miles above Burlington. Its chief tributary is Cedar River, which rises in Minnesota and flows into the Iowa about 50 miles above the mouth of the latter. The total drainage area of the Iowa is 12,400 square miles, 4,470 square miles of this being tributary to it above its junction with Cedar River at Columbus Junction. Cedar River drains 7,600 square miles above its union with Iowa River.

The chief power plants in the Iowa basin are at Iowa City, Marshalltown, Cedar Rapids, Waterloo, and Cedar Falls. The data collected in this basin are valuable for water-power purposes.

IOWA RIVER AT IOWA CITY, IOWA.

This station was established June 1, 1903, and was discontinued July 21, 1906. It is located on the county bridge directly west of the university grounds. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 83, where are given also references to publications that contain data for previous years.

A measurement was made at this station on June 1, 1906, by M. S. Brennan, giving the following results:

Width, 171 feet; area, 735 square feet; gage height, —0.35 foot; discharge, 470 feet.

At the time of this measurement there was ice along the shore. Therefore the discharge was about 70 per cent of the open-channel rating.

Daily gage height, in feet, of Iowa River at Iowa City, Iowa, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1			9.3	6.8	1.9		
2			9.9	7.2	1.9		1.1
3		2.2	8.3	7.6	2.0		.9
4			7.7	7.6	1.9	1.3	2.3
5			6.8	7.6	1.8	1.2	1.8
6			6.6	7.6	1.7	1.5	1.5
7			5.8	7.0	1.7	1.5	1.2
8			4.7	6.1	1.9	1.3	.8
9		1.2	4.4	6.2	1.9	1.2	.4
10			4.0	5.8	1.8	.9	.4
11			3.4	5.5	1.6	.8	— .2
12			2.8	5.4		.6	— .3
13	—0.1		2.4	5.0	1.3	.6	— .5
14			2.0	4.7	1.1	.6	— .5
15			1.8	4.6	1.1	.5	— .7
16			1.8	4.2	1.0	.5	— .7
17		1.2	2.5	4.1	.9	.5	— .7
18			2.4	4.2	.9	.3	—1.0
19			1.[illegible]	4.3	.8	.5	— .8
20			2.7	4.2	.6	.6	— .9

Daily gage height, in feet, of Iowa River at Iowa City, Iowa, for 1906—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
21	6.0	.....	2.3	4.0	0.6	.....	−0.8
22	.....	.....	2.1	3.7	1.3	1.1	.....
23	.....	.....	1.9	3.4	1.8	1.0	.....
24	.....	7.6	1.4	3.1	2.1	1.1	.....
25	.....	8.0	1.4	2.8	2.3	1.1	.....
26	.....	8.0	5.95	2.5	.....	1.0	.....
27	2.7	9.4	5.4	2.2	2.5	.9	.....
28	.....	9.6	4.5	2.1	1.7	.7	.....
29	.....	.....	5.3	1.9	1.8	.6	.....
30	.....	.....	6.2	1.8	1.7	1.0	.....
31	.....	.....	6.6	.....	1.7	.....	.....

NOTE.—River frozen, January 1 to February 23; January 13, ice 0.8 foot thick; January 21, rise caused by ice jam; January 27, open water within 2 feet of gage; February 3, open water within 4 feet of gage; February 9, small opening below gage; February 17, gage reading to top of ice; February 24 and 25, ice jam. After June 3 gage heights were affected slightly by the construction of a dam below the station.

Rating table for Iowa River at Iowa City, Iowa, for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
−1.00	360	0.30	916	1.60	1,760	3.80	3,650
−0.90	392	0.40	971	1.70	1,830	4.00	3,840
−0.80	426	0.50	1,028	1.80	1,900	4.20	4,030
−0.70	462	0.60	1,087	1.90	1,970	4.40	4,220
−0.60	499	0.70	1,148	2.00	2,040	4.60	4,410
−0.50	538	0.80	1,210	2.20	2,190	4.80	4,600
−0.40	579	0.90	1,274	2.40	2,350	5.00	4,800
−0.30	622	1.00	1,340	2.60	2,520	6.00	5,900
−0.20	666	1.10	1,410	2.80	2,700	7.00	7,150
−0.10	712	1.20	1,480	3.00	2,890	8.00	8,540
0.00	760	1.30	1,550	3.20	3,080	9.00	10,040
0.10	810	1.40	1,620	3.40	3,270	10.00	11,600
0.20	862	1.50	1,690	3.60	3,460		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1905. It is well defined above gage height −1 foot.

Monthly discharge of Iowa River at Iowa City, Iowa, for 1906.

[Drainage area, 3,320 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft per sq. mile.	Depth in inches.
March	11,400	1,620	4,420	1.33	1.53
April	7,960	1,900	4,750	1.43	1.60
May	2,440	1,090	1,760	.530	.61
June	1,760	916	1,310	.395	.44
July (1–21)	2,270	360	948	.286	.22

NOTE.—Values are rated as follows: March, June, and July, good; April and May, excellent. The minimum flow during ice period was at least as low as 470 second-feet.

CEDAR RIVER AT CEDAR RAPIDS, IOWA.

This station was established October 26, 1902. It is located at Cedar Rapids, Iowa, about 50 miles above the mouth of the river, and is near the city gas works and the plant of the Iowa Windmill and Pump Company. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 86, where are given also references to publications that contain data for previous years.

Discharge measurements of Cedar River at Cedar Rapids, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 31	M. S. Brennan	658	6,550	11.82	32,900
March 31	do	658	6,060	11.05	29,900
April 1	do	653	4,390	8.60	20,200
April 1	do	658	4,740	9.15	22,200
April 2	do	651	3,740	7.60	15,700

Daily gage height, in feet, of Cedar River at Cedar Rapids, Iowa, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	3.35	8.25	8.2	4.15	5.55	3.75	3.5	3.35	4.05	3.75	4.15
2	2.9	3.55	7.4	7.1	4.15	5.3	3.7	3.45	3.3	4.0	3.65	4.15
3	2.85	3.6	7.55	6.3	4.15	4.95	3.8	3.4	3.3	3.9	3.65	4.05
4	2.85	3.55	7.5	6.05	4.3	4.7	3.7	3.35	3.25	3.85	3.6	4.1
5	2.9	3.5	7.4	5.8	4.5	4.5	3.8	3.3	3.55	3.75	3.6	4.05
6	2.9	3.45	7.2	5.6	4.45	4.35	4.05	3.3	3.65	3.75	3.6	4.0
7	3.0	3.55	6.65	5.55	4.4	4.25	3.85	3.7	3.7	3.6	3.55	3.95
8	3.2	3.65	6.3	5.55	4.35	4.2	3.75	3.85	3.65	3.55	3.55	3.15
9	3.15	3.5	5.8	5.75	4.2	4.2	3.6	4.4	3.6	3.45	3.5	3.45
10	2.8	3.45	5.6	5.8	4.1	4.2	3.55	4.3	3.55	3.45	3.45	3.35
11	2.8	3.45	5.4	5.7	4.05	4.15	3.45	4.6	3.45	3.45	3.5	3.4
12	2.75	3.4	5.2	5.65	4.0	4.05	3.45	4.95	3.4	3.4	3.6	3.45
13	2.85	3.35	4.3	5.8	3.95	3.95	3.45	4.9	3.35	3.4	3.55	3.6
14	3.0	3.35	4.15	5.65	3.95	3.9	3.45	4.65	3.3	3.3	3.55	3.85
15	3.15	3.3	4.25	5.45	3.9	3.85	3.4	4.4	3.3	3.25	3.55	4.45
16	3.15	3.3	4.4	5.55	3.85	3.75	3.35	4.25	3.2	3.3	3.55	4.7
17	3.25	3.3	4.35	5.75	4.0	3.7	3.4	4.05	3.3	3.3	3.55	4.2
18	3.2	3.45	4.3	5.9	5.05	3.65	3.4	4.0	3.35	3.3	3.55	4.35
19	3.15	3.5	4.25	5.85	5.85	3.75	3.35	3.85	3.5	3.25	3.55	4.05
20	3.0	4.3	4.25	5.55	6.35	3.65	3.35	3.85	4.4	3.3	3.55	3.9
21	3.9	4.5	4.2	5.3	5.9	3.55	3.4	3.8	4.6	3.25	3.6	3.95
22	4.5	4.6	4.2	5.2	5.45	3.6	3.45	3.65	4.55	3.25	3.65	4.65
23	3.8	5.55	4.15	4.8	5.1	3.65	3.55	3.65	4.5	3.2	3.5	4.5
24	3.5	5.45	4.2	4.65	4.75	3.8	.....	3.7	4.6	3.35	3.45	4.45
25	3.4	5.55	4.15	4.5	4.7	3.85	.....	3.65	4.75	3.35	3.5	4.45
26	3.4	5.85	5.1	4.4	4.5	3.75	.....	3.7	4.8	3.3	3.65	4.2
27	3.3	7.8	5.5	4.25	4.5	3.7	3.3	3.65	4.65	3.45	3.85	4.05
28	3.3	8.37	6.45	4.2	4.85	3.65	3.3	3.45	4.45	3.6	3.9	3.95
29	3.3	.....	10.29	4.15	4.95	3.6	3.25	3.4	4.25	3.8	3.9	3.8
30	3.25	.....	16.27	4.1	5.2	3.65	3.25	3.4	4.15	3.8	4.1	3.95
31	3.3	.....	12.1	.....	5.55	.....	3.3	3.35	.....	3.75	.....	4.25

NOTE.—River generally frozen over January 1 to March 15; open channel at gage during ice period; river frozen along shore December 17 to 31.

Rating table for Cedar River at Cedar Rapids, Iowa, for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.70	600	3.80	2,575	4.90	6,150	6.00	10,000
2.80	720	3.90	2,875	5.00	6,500	6.20	10,750
2.90	840	4.00	3,175	5.10	6,850	6.40	11,510
3.00	970	4.10	3,475	5.20	7,200	6.60	12,280
3.10	1,110	4.20	3,800	5.30	7,550	6.80	13,060
3.20	1,270	4.30	4,125	5.40	7,900	7.00	13,850
3.30	1,440	4.40	4,450	5.50	8,250	8.00	17,800
3.40	1,625	4.50	4,775	5.60	8,600	10.00	25,700
3.50	1,825	4.60	5,100	5.70	8,950	12.00	33,600
3.60	2,050	4.70	5,450	5.80	9,300	14.00	41,500
3.70	2,300	4.80	5,800	5.90	9,650	16.00	49,400

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906. It is well defined between gage heights 2.9 feet and 12 feet. Above gage height 7 feet the rating curve is a tangent, the difference being 395 per tenth.

Monthly discharge of Cedar River at Cedar Rapids, Iowa, for 1906.

[Drainage area, 6,320 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
January	4,780	660	1,350	0.214	0.25
February	19,300	1,440	4,200	.665	.69
March	50,500	3,640	11,000	1.74	2.01
April	18,600	3,480	8,210	1.30	1.45
May	11,300	2,720	5,240	.829	.96
June	8,420	1,940	3,400	.538	.60
July	3,320	1,360	1,880	.297	.34
August	6,320	1,440	2,860	.453	.52
September	5,800	1,270	5,810	.919	1.03
October	3,320	1,270	1,910	.302	.35
November	3,480	1,720	2,120	.335	.37
December	5,450	1,190	3,310	.524	.60
The year	50,500	660	4,270	.676	9.17

NOTE.—Discharge applied as for open channel during winter period, which may give somewhat excessive results. Values are rated as follows: January, February, and December, good; March to November, excellent.

RED CEDAR RIVER AT JANESVILLE, IOWA.

This station was established April 26, 1905, and was discontinued September 30, 1906. It is located on the Illinois Central Railroad bridge at Janesville, Iowa, about one-fourth mile below the highway bridge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 86, where are given also references to publications that contain data for previous years.

Discharge measurements of Red Cedar River at Janesville, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 11	M. S. Brennan	136	178	1.70	[a]238
March 18	A. H. Horton	236	1,118	5.72	[b]1,930
March 28	M. S. Brennan	229	2,570	12.12	17,500
March 29	do	229	2,150	10.26	11,200
March 29	do	229	1,980	9.51	9,370
March 29	do	229	1,860	9.01	8,310
March 30	do	229	1,430	7.14	5,350
March 30	do	229	1,510	7.46	5,730

[a] River frozen entirely across. Gage height to bottom of ice, 0.70 foot: ice, 1.2 feet thick. Discharge about 70 per cent less than the open-channel rating at gage height 1.70 feet.
[b] Ice gorge one-fourth mile below station reduced the discharge about 50 per cent.

Daily gage height, in feet, of Red Cedar River at Janesville, Iowa, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1			6.7	4.9	1.8	3.8	1.7	1.3	1.0
2				4.1	2.0	3.2	1.6	1.2	1.0
3		1.9	10.0	3.8	2.2	2.8	1.5	1.1	1.3
4			9.4	3.6	2.5	2.6	1.8	1.1	1.7
5	1.7		8.8	3.5	2.4	2.4	1.5	1.1	1.7
6			7.6	3.5	2.2	2.3	1.4	1.4	1.8
7			6.2	3.6	2.0	2.3	1.4	1.3	1.7
8			5.7	3.5	1.9	2.7	1.3	1.9	1.5
9			6.0	3.8	1.8	2.6	1.2	2.3	1.4
10		1.7	4.0	4.1	1.7	2.6	1.2	3.6	1.3

Daily gage height, in feet, of Red Cedar River at Janesville, Iowa, for 1906—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
11	1.7			4.1	1.7	2.2	1.2	3.4	1.1
12	1.7		6.1	4.0	1.7	2.0	1.1	2.7	1.2
13			6.1	3.7	1.6	1.9	1.2	2.2	1.1
14			6.2	3.8	1.6	1.8	1.2	2.0	1.0
15			5.7	5.1	1.6	1.7	1.2	1.7	1.0
16			5.5	5.6	4.5	1.6	1.2	1.6	1.0
17		2.0	5.0	4.9	8.3	1.6	1.2	1.5	1.8
18			4.9	4.0	7.2	1.5	1.1	1.4	3.8
19	1.9		4.6	3.4	5.6	1.5	1.1	1.4	4.3
20			4.0	3.0	4.0	1.5	1.1	1.3	3.5
21			4.1	2.8	3.3	1.5	[a] 1.1	1.2	3.1
22			3.6	2.6	2.7	1.4	1.1	1.2	2.9
23			3.6	2.5	2.4	1.4	1.1	1.2	4.5
24		6.6	3.6	2.3	2.2	1.4	1.1	1.2	5.0
25		8.3	2.4	2.2	2.3	1.3	1.1	1.2	4.5
26		10.0	6.9	2.1	3.2	1.3	1.1	1.1	3.3
27	1.9	8.4	12.5	1.9	4.7	1.3	1.1	1.1	2.6
28		8.1	13.3	2.0	6.1	1.3	1.1	1.1	2.2
29			10.1	1.9	6.3	2.0	1.5	1.1	2.0
30			7.2	1.8	6.0	1.5	1.7	1.0	1.8
31			6.0		4.7		1.4	1.0	

[a] Interpolated July 21 to 27.

NOTE.—Ice conditions January 1 to March 25: Thickness of ice January 12 to February 17, 1.3 feet. February 24 to March 1, ice broken up. March 3 to 9, river clear of floating ice but gorged below gage. March 12 to 21, river blocked with ice.

Rating table for Red Cedar River at Janesville, Iowa, for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.00	380	2.40	1,300	3.80	2,340	6.40	4,560
1.10	440	2.50	1,370	3.90	2,420	6.60	4,760
1.20	500	2.60	1,440	4.00	2,500	6.80	4,970
1.30	560	2.70	1,510	4.20	2,660	7.00	5,190
1.40	620	2.80	1,580	4.40	2,820	7.20	5,420
1.50	680	2.90	1,650	4.60	2,980	7.40	5,660
1.60	740	3.00	1,720	4.80	3,140	7.60	5,910
1.70	810	3.10	1,790	5.00	3,300	7.80	6,180
1.80	880	3.20	1,860	5.20	3,470	8.00	6,500
1.90	950	3.30	1,940	5.40	3,640	9.00	8,270
2.00	1,020	3.40	2,020	5.60	3,820	10.00	10,500
2.10	1,090	3.50	2,100	5.80	4,000	11.00	13,500
2.20	1,160	3.60	2,180	6.00	4,180	12.00	17,000
2.30	1,230	3.70	2,260	6.20	4,370	13.00	21,100

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6. It is well defined between gage heights 1 foot and 12 feet.

Monthly discharge of Red Cedar River at Janesville, Iowa, for 1906.

[Drainage area, 1,840 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
March (26–31)	22,600	4,180	11,200	6.09	1.36
April	3,820	880	2,060	1.12	1.25
May	7,030	740	2,070	1.12	1.29
June	2,340	560	1,010	.549	.61
July	880	440	548	.298	.34
August	2,180	380	732	.398	.46
September	3,300	380	1,200	.652	.73

NOTE.—Values for 1906 are excellent. The flow during the winter period probably did not fall much below 240 second-feet.

DES MOINES RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Des Moines River rises in the southern part of Minnesota, flows to the south and southeast, and enters the Mississippi near Keokuk, Iowa. Its principal tributary is Raccoon River, which joins it at the city of Des Moines. The total drainage area of the Des Moines is 14,700 square miles. Above the mouth of the Raccoon its drainage area is 6,460 miles, while that of the Raccoon at its confluence with the Des Moines is 3,680 square miles.

The Des Moines is the largest stream in the State of Iowa and affords numerous opportunities for the development of water power. It is the natural recipient of the sewage of many towns.

DES MOINES RIVER AT FORT DODGE, IOWA.

This station was established April 22, 1905, and was discontinued July 19, 1906. It is located at the "Swede Town" bridge, the only highway bridge in Fort Dodge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 90.

Discharge measurements of Des Moines River at Fort Dodge, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 3	M. S. Brennan	272	1,240	5.25	3,550
May 23	do	249	694	3.31	1,130

Daily gage height, in feet, of Des Moines River at Fort Dodge, Iowa, for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Day.	Mar.	Apr.	May.	June.	July.
1	.....	5.7	5.9	3.8	3.5	17	.....	6.25	4.0	3.15	2.8
2	.....	5.45	6.1	3.6	3.35	18	.....	6.15	3.9	3.1	2.6
3	.....	5.25	6.05	3.85	3.3	19	.....	6.0	3.7	3.6	2.7
4	.....	5.2	5.8	3.8	3.25	20	.....	5.95	3.5	4.0	.....
5	.....	5.15	5.5	3.8	3.2	21	.....	5.5	3.45	4.0	.....
6	.....	5.2	5.15	3.8	3.2	22	.....	5.5	3.45	4.0	.....
7	.....	5.3	4.85	3.7	3.1	23	.....	5.4	3.35	3.85	.....
8	.....	5.45	4.65	3.7	3.05	24	.....	5.1	4.1	3.75	.....
9	.....	5.7	4.45	3.6	2.95	25	.....	4.9	3.8	3.7	.....
10	.....	5.85	4.25	3.5	2.9	26	9.9	4.7	3.8	3.7	.....
11	.....	5.85	4.15	3.45	2.9	27	7.75	4.5	3.75	3.8	.....
12	.....	5.75	4.0	3.35	2.7	28	7.75	4.5	3.7	3.85	.....
13	.....	6.05	3.9	3.3	2.7	29	6.8	4.35	3.7	3.7	.....
14	.....	6.25	3.8	3.3	2.8	30	6.25	4.25	3.7	3.6	.....
15	.....	6.4	4.35	3.25	2.85	31	5.8	.....	.....	.....	.....
16	.....	6.4	4.1	3.2	2.85						

NOTE.—Ice conditions January 1 to March 25.

Rating table for Des Moines River at Fort Dodge, Iowa, for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.60	550	3.70	1,450	4.80	2,835	5.90	4,535
2.70	615	3.80	1,555	4.90	2,985	6.00	4,690
2.80	685	3.90	1,665	5.00	3,140	6.20	5,010
2.90	755	4.00	1,780	5.10	3,295	6.40	5,350
3.00	830	4.10	1,895	5.20	3,450	6.60	5,710
3.10	905	4.20	2,015	5.30	3,605	6.80	6,080
3.20	985	4.30	2,140	5.40	3,760	7.00	6,460
3.30	1,070	4.40	2,270	5.50	3,915	7.20	6,840
3.40	1,160	4.50	2,405	5.60	4,070	7.40	7,220
3.50	1,255	4.60	2,545	5.70	4,225	7.60	7,600
3.60	1,350	4.70	2,690	5.80	4,380	7.80	7,980

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905 and 1906. It is well defined between gage heights 3.3 feet and 6 feet.

Monthly discharge of Des Moines River at Fort Dodge, Iowa, for 1906.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
March (26–31)	[a] 12,000	4,380	7,220
April	5,350	2,080	3,880
May	4,850	1,120	2,220
June	1,780	905	1,390
July (1–19)	1,260	550	828

[a] Discharge estimated.

NOTE.—Values are rated as follows: March to June, excellent; July, good.

DES MOINES RIVER AT DES MOINES, IOWA.

This station was established May 24, 1905, and was discontinued July 20, 1906. It was located at the Interurban Bridge at Des Moines, Iowa, near the suburb of Highland Park. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 92, where are given also references to publications that contain data for previous years.

Discharge measurements of Des Moines River at Des Moines, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 10	A. H. Horton	284	1,910	7.50	3,420
April 4	M. S. Brennan	289	2,440	8.90	5,650
May 22	do	278	1,680	6.96	2,500

Daily gage height, in feet, of Des Moines River at Des Moines, Iowa, for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Day.	Mar.	Apr.	May.	June.	July.
1	8.6	10.2	7.8	6.6	6.2	17	8.0	11.7	8.2	6.1	5.7
2	8.4	9.1	8.5	6.6	6.1	18	7.9	11.5	8.0	6.1	5.8
3	8.3	8.8	9.3	6.6	6.1	19	8.0	10.4	7.8	6.9	5.8
4	8.3	8.75	9.6	6.5	6.1	20	8.0	9.3	7.7	6.6	5.8
5	7.9	9.0	9.4	6.5	6.05	21	7.6	9.35	7.5	6.4	.....
6	7.6	8.8	9.0	6.4	6.0	22	7.4	9.0	7.4	6.3	.....
7	7.6	8.75	8.4	6.4	6.0	23	7.4	8.6	7.3	6.3	.....
8	7.4	8.8	8.1	6.3	5.9	24	7.6	8.3	7.1	6.4	.....
9	7.3	8.9	7.7	6.3	5.9	25	7.7	7.6	7.1	6.3	.....
10	6.7	9.5	7.4	6.4	5.9	26	8.8	7.3	7.0	6.3	.....
11	6.9	9.7	7.2	6.4	5.7	27	9.6	7.5	6.9	6.2	.....
12	7.3	9.7	7.1	6.3	5.75	28	11.5	7.3	6.8	6.2	.....
13	8.0	10.3	7.0	6.2	5.8	29	12.5	7.3	6.7	6.1	.....
14	8.2	10.6	6.8	6.2	5.7	30	12.9	7.4	6.7	6.1	.....
15	8.1	11.1	6.8	6.2	5.8	31	11.8	.....	6.6	.....	.....
16	8.0	11.4	6.9	6.1	5.7						

NOTE.—River open March 1 to 12, but frozen March 13 to 25.

Rating table for Des Moines River at Des Moines, Iowa, for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
5.20	790	6.60	2,130	8.00	4,100	9.80	7,320
5.30	860	6.70	2,250	8.10	4,260	10.00	7,700
5.40	940	6.80	2,370	8.20	4,430	10.20	8,100
5.50	1,020	6.90	2,490	8.30	4,600	10.40	8,500
5.60	1,100	7.00	2,620	8.40	4,770	10.60	8,900
5.70	1,190	7.10	2,760	8.50	4,940	10.80	9,300
5.80	1,280	7.20	2,900	8.60	5,110	11.00	9,700
5.90	1,370	7.30	3,040	8.70	5,290	11.20	10,100
6.00	1,470	7.40	3,190	8.80	5,470	11.40	10,520
6.10	1,570	7.50	3,340	8.90	5,650	11.60	10,940
6.20	1,680	7.60	3,490	9.00	5,830	11.80	11,360
6.30	1,790	7.70	3,640	9.20	6,200	12.00	11,780
6.40	1,900	7.80	3,790	9.40	6,570	13.00	13,940
6.50	2,010	7.90	3,940	9.60	6,940		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1905–6. It is well defined between gage heights 5.5 feet and 9 feet.

Monthly discharge of Des Moines River at Des Moines, Iowa, for 1906.

[Drainage area, 6,460 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
March	13,700	2,250	5,000	0.774	0.89
April	11,200	3,040	6,310	.977	1.09
May	6,940	2,130	3,580	.554	.64
June	2,490	1,570	1,840	.285	.32
July (1–20)	6,800	1,190	1,620	.251	.19

NOTE.—Values are rated as follows: March, good; April to July, excellent. Flow during March was probably not greatly affected by ice conditions.

DES MOINES RIVER AT KEOSAUQUA, IOWA.

This station was established May 30, 1903, and discontinued July 21, 1906. It is located on the county bridge, one-fourth mile above the old dam site and Government locks. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 94, where are given also references to publications that contain data for previous years. The data collected at this point are valuable for water-power purposes.

Discharge measurements of Des Moines River at Keosauqua, Iowa, in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 13	M. S. Brennan	565	1,980	2.45	[a] 2,260
March 12	A. H. Horton	587	2,870	3.64	7,860
April 5	M. S. Brennan	588	4,290	5.93	14,600
May 21	..do	584	2,710	3.34	6,960

[a] River frozen entirely across: gage height to bottom of ice is 2.10 feet; ice 0.3 to 1.0 foot thick. The discharge was about 50 per cent of the open-channel rating for gage height 2.45 feet.

Daily gage height, in feet, of Des Moines River at Keosauqua, Iowa, for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	1.52	3.15	6.50	9.40	3.58	2.20	2.62
2	1.50	3.18	6.60	9.08	3.50	2.15	2.40
3	1.80	3.20	5.90	7.65	3.32	2.10	2.18
4	3.00	2.95	5.35	6.42	3.32	2.05	2.68
5	3.35	2.55	4.98	5.95	3.95	2.00	2.95
6	3.60	2.45	4.58	5.85	4.60	2.00	2.02
7	.....	2.20	4.12	5.62	4.70	2.42	1.70
8	.....	2.02	3.92	5.50	4.62	2.70	1.52
9	.....	1.85	4.40	5.75	4.42	2.60	1.42
10	.....	1.80	4.40	5.85	4.10	2.05	1.30
11	.....	3.15	4.00	6.52	3.75	1.88	1.28
12	.....	4.55	3.60	6.55	3.50	1.72	1.20
13	2.55	2.00	3.20	6.05	3.12	1.68	1.20
14	.....	3.45	3.05	6.22	2.95	1.60	1.25
15	.....	2.95	2.32	7.10	2.78	1.55	1.20
16	.....	3.40	2.02	7.82	2.68	1.48	1.10
17	.....	5.30	2.02	7.18	2.52	1.42	1.15
18	.....	5.60	2.08	7.75	2.80	1.40	1.18
19	.....	1.75	2.05	6.62	3.42	1.40	1.15
20	6.15	2.48	1.98	6.35	3.50	2.65	1.15
21	7.90	6.00	1.98	5.80	3.35	2.40	1.12
22	5.90	5.62	2.00	5.22	3.02	2.18	.....
23	3.95	7.30	2.20	4.88	2.75	2.00	.....
24	3.20	8.75	2.48	4.48	2.60	2.02	.....
25	3.10	10.65	2.55	4.22	2.45	1.92	.....
26	2.90	7.75	5.55	3.95	2.32	1.90	.....
27	2.48	6.02	8.70	3.68	2.25	1.88	.....
28	2.18	6.28	9.28	3.52	2.28	1.82	.....
29	2.08	.....	9.40	3.55	2.30	1.72	.....
30	2.30	.....	9.88	3.52	2.30	2.18	.....
31	2.72	.....	9.80	.....	2.25	.....	.....

NOTE.—Ice conditions January 4 to 20, February 11 to 18. Ice gorged February 15 to 18.

Rating table for Des Moines River at Keosauqua, Iowa, for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.10	1,350	2.40	4,285	3.70	7,740	6.00	14,550
1.20	1,550	2.50	4,540	3.80	8,010	6.20	15,210
1.30	1,755	2.60	4,795	3.90	8,280	6.40	15,870
1.40	1,965	2.70	5,055	4.00	8,550	6.60	16,530
1.50	2,180	2.80	5,320	4.20	9,090	6.80	17,210
1.60	2,395	2.90	5,585	4.40	9,650	7.00	17,890
1.70	2,615	3.00	5,850	4.60	10,220	8.00	21,290
1.80	2,840	3.10	6,120	4.80	10,800	9.00	24,790
1.90	3,070	3.20	6,390	5.00	11,400	10.00	28,390
2.00	3,305	3.30	6,660	5.20	12,000	11.00	32,090
2.10	3,545	3.40	6,930	5.40	12,620		
2.20	3,790	3.50	7,200	5.60	13,250		
2.30	4,035	3.60	7,470	5.80	13,890		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906. It is fairly well defined between gage heights 1.1 feet and 6.4 feet. The table has been extended beyond these limits, being based on one measurement at 15.7 feet.

Monthly discharge of Des Moines River at Keosauqua, Iowa, for 1906.

[Drainage area, 14,300 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
January	21,000	2,180	[a] 4,160	0.291	0.34
February	30,800	2,700	[b] 8,130	.569	.59
March	28,000	3,260	10,700	.748	.86
April	26,200	7,250	14,600	1.02	1.14
May	10,500	3,910	6,400	.448	.52
June	5,060	1,960	3,260	.228	.25
July (1–21)	5,720	1,350	2,480	.173	.14

[a] Discharge estimated January 4 to 20. [b] Discharge estimated February 11 to 18.

NOTE.—Values are rated as follows: January and February, fair; March to May, excellent; June and July, good.

ILLINOIS RIVER DRAINAGE BASIN.

DESCRIPTION OF BASIN.

Illinois River, the most extensive of all the tributaries of the upper Mississippi, enters the main stream from the east about 24 miles above the mouth of the Missouri. Its drainage area of 29,000 square miles is distributed among three States—Illinois, Wisconsin, and Indiana; 24,700 square miles are in Illinois, 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 3,210 square miles are in Indiana, projecting east from the same area.

The eastern projection is the basin of Kankakee River, while the northern one consists of the basins of Fox and Des Plaines rivers. The union of the drainages of these projections may be considered the origin of the Illinois. 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 and undulating and includes some of the finest land in the United States. Many large and pros-

perous cities are situated within it, and it is covered with a network of railroads.

The drainage into the Illinois is quite evenly distributed along its course. The more important tributaries are Fox and Spoon rivers from the west, and the Kankakee, Vermilion, and Sangamon from the east.

ILLINOIS RIVER NEAR PEORIA, ILL.

This station was established March 10, 1903, and was discontinued July 21, 1906. It is located on the Peoria and Pekin Union Railroad bridge over the Illinois River, 1½ miles southwest of Peoria. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 97, where are given also references to publications that contain data for previous years. The data collected at this station are valuable for the purpose of studying the effect of the Chicago drainage canal on the river.

Discharge measurements of Illinois River near Peoria, Ill., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
January 15	M. S. Brennan	910	8,030	9.35	[a] 9,250
March 10	do	953	13,900	15.60	27,100
April 6	do	949	13,300	14.94	24,200
May 22	A. H. Horton	914	8,530	9.85	10,300

[a] No ice conditions.

Daily gage height, in feet, of Illinois River near Peoria, Ill., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	8.75	14.00	15.17	15.33	12.62	9.33	7.83
2	8.75	14.08	15.25	15.33	12.46	9.29	7.75
3	8.75	14.00	15.25	15.29	12.29	9.21	7.75
4	8.83	13.83	15.38	15.17	12.25	8.88	7.67
5	8.96	13.67	15.50	15.08	12.17	8.83	7.54
6	9.12	13.42	15.58	14.96	12.04	8.79	7.38
7	9.42	13.33	15.67	14.75	11.79	8.67	7.25
8	9.33	13.25	15.67	14.75	11.75	8.79	7.33
9	9.38	13.17	15.67	14.79	11.50	8.79	7.12
10	9.50	13.04	15.67	14.83	11.38	8.88	7.00
11	9.50	12.83	15.67	14.96	11.12	8.92	6.96
12	9.50	12.75	15.58	15.08	10.96	8.83	6.92
13	9.50	12.67	15.50	15.08	10.92	8.83	6.92
14	9.50	12.67	15.42	15.17	10.83	8.83	6.83
15	9.58	12.67	15.17	15.25	10.67	8.75	6.83
16	9.79	12.67	14.83	15.29	10.46	8.75	6.83
17	9.83	12.67	14.62	15.12	10.71	8.75	6.75
18	9.83	12.58	14.46	14.96	10.50	8.67	6.67
19	9.75	12.50	14.29	14.83	10.42	8.58	6.67
20	9.67	12.50	14.08	14.71	10.21	8.58	6.67
21	10.04	12.96	13.88	14.58	10.00	8.50	6.75
22	10.42	13.17	13.75	14.46	9.88	8.50	.....
23	10.50	13.50	13.67	14.17	9.75	8.50	.....
24	11.17	13.92	13.54	13.83	9.71	8.50	.....
25	11.79	14.25	13.46	13.67	9.54	8.38	.....
26	12.38	14.71	13.42	13.62	9.58	8.33	.....
27	12.83	15.12	13.79	13.38	9.62	8.21	.....
28	13.21	15.17	14.25	13.17	9.67	7.96	.....
29	13.38	.....	14.71	13.00	9.54	7.83	.....
30	13.62	.....	15.17	12.88	9.38	7.92	.....
31	13.79	.....	15.33	.....	9.29	.....	.....

NOTE.—Running ice during greater portion of January, February, and March.

Rating table for Illinois River near Peoria, Ill., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
6.60	6,100	8.10	7,660	9.60	9,710	12.20	15,210
6.70	6,200	8.20	7,780	9.70	9,870	12.40	15.730
6.80	6,300	8.30	7,900	9.80	10,040	12.60	16,270
6.90	6,400	8.40	8,020	9.90	10,210	12.80	16,820
7.00	6,500	8.50	8,140	10.00	10,390	13.00	17,400
7.10	6,600	8.60	8,260	10.20	10,760	13.20	17,990
7.20	6,700	8.70	8,390	10.40	11,140	13.40	18,590
7.30	6,800	8.80	8,520	10.60	11,540	13.60	19,210
7.40	6,900	8.90	8,650	10.80	11,960	13.80	19,840
7.50	7,000	9.00	8,790	11.00	12,390	14.00	20,480
7.60	7,110	9.10	8,930	11.20	12,830	15.00	24,090
7.70	7,220	9.20	9,080	11.40	13,280	16.00	28,600
7.80	7,330	9.30	9,230	11.60	13,740		
7.90	7,440	9.40	9,390	11.80	14,220		
8.00	7,550	9.50	9,550	12.00	14,700		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906. It is well defined between gage heights 8.3 feet and 16 feet. Below gage height 8 feet the table is approximate.

Monthly discharge of Illinois River near Peoria, Ill., for 1906.

[Drainage area, 13,200 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Sec.-ft. per sq. mile.	Depth in inches.
January	19,800	8,460	11,500	0.871	1.00
February	24,800	16,000	18,700	1.42	1.48
March	27,000	18,700	23,600	1.79	2.06
April	25,500	17,100	22,700	1.72	1.92
May	16,300	9,220	12,000	.909	1.05
June	9,280	7,360	8,350	.633	.71
July (1–21)	7,360	6,170	6,620	.502	.39

NOTE.—Values for 1906 are excellent, except those for July, which are good. Discharge during January to March probably only slightly reduced by floating ice.

DESPLAINES RIVER NEAR CHANNAHON, ILL.

This station was established October 23, 1902, and discontinued July 24, 1906. It is located just above the mouth of Jackson Creek, 2½ miles southwest and 2 miles east of Channahon, Ill. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 100, where are given also references to publications that contain data for previous years. The data collected at this station are valuable for the purpose of studying the effect of the Chicago drainage canal on the river.

Daily gage height, in feet, of Desplaines River near Channahon, Ill., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	83.42	82.18	81.95	.....	83.15	83.25	84.20
2	83.40	82.65	81.95	.....	82.95	83.22	84.25
3	83.42	82.58	81.28	82.90	82.90	83.15	84.18
4	83.30	82.68	81.44	82.90	82.82	83.16	84.22
5	83.50	82.44	81.36	82.90	82.90	83.15	84.12
6	83.30	82.52	81.75	82.92	82.95	83.15	84.18
7	83.05	82.55	82.05	82.95	82.98	83.12	84.28
8	83.00	82.61	82.25	82.60	82.00	83.22	84.08
9	83.18	82.68	82.32	82.22	83.15	83.26	84.10
10	82.82	82.82	82.42	81.82	83.16	83.28	84.05
11	82.80	83.00	82.45	81.84	83.08	83.25	83.95
12	82.78	82.82	82.50	81.90	83.24	83.20	83.92
13	82.68	82.86	82.75	82.15	83.25	83.26	83.82
14	82.88	82.45	83.00	82.25	83.10	83.24	84.02
15	82.95	83.02	82.50	82.36	83.15	83.22	83.82
16	83.05	82.59	83.00	82.42	82.90	83.28	83.88
17	82.85	82.56	82.98	82.58	83.05	83.28	84.00
18	82.85	82.68	82.98	82.52	83.12	83.24	83.92
19	82.72	82.74	82.88	82.62	83.18	83.21	83.90
20	82.70	82.78	83.40	82.78	83.15	83.18	83.85
21	82.36	80.98	83.35	82.80	83.11	83.25	83.65
22	80.60	81.70	83.50	82.93	83.18	83.30	83.20
23	80.98	81.45	82.90	83.00	83.24	83.22	83.42
24	81.72	80.25	83.20	83.08	82.98	83.22	83.85
25	81.92	79.82	83.05	83.05	83.10	83.66	.....
26	81.84	80.48	82.80	83.00	83.15	84.20	.....
27	81.98	81.20	81.90	82.98	.....	84.25	.....
28	82.00	81.60	81.90	83.09	83.10	84.25	.....
29	82.00	.....	81.80	83.10	83.30	.....	.....
30	81.82	.....	81.85	83.16	83.22	84.20	.....
31	81.21	.....	82.30	.....	83.15	.....	.....

NOTE.—No estimates have been published for 1905 or 1906, as no discharge measurements were made. So far as known, the 1904 rating table is applicable for these two years, but as the information is very meager, there is a large element of uncertainty.

KANKAKEE RIVER AT DAVIS, IND.

This station was established July 13, 1905, and was discontinued July 21, 1906. It is located at the railroad bridge at Davis, 8 miles west of Hamlet, Ind. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 101. The data collected are valuable in connection with the drainage of Kankakee Swamp.

Discharge measurements of Kankakee River at Davis, Ind., in 1905 and 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 22	M. S. Brennan	72	241	4.55	213
October 3	do	74	238	4.70	317
1906.					
April 28	E. F. Kriegsman	75	354	5.55	463
June 12	do	69	257	5.07	294
June 30	do	64	214	4.60	272

Daily gage height, in feet, of Kankakee River at Davis, Ind., for 1906.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	5.4	4.9	4.8	17	.....	5.1	4.9	4.6
2	.....	5.5	4.8	4.6	18	.....	5.0	4.8	4.5
3	.....	5.5	4.8	4.5	19	.....	5.0	4.7	4.4
4	.....	5.5	4.8	4.6	20	.....	4.9	4.9	4.2
5	.....	5.4	4.8	4.6	21	.....	4.9	5.0	4.1
6	.....	5.3	4.8	4.5	22	.....	4.8	4.9	.....
7	.....	5.4	4.8	4.4	23	.....	4.8	4.8	.....
8	.....	5.4	5.0	4.4	24	.....	4.8	4.8	.....
9	.....	5.5	5.8	4.4	25	.....	4.8	4.7	.....
10	.....	5.4	5.8	4.4	26	.....	4.8	4.7	.....
11	.....	5.3	5.6	4.3	27	.....	5.1	4.7	.....
12	.....	5.2	5.5	4.2	28	5.5	5.2	4.7	.....
13	.....	5.4	5.4	4.2	29	5.5	5.1	4.6	.....
14	.....	5.5	5.3	4.3	30	5.5	5.0	4.6	.....
15	.....	5.4	5.1	4.3	31	.....	5.0	.....	.....
16	.....	5.3	5.0	4.4					

Daily discharge, in second-feet, of Kankakee River at Davis, Ind.

JULY TO DECEMBER, 1905.[a]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	280	260	295	340	595	17	725	240	520	295	385	.....
2	.....	280	690	295	360	570	18	500	225	520	340	385	.....
3	.....	280	960	295	360	515	19	395	225	470	360	385	.....
4	.....	260	1,110	295	340	.....	20	350	260	440	385	385	.....
5	.....	225	1,140	295	360	.....	21	305	240	415	385	385	.....
6	.....	420	1,110	295	360	.....	22	280	280	390	385	385	.....
7	.....	350	960	295	510	.....	23	260	225	365	385	360	.....
8	.....	280	750	295	510	.....	24	240	225	340	360	360	.....
9	.....	225	605	295	485	.....	25	240	280	340	360	385	.....
10	.....	225	575	315	460	.....	26	240	305	320	340	385	.....
11	.....	225	520	315	435	.....	27	240	305	300	340	385	.....
12	.....	225	495	315	410	.....	28	260	280	315	340	410	.....
13	.....	260	470	295	410	.....	29	470	280	315	340	435	.....
14	1,000	225	445	275	385	.....	30	420	260	295	315	625	.....
15	1,030	225	395	275	385	.....	31	350	240	.....	295	.....	.....
16	940	260	420	275	385	.....							

APRIL TO JULY, 1906.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	425	270	315	17	.....	330	280	270
2	.....	450	250	270	18	.....	305	260	250
3	.....	450	.....	250	19	.....	305	240	235
4	.....	450	.....	270	20	.....	285	295	200
5	.....	425	.....	270	21	.....	285	315	180
6	.....	385	.....	250	22	.....	260	295	.....
7	.....	410	250	235	23	.....	.....	275	.....
8	.....	410	280	235	24	.....	.....	295	.....
9	.....	435	470	235	25	.....	.....	275	.....
10	.....	410	470	235	26	.....	260	275	.....
11	.....	385	420	215	27	.....	330	275	.....
12	.....	360	390	200	28	450	335	290	.....
13	.....	410	370	200	29	450	315	270	.....
14	.....	435	345	215	30	450	295	270	.....
15	.....	410	300	215	31	.....	295	.....	.....
16	.....	385	300	235					

[a] Gage heights for 1905 were published in Water-Supply Paper No. 171.

NOTE.—On account of the shifting character of the river the discharge has been obtained indirectly from the discharge measurements. (See introduction to Water-Supply Paper No. 211.)

Monthly discharge of Kankakee River at Davis, Ind., for 1905–6.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1905.			
July (14–31)	1,030	240	458
August	420	225	262
September	1,140	260	542
October	385	275	321
November	625	340	405
1906.			
May	450	260	355
June	470	240	301
July (1–21)	315	180	237

NOTE.—Values for 1905 and 1906 are approximate, owing to changing conditions of flow at the gaging section.

KANKAKEE RIVER AT MOMENCE, ILL.

This station was established February 22, 1905, and was discontinued July 20, 1906. It is located on the highway bridge in Momence, Ill., about one-half mile below the Chicago and Eastern Illinois Railway bridge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 102. The data collected at this station are valuable in connection with the drainage of Kankakee Swamp.

Discharge measurements of Kankakee River at Momence, Ill., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
March 9	M. S. Brennan	501	1,190	3.27	3,920
April 24	E. F. Kriegsman	473	851	2.75	2,350
April 27	do	466	822	2.68	2,230
June 13	do	440	592	2.12	1,200

Daily gage height, in feet, of Kankakee River at Momence, Ill., for 1906.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Day.	Feb.	Mar.	Apr.	May.	June.	July.
1		2.70	2.95	2.52	2.00	1.80	17		3.05	2.95	2.10	2.00	1.65
2		2.70	2.90	2.50	2.00	1.80	18		3.02	2.90	2.10	2.00	1.65
3		3.30	2.90	2.45	2.00	1.80	19		2.95	2.90	2.10	2.05	1.65
4		3.42	2.90	2.42	2.00	1.80	20		2.92	2.82	2.05	2.10	1.65
5		3.35	2.90	2.38	2.00	1.80	21	2.68	2.85	2.80	2.02	2.08	.....
6		3.25	3.00	2.35	1.95	1.78	22	2.70	2.82	2.80	2.00	2.08	.....
7		3.20	3.02	2.30	1.98	1.73	23	2.75	2.78	2.75	2.00	2.05	.....
8		3.35	3.05	2.25	2.08	1.70	24	2.85	2.75	2.75	1.98	2.00	.....
9		3.30	3.42	2.25	2.20	1.70	25	3.10	2.78	2.70	1.95	1.95	.....
10		3.30	3.50	2.20	2.20	1.70	26	3.02	2.92	2.70	1.95	1.90	.....
11		3.20	3.38	2.20	2.20	1.70	27	2.88	3.20	2.65	1.95	1.90	.....
12		3.12	3.22	2.20	2.18	1.70	28	2.78	3.25	2.65	2.00	1.90	.....
13		3.05	3.10	2.20	2.10	1.65	29		3.12	2.60	2.00	1.88	.....
14		3.02	3.08	2.18	2.08	1.65	30		3.00	2.58	2.00	1.85	.....
15		3.02	3.02	2.12	2.05	1.65	31		3.00		2.00		.....
16		3.02	3.00	2.10	2.05	1.68							

Rating table for Kankakee River at Momence, Ill., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.60	310	2.10	980	2.60	2,030	3.10	3,210
1.70	410	2.20	1,170	2.70	2,260	3.20	3,460
1.80	529	2.30	1,380	2.80	2,490	3.30	3,710
1.90	650	2.40	1,590	2.90	2,730	3.40	3,970
2.00	810	2.50	1,810	3.00	2,970	3.50	4,230

NOTE.—The above table is applicable only for open-channel conditions. It is based on 9 discharge measurements made during 1905 and 1906. It is well defined between gage heights 2.1 feet and 4 feet. Below gage height 2.1 feet the table is uncertain, as the two lowest measurements are inconsistent.

Monthly discharge of Kankakee River at Momence, Ill., for 1906.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
February (21–28)	3,020	2,210	2,600
March	4,020	2,260	3,110
April	4,230	1,990	2,810
May	1,850	730	1,110
June	1,170	585	861
July (1–20)	520	360	425

NOTE.—Values for 1906 are excellent, except those for July, which are good.

YELLOW RIVER AT KNOX, IND.

This station was established August 21, 1905, and discontinued July 23, 1906. It is located on the North Heaton Street Highway Bridge, 100 rods north of the New York, Chicago, and St. Louis Railroad. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 104. The data are valuable in connection with the drainage of Kankakee Swamp.

Discharge measurements of Yellow River at Knox, Ind., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
August 21	M. S. Brennan	91	98	2.02	142
October 3	do	94	96	2.03	151
1906.					
March 11	E. F. Kriegsman	120	294	4.65	664
April 28	do	84	158	3.06	294
June 11	do	117	269	4.07	491
June 12	do	117	241	3.68	438
June 12	do	116	198	3.46	381
June 28	do	92	120	2.59	249

Daily gage height, in feet, of Yellow River at Knox, Ind., for 1906.

Day.	Mar.	Apr.	May.	June.	July.	Day.	Mar.	Apr.	May.	June.	July.
1	3.4	5.1	2.7	2.6	2.5	17	3.3	5.7	2.4	2.6	2.0
2	3.7	5.0	2.8	2.6	2.4	18	3.2	5.0	2.35	2.5	2.0
3	4.0	4.0	2.85	2.5	2.35	19	3.2	4.7	2.3	2.35	2.1
4	5.9	3.8	2.9	2.4	2.35	20	3.15	3.9	2.3	2.4	2.0
5	6.4	3.5	2.8	2.2	2.2	21	3.1	3.7	2.3	2.5	1.9
6	6.95	3.8	2.85	2.3	2.1	22	3.0	3.5	2.25	2.5	2.0
7	6.65	4.1	2.7	2.5	2.0	23	3.0	3.3	2.2	2.5	2.0
8	5.7	4.2	2.6	2.6	1.9	24	2.9	3.15	2.2	2.4	.....
9	5.2	4.3	2.55	3.5	1.9	25	3.0	3.0	2.2	2.3	.....
10	5.15	4.5	2.5	4.3	2.0	26	3.3	3.0	2.4	2.25	.....
11	4.65	4.9	2.5	4.5	2.1	27	4.3	3.1	2.5	2.2	.....
12	4.4	4.7	2.45	3.7	2.15	28	6.4	3.05	2.6	2.7	.....
13	4.0	4.5	2.45	3.1	2.1	29	6.1	2.9	2.7	2.6	.....
14	3.8	4.7	2.4	2.8	2.0	30	6.0	2.8	2.75	2.5	.....
15	3.5	4.8	2.4	2.7	2.0	31	5.4	.....	2.7	.....	.....
16	3.4	5.4	2.4	2.7	2.0						

Rating table for Yellow River at Knox, Ind., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1.00	56	2.20	171	3.40	368	5.20	792
1.10	63	2.30	185	3.50	387	5.40	848
1.20	70	2.40	199	3.60	407	5.60	906
1.30	78	2.50	214	3.70	428	5.80	966
1.40	86	2.60	230	3.80	449	6.00	1,028
1.50	94	2.70	246	3.90	471	6.20	1,091
1.60	103	2.80	262	4.00	493	6.40	1,155
1.70	113	2.90	278	4.20	539	6.50	1,187
1.80	123	3.00	294	4.40	586	6.60	1,219
1.90	133	3.10	312	4.60	634	6.80	1,284
2.00	145	3.20	330	4.80	685	7.00	1,350
2.10	158	3.30	349	5.00	738		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6. It is well defined between gage heights 2 feet and 5 feet. Beyond these limits the table is approximate.

Monthly discharge of Yellow River at Knox, Ind., for 1905–6.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1905.[a]			
August (21–31)	133	56	77.7
September	294	133	215
October	230	86	144
November	294	145	199
December (1–16)	387	214	320
1906.			
March	1,330	278	628
April	936	262	524
May	278	171	218
June	610	171	254
July (1–23)	214	133	157

[a] For 1905 gage heights see Water-Supply Paper No. 171.

NOTE.—Values are rated as follows: August, 1905, fair; October, 1905, good; remainder of the above period, excellent.

FOX RIVER AT SHERIDAN, ILL.

This station was established in September, 1905, and was discontinued July 20, 1906. It is located at the Glen Park highway bridge at Sheridan, Ill. The conditions at this station and the bench marks are described in Water-Supply Paper No. 171, page 105. The data collected are valuable for water-power purposes.

Discharge measurements of Fox River at Sheridan, Ill., in 1905–6.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1905.		*Feet.*	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 19	Hanna and Brennan	199	1,020	4.05	1,100
October 31	M. S. Brennan	199	1,000	4.12	1,080
1906.					
March 11	M. S. Brennan	196	1,340	5.70	3,330
March 29	A. H. Horton	204	1,340	5.70	3,320
March 30	do	204	1,320	5.60	3,180
May 21	do	199	916	3.58	596
May 21	do	199	916	3.58	595
June 20	M. S. Brennan	198	814	3.20	387

Daily gage height, in feet, of Fox River at Sheridan, Ill., for 1906.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Day.	Feb.	Mar.	Apr.	May.	June.	July.
1	.....	6.3	5.5	4.25	3.75	3.65	17	.....	5.1	5.35	3.85	3.25	2.95
2	.....	6.65	5.4	4.6	3.6	3.3	18	.....	5.2	5.3	3.85	3.0	3.0
3	.....	8.2	5.3	4.65	3.45	3.4	19	.....	5.1	5.2	3.8	3.2	3.05
4	.....	7.35	5.25	4.35	3.3	3.4	20	.....	4.95	5.1	3.75	3.25	3.05
5	.....	6.7	5.1	4.25	3.5	3.1	21	.....	4.85	5.0	3.65	3.15	.....
6	.....	6.7	5.3	4.15	3.55	3.15	22	6.8	4.5	4.85	3.85	3.05	.....
7	.....	6.5	5.2	4.0	3.45	3.2	23	6.15	4.45	4.75	3.8	3.1	.....
8	.....	6.45	5.15	4.2	3.35	3.05	24	6.7	4.25	4.75	4.0	3.05	.....
9	.....	6.35	5.9	4.15	3.3	3.0	25	9.05	4.70	4.6	4.15	3.0	.....
10	.....	6.25	6.35	4.1	3.4	3.25	26	7.6	4.85	4.55	4.0	3.0	.....
11	.....	6.1	6.0	4.05	3.15	3.05	27	6.5	7.40	4.45	3.9	3.0	.....
12	.....	5.8	5.75	4.0	3.2	3.0	28	6.5	6.9	4.4	3.8	3.25	.....
13	.....	5.35	5.65	3.95	3.35	3.15	29	.....	5.9	4.3	4.0	3.1	.....
14	.....	5.1	5.5	3.75	3.4	3.05	30	.....	5.6	4.2	3.95	3.65	.....
15	.....	5.1	5.5	3.95	3.35	3.0	31	.....	5.65	.....	3.70	.....	.....
16	.....	4.9	5.45	3.85	3.4	2.95							

Rating table for Fox River at Sheridan, Ill., for 1905–6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.90	220	4.10	1,100	5.30	2,710	7.00	5,630
3.00	260	4.20	1,210	5.40	2,860	7.20	6,010
3.10	310	4.30	1,330	5.50	3,020	7.40	6,400
3.20	360	4.40	1,450	5.60	3,180	7.60	6,800
3.30	420	4.50	1,570	5.70	3,340	7.80	7,200
3.40	480	4.60	1,700	5.80	3,500	8.00	7,600
3.50	550	4.70	1,830	5.90	3,660	8.20	8,020
3.60	630	4.80	1,970	6.00	3,830	8.40	8,440
3.70	710	4.90	2,110	6.20	4,170	8.60	8,860
3.80	800	5.00	2,260	6.40	4,520	8.80	9,280
3.90	900	5.10	2,410	6.60	4,880	9.00	9,700
4.00	1,000	5.20	2,560	6.80	5,250		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6. It is well defined between gage heights 3.2 feet and 5.7 feet.

Monthly discharge of Fox River at Sheridan, Ill., for 1905–6.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1905.[a]			
September (20–30)	1,050	710	831
October	1,510	420	863
November	1,210	515	912
1906.			
February (22–28)	9,780	4,080	5,770
March	8,020	1,270	3,570
April	4,430	1,210	2,540
May	1,760	670	1,020
June	755	260	422
July (1–20)	670	240	336

[a] For 1905 gage heights, see Water-Supply Paper No. 171.

NOTE.—Values are rated as follows: 1905 and March to May, 1906, excellent; February, June, and July, 1906, good.

INDEX.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 207.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are delivered to Senators and Representatives in Congress, for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports; Q, Fuels; R, Structural materials.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements (* means out of stock). A detailed index of these reports (1888–1903) is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II*.
1889. Eleventh Annual Report, Part II*.
1890. Twelfth Annual Report, Part II*.
1891. Thirteenth Annual Report, Part III*.
1892. Fourteenth Annual Report, Part II*.
1893. Bulletin No. 131*.
1894. Bulletin No. 131*; Sixteenth Annual Report, Part II*.
1895. Bulletin No. 140*.
1896. Water-Supply Paper No. 11*; Eighteenth Annual Report, Part IV*.
1897. Water-Supply Papers Nos. 15* and 16*; Nineteenth Annual Report, Part IV*.
1898. Water-Supply Papers Nos. 27* and 28*; Twentieth Annual Report, Part IV*.
1899. Water-Supply Papers Nos. 35*, 36*, 37*, 38*, and 39*; Twenty-first Annual Report, Part IV*.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65* and 75*.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75*.

1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.
1905. East of Mississippi River, Water-Supply Papers Nos. 165*, 166*, 167, 168*, 169, 170, and 171.
West of Mississippi River, Water-Supply Papers Nos. 171, 172*, 173*, 174, 175*, 176, 177, and 178.
1906. East of Mississippi River, Water-Supply Papers Nos. 201, 202, 203, 204, 205, 206, and 207.
West of Mississippi River, Water-Supply Papers Nos. 207, 208, 209, 210, 211, 212, 213, and 214.

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OCTOBER, 1907.

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