Water-Supply and Irrigation Paper No. 171 Series P, Hydrographic Progress Reports, 47

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

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1905

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

PART VII.—Hudson Bay and Upper Eastern and Western Mississippi River Drainages

BY

F. W. HANNA and JOHN C. HOYT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1906

Water-Supply and Irrigation Paper No. 171 Series P, Hydrographic Progress Reports, 47

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

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

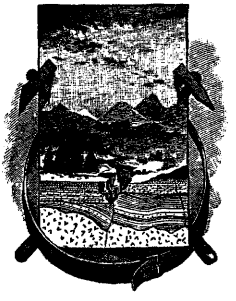
THE CALENDAR YEAR 1905

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

PART VII.—Hudson Bay and Upper Eastern and Western Mississippi River Drainages

BY

F. W. HANNA and JOHN C. HOYT



WASHINGTON
GOVERNMENT PRINTING OFFICE
1906

CONTENTS.

ILLUSTRATIONS.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1905.

PART VII.

By F. W. HANNA and JOHN C. HOYT.

INTRODUCTION.

ORGANIZATION AND SCOPE OF WORK.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. The first specific appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500 "for gauging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semi-arid sections." (Stat. L., vol. 28, p. 398.)

Since that time appropriations have been gradually increased, as shown by the following table:

Annual appropriations for hydrographic surveys for the fiscal years ending June 30, 1895 to 1906.

1895	$12,500	1901	$100,000
1896	20,000	1902	100,000
1897	50,000	1903	200,000
1898	50,000	1904	200,000
1899	50,000	1905	200,000
1900	50,000	1906	200,000

As a result of the increased appropriations the work has been greatly extended, and at the same time it has been more thoroughly systemized by the adoption of standard methods and by grouping the States into districts, in each of which a district hydrographer and a corps of assistants carry on a comprehensive study of the hydrographic resources.

The chief features of the hydrographic work are the collection of data relating to the flow of surface waters and the study of the conditions affecting this flow. There is also collected information concerning river profiles, duration and magnitude of floods, water power, etc., which may be of use in hydrographic studies. This work includes the study of the hydrography of every important river basin in the United States and is of direct value in the commercial and agricultural development of the country.

In order to collect the material from which estimates of daily flow are made, gaging stations are established. The selection of a site for a gaging station and the length of time it is maintained depend largely upon the physical features and the needs of each locality.

If the water is to be used for power, special effort is made to obtain information concerning the minimum flow; if water is to be stored, the maximum flow receives special attention. In all sections of the country permanent gaging stations are maintained for general statistical purposes to show the conditions existing through long periods. They are also used as primary stations, and their records, in connection with short series of measurements serve as bases for estimating the flow at other points in the drainage basin.

During the calendar year 1905 the division of hydrography has continued measuring the flow of streams on the same general lines as in previous years. Many new and improved methods have been introduced, by which the accuracy and value of the results have been increased. Approximately 800 regular gaging stations were maintained during the year, and an exceptionally large number of miscellaneous measurements and special investigations were made. "The Report of Progress of Stream Measurements," which contains the results of this work, is published in a series of fourteen Water-Supply and Irrigation Papers, Nos. 165 to 178, as follows:

No. 165. Atlantic coast of New England drainage.
No. 166. Hudson, Passaic, Raritan, and Delaware river drainages.
No. 167. Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages.
No. 168. Santee, Savannah, Ogeechee and Altamaha rivers and eastern Gulf of Mexico drainages.
No. 169. Ohio and lower eastern Mississippi river drainages.
No. 170. Great Lakes and St. Lawrence River drainages.
No. 171. Hudson Bay, and upper eastern and western Mississippi River drainages.
No. 172. Missouri River drainage.
No. 173. Meramec, Arkansas, Red, and lower western Mississippi River drainages.
No. 174. Western Gulf of Mexico and Rio Grande drainages.
No. 175. Colorado River drainage.
No. 176. The Great Basin drainage.
No. 177. The Great Basin and Pacific Ocean drainages in California.
No. 178. Columbia River and Puget Sound drainages.

These papers embody the data collected at the regular gaging stations, the results of the computations based upon the observations, and such other information as may have a direct bearing on the study of the subject, and include, as far as practicable, descriptions of the basins and the streams draining them.

For the purpose of introducing uniformity into the reports for the various years the drainages of the United States have been divided into eleven grand divisions, which have been again divided into secondary divisions, as shown in the following list. The progress report has been made to conform to this arrangement, each part containing the data for one or more of the secondary divisions. The secondary divisions have in most cases been redivided, and the facts have been arranged, as far as practicable, geographically.

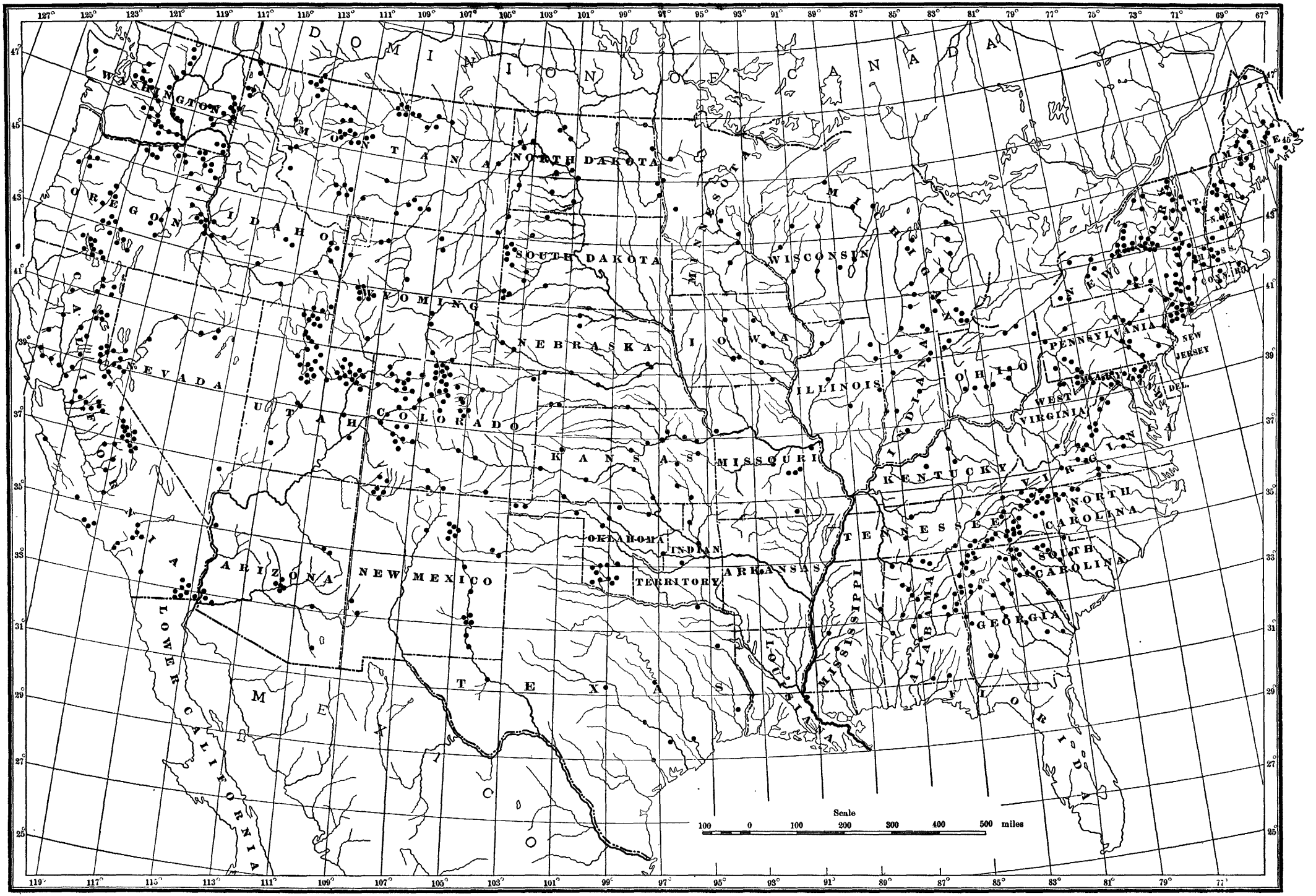
List of drainage basins in the United States.

NORTHERN ATLANTIC DRAINAGE BASINS.

St. John.	Thames.
St. Croix.	Housatonic.
Penobscot.	Hudson.
Kennebec.	Passaic.
Androscoggin.	Raritan.
Presumpscot.	Delaware.
Saco.	Susquehanna.
Merrimac.	Potomac.
Connecticut.	Minor Chesapeake Bay.
Blackstone.	Minor Northern Atlantic.

SOUTHERN ATLANTIC DRAINAGE BASINS.

James.	Great Pedee (Yadkin).
Chowan.	Santee.
Roanoke.	Savannah.
Tar.	Ogeechee.
Neuse.	Altamaha.
Cape Fear.	Minor Southern Atlantic.



MAP OF THE UNITED STATES, SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1905.

List of drainage basins in the United States—Continued.

EASTERN GULF OF MEXICO DRAINAGE BASINS.

Suwanee.
Apalachicola.
Mobile.
Pearl.
Minor Eastern Gulf of Mexico.

EASTERN MISSISSIPPI RIVER DRAINAGE BASINS.

Lower eastern Mississippi.
Ohio.
Upper eastern Mississippi.

ST. LAWRENCE RIVER DRAINAGE BASINS.

Lake Superior.
Lake Michigan.
Lake Huron.
Lake St. Clair.
Lake Erie.
Niagara River.
Lake Ontario.
Lake Champlain (Richelieu River).
Minor St. Lawrence.

WESTERN MISSISSIPPI RIVER DRAINAGE BASINS.

Upper western Mississippi.
Missouri.
Meramec.
Lower western Mississippi.
Arkansas.
Red.

WESTERN GULF OF MEXICO DRAINAGE BASINS.

Sabine.
Neches.
Trinity.
Brazos.
Colorado (of Texas).
Guadelupe.
San Antonio.
Nueces.
Rio Grande.
Minor Western Gulf of Mexico.

COLORADO RIVER DRAINAGE BASIN.

THE GREAT BASIN.

Wasatch Mountains.
Humboldt.
Sierra Nevada.
Minor streams in Great Basin.

PACIFIC COAST DRAINAGE BASINS.

Southern Pacific.
San Francisco Bay.
Northern Pacific.
Columbia.
Puget Sound.

HUDSON BAY DRAINAGE BASINS.

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 inch, and run-off in second-feet per square mile; and (2) those which represent the actual quantity of water, as run-off in depth in inches and acre-foot. 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 one foot wide, one foot deep, at a rate of one 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 one 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. In most States the California miner's inch is used, which is the fiftieth part of a second-foot.

"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 one 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 two acre-feet.

EXPLANATION 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 estimated monthly and yearly discharges and run-off, based upon all the facts obtained to date.

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 gage height, the area of cross section, the mean velocity, 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 readings 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 rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated monthly discharges 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 three remaining columns, which are defined on page 8, are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.
2. All items of computation should be expressed by at least two and not more than four significant figures.
3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent of error of all the other measurements should be rejected.
4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out to at least three significant figures, except in the case of decimals where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25; 0.125; 0.012; 0.0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

CONVENIENT EQUIVALENTS.

1 second-foot equals 50 California miner's inches.
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 deep, 13.572 inches deep.
1 second-foot for one year equals 0.000214 cubic mile; equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot falling 10 feet equals 1.136 horsepower.
100 California miner's inches equal 15 United States gallons per second.
100 California miner s inches equal 77 Colorado miner's inches.
100 California miner's inches for one day equal 4 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 130 California miner's inches.
100 Colorado miner's inches for one day equal 5.2 acre-feet.
100 United States gallons per minute equal .223 second-foot.
100 United States gallons per minute for one day equal 0.44 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 inch equals 2.54 centimeters.
1 foot equals 0.3048 meter.
1 yard equals 0.9144 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 1,760 yards; equals 5,280 feet; equals 63,360 inches.
1 square yard equals 0.836 square meter.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet; equals 4,840 square yards.
1 acre equals 209 feet square, nearly.
1 square mile equals 259 hectares.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons; equals 0.804 bushel.
1 cubic foot of water weighs 62.5 pounds.
1 cubic yard equals 0.7646 cubic meter.
1 cubic mile equals 147,198,000,000 cubic feet.
1 cubic mile equals 4,667 second-feet for one year.
1 gallon equals 3.7854 liters.
1 gallon equals 8.36 pounds of water.
1 gallon equals 231 cubic inches (liquid measure).
1 pound equals 0.4536 kilogram.
1 avoirdupois pound equals 7,000 grains.
1 troy pound equals 5,760 grams.
1 meter equals 39.37 inches. Log. 1.5951654.
1 meter equals 3.280833 feet. Log. 0.5159842.
1 meter equals 1.093611 yards. Log. 0.0388629.
1 kilometer equals 3,281 feet; equals five-eighths mile, nearly.

1 square meter equals 10,764 square feet; equals 1,196 square yards.
1 hectare equals 2.471 acres.
1 cub c meter equals 35.314 cubic feet; equals 1.308 cubic yards.
1 liter equals 1.0567 quarts.
1 gram equals 15.43 grains.
1 kilogram equals 2.2046 pounds.
1 tonneau equals 2,204.6 pounds.
1 foot per second equals 1.097 kilometers per hour.
1 foot per second equals 0.68 mile per hour.
1 cubic meter per minute equals 0.5886 second-foot.
1 atmosphere equals 15 pounds per square inch, equals 1 ton per square foot, equals 1 kilogram per square centimeter.
Acceleration of gravity equals 32.16 feet per second every second.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.8 feet.
1⅓ horsepower equals about 1 kilowatt.
To calculate water power quickly: $\frac{\text{Sec. ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel, realizing 80 per cent of the theoretical power.
Quick formula for computing discharge over weirs: Cubic feet per minute equal $0.4025\ l\sqrt{h^3}$; l = length of weir in inches; h = head in inches flowing over weir, measured from surface of still water.
To change miles to inches on map:

Scale 1 : 125000, 1 mile = 0.50688 inch.
Scale 1 : 90000, 1 mile = 0.70400 inch.
Scale 1 : 62500, 1 mile = 1.01376 inches.
Scale 1 : 45000, 1 mile = 1.40800 inches.

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 persons using this report may readily become acquainted with the general methods employed, the following brief description is 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 estimating the daily flow special methods are necessary for each class. The data upon which these estimates 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 of 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 estimating the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions.

Weir method.—When funds are available and the conditions are such that sharp-crested weirs can be erected, these offer the best facilities for determining flow. If dams are suitably situated and constructed they may be utilized for obtaining reliable estimates 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 the 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 Paper No. 150); (f) either no flashboards 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, a 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 estimates 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 estimates of flow will not involve, for a critical stage of considerable duration, the use of a head, on a broad-crested dam, of less than 6 inches. Moreover, when all other conditions

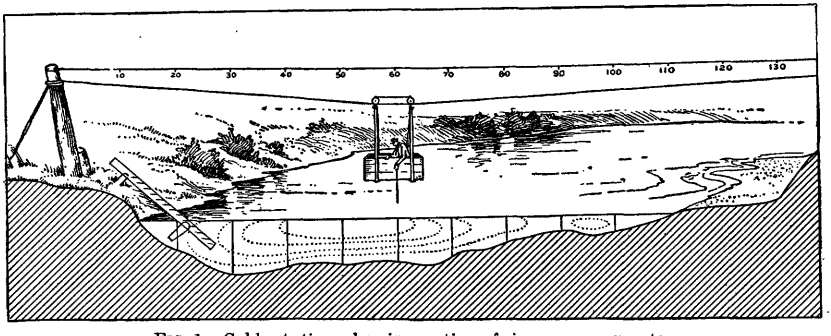


FIG. 1.—Cable station, showing section of river, car, gage, etc.

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 periods 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 on the contour of the bed and the fluctuations of the 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 dams or other artificial obstructions that the gage height shall be an index of the discharge.

There are generally pertinent to a gaging station certain permanent or semipermanent structures which are usually referred to as "equipment." 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 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, 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, cable, a boat, or by wading, and gaging stations may be classified in accordance with such use. Figure 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 conditions 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, 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.

There are in general use three classes of methods of measuring velocity with current meters—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 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. Assuming 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 where the depth is over 5 feet and the bed comparatively smooth, and moreover the indications are that it will hold 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 the majority of 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 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 in the vertical is measured twice. It is well adapted for measurements under ice and 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 vertical velocity-curve method, 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 varying thickness of ice. Such data as are available in regard to this subject are published in Water-Supply Paper No. 146, pp. 141–148.

OFFICE METHODS OF COMPUTING RUN-OFF.

There are two principal methods of estimating 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 the 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, and a thorough knowledge of the conditions at and in the vicinity of the station.

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 the conditions at or near the gaging station remain constant. (2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage. (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 change 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. This 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.

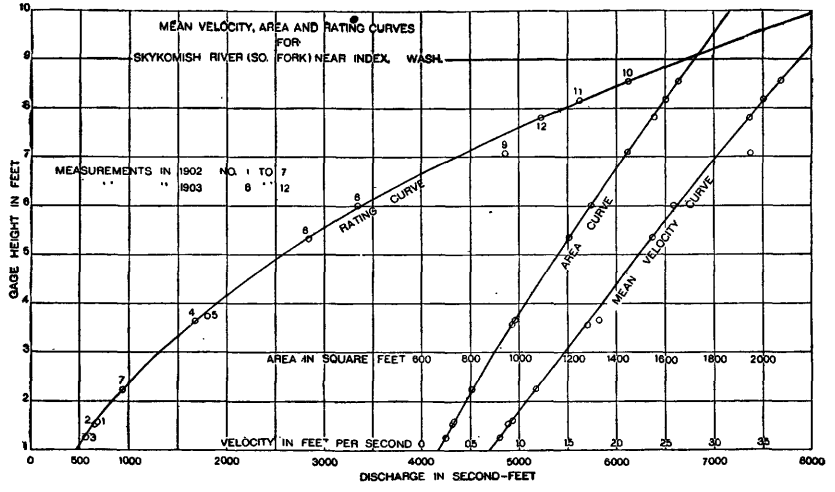


FIG. 2.—Rating, area, and mean velocity curves for South Fork Skykomish River near Index, Wash.

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, estimates can be obtained by its use. In case of velocity-area stations frequent discharge measurements must be made if the estimates 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 discharges 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, Part IV, p. 323, and in the Engineering News of April 21, 1904. This method, or a graphical application of it, is also much used in estimating flow at stations where the bed shifts but slowly.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and to corporations who have assisted the local hydrographers in any way, either by furnishing records of the height of water or by supplying transportation.

The following list, arranged alphabetically by States, gives the names of the district hydrographers and others who have aided in furnishing and preparing the data contained in this report:

Illinois.—District hydrographer, F. W. Hanna,[a] assisted by M. S. Brennan and Sidney K. Clapp. Acknowledgment is due to the Sterling Manufacturing Company for the establishment of two chain gages on the Avenue G Bridge, Sterling, Ill.

Indiana.—District hydrographer, F. W. Hanna, assisted by M. S. Brennan and Sidney K. Clapp.

Iowa.—District hydrographer, F. W. Hanna, assisted by M. S. Brennan. Acknowledgment should be made to Frank Dearborn, of Stone City, Iowa, for voluntary gage readings for the station on Wapsipinicon River.

Minnesota.—District hydrographer, F. W. Hanna, assisted by E. F. Chandler, of the engineering department of the University of North Dakota.

Montana.—District hydrographer, C. C. Babb, assisted by L. R. Stockman, H. M. Morse, W. B. Freeman, and A. M. Crain.

North Dakota.—District hydrographer, F. W. Hanna, assisted by E. F. Chandler, of the engineering department of the University of North Dakota.

Wisconsin.—District hydrographer, F. W. Hanna, assisted by M. S. Brennan.

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, and separated from it by a narrow strip of land, is Lower St. Mary Lake. The aggregate length of these two lakes is about 22 miles. The river flows out of the lower lake, the elevation of which is 4,460 feet above sea level, and within 2 miles is joined by 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.

[a] Office of the district hydrographer for Mississippi Valley, 876-877 Federal Building, Chicago, Ill.

ST. MARY RIVER NEAR BABB, MONT.

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 channel is straight for 500 feet above and 200 feet below the station. The right bank is high and rocky and is not liable to overflow; the left bank is comparatively low and might be overflowed by extremely high water. The bed of the stream is covered with gravel and bowlders. The velocity of the current is moderate.

Discharge measurements are made by means of a cable, car, and tagged wire. The initial point for soundings is on the left bank at the middle of the cottonwood tree to which the cable is fastened.

The gage is read once daily by Henry Henkel. The original gage was of the wire type and was supported on a horizontal arm extending over the river and fastened to a cottonwood stump about 1,000 feet above the cable from which measurements were made. The length of the wire from the marker to the bottom of the weight was 11.40 feet. This was replaced on August 23, 1905, by a chain gage, 11.35 feet long. The gage is referred to bench marks as follows: (1) Spike in the foot of a cottonwood tree 30 feet north of the gage, marked "B. M. 9.24," the figures denoting elevation above gage datum. (2) A 60-penny spike in the base of a cottonwood tree 125 feet above the gage; elevation above gage datum, 9.61 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 85, p 231; 100, pp 483–484; 130, pp 20–21.
Discharge: 85, p 232; 100, p 484.
Discharge, monthly: 85, p 233; 100, p 486; 130, p 23–24.
Gage heights: 85, p 232; 100, pp 484–485; 130, pp 21–22.
Rating tables: 85, p 233; 100, p 485; 130, p 22.

Discharge measurements of St. Mary River near Babb, Mont., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 26	Stockman and Morse	56	79	2.51	1.85	194
May 29	H. M. Morse	96	212	3.96	3.32	840
June 18	do	100	269	5.44	4.01	1,458
July 18	A. M. Crain	97	219	4.86	3.48	1,047
July 20	H. M. Morse	95	212	4.34	3.30	922
August 11	A. M. Crain	94	163	4.07	2.92	666
September 6	do	81	109	3.14	2.11	344
September 23	Morse and Freeman	68	95	2.45	1.98	233
November 17	W. B. Freeman	.....	80	2.15	1.85	172

Daily gage height, in feet, of St. Mary River near Babb, Mont., for 1905.

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

NOTE.—River frozen and readings to top of ice January 1 to March 1, inclusive, and November 26 to December 31, inclusive. Ice went out March 2.

Station rating table for St. Mary River near Babb, Mont., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.30	45	2.50	455	3.70	1,220	4.90	2,255
1.40	65	2.60	505	3.80	1,300	5.00	2,350
1.50	90	2.70	555	3.90	1,380	5.10	2,450
1.60	115	2.80	610	4.00	1,460	5.20	2,550
1.70	145	2.90	665	4.10	1,545	5.30	2,650
1.80	175	3.00	725	4.20	1,630	5.40	2,760
1.90	210	3.10	790	4.30	1,715	5.50	2,870
2.00	245	3.20	855	4.40	1,800	5.60	2,980
2.10	285	3.30	925	4.50	1,890	5.70	3,100
2.20	325	3.40	995	4.60	1,980	5.80	3,220
2.30	365	3.50	1,070	4.70	2,070	5.90	3,340
2.40	410	3.60	1,145	4.80	2,160	6.00	3,460

The above table is applicable only for open-channel conditions. It is based on nine discharge measurements made during 1905. It is well defined between gage heights 1.8 feet and 4 feet. The table has been extended beyond these limits. Below 1.7 feet the table is uncertain.

Estimated monthly discharge of St. Mary River near Babb, Mont., for 1905.

[Drainage area, 177 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a]45	2,767	0.254	0.293
February	.....	.....	[a]40	2,221	.226	.235
March	145	45	79	4,701	.446	.514
April	410	115	161	9,580	.910	1.02
May	925	365	625	38,430	3.53	4.07
June	1,890	925	1,454	86,520	8.21	9.16
July	1,220	855	1,015	62,410	5.73	6.61
August	855	325	577	35,480	3.26	3.76
September	325	210	270	16,070	1.53	1.71
October	665	210	425	26,130	2.40	2.77
November	285	175	[a]204	12,140	1.15	1.28
December	.....	.....	[a]170	10,450	.960	1.11
The year	.....	.....	422	306,900	2.38	32.53

[a] Frozen period estimated.

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 channel is straight for 100 yards above and 50 yards below the station. The right bank is high and not liable to overflow; the left bank is sloping and the water has been known to rise to a level considerably above the foot of the cable support. The bed of the stream is of sand and gravel and is liable to slight changes. There is but one channel, and the current is swift near the right bank.

Discharge measurements are made by means of a cable, car, and tagged wire. The initial point for soundings is the zero of the tagged wire at the left bank.

The gage, which is read daily by Vernon Shaw, is located at an old crossing about 1,200 feet above the cable. The gage first established was replaced in June, 1903, by the present gage. The length of the chain is 10.78 feet, and the datum is the same as that of the old gage. The gage bar is fastened to a tree and post on the left bank. The gage is referred to bench marks as follows: (1) A 60-penny spike driven into a cottonwood tree located directly back of the gage rod; elevation, 12.92 feet above zero of gage. (2) A 60-penny spike driven into a post 1 foot in diameter and 2 feet high, which is set in the ground 92 feet northeast of the gage rod; elevation, 17.56 feet above gage datum.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 85, p 225; 100, pp 476–477; 130, pp 24–25.
Discharge: 85, p 225; 100, p 477; 130, p 25.
Discharge, monthly: 100, p 479; 130, p 27.
Gage heights: 85, p 226; 100, p 478; 130, pp 25–26.
Rating table: 100, p 478; 130, p 26.

Discharge measurements of St. Mary River near Cardston, Alberta, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 27	L. R. Stockman	127	263	3.48	4.40	918
May 30	H. M. Morse	136	348	4.26	5.11	1,480
June 17	do	148	444	5.54	5.60	2,460
July 19	Morse and Crain	136	324	4.39	4.96	1,420
August 12	A. M. Crain	132	281	3.62	4.59	1,017
September 5	do	114	197	2.11	3.71	416
September 25[a]	H. M. Morse	108	166	1.96	3.53	324
November 17	W. B. Freeman	.....	160	1.59	3.30	255

[a] Made by wading.

Daily gage height, in feet, of St. Mary River near Cardston, Alberta, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.45	3.9	4.7	3.0	4.2	5.35	5.35	4.95	3.8	3.5	3.95	3.75
2	.....	3.9	.....	2.95	4.15	5.55	5.35	[a]4.9	3.8	3.5	3.85	3.9
3	4.3	.....	3.95	[a]2.95	4.15	5.75	5.35	4.8	3.75	[a]4.0	3.7	3.95
4	4.05	4.15	3.65	2.95	4.1	5.9	[a]5.3	4.7	3.7	4.6	3.7	3.8
5	4.1	4.1	3.0	2.95	4.1	6.0	5.35	[a]4.7	3.7	4.7	[a]3.7	3.75
6	4.05	4.15	3.0	2.95	4.1	[a]6.0	5.35	[a]4.6	[a]3.7	4.85	3.65	3.8
7	4.0	4.25	3.05	3.0	4.1	6.05	5.3	4.6	[a]3.7	4.9	3.6	3.8
8	3.7	.....	3.05	3.0	[a]4.35	6.0	[a]5.3	4.6	[a]3.7	4.9	3.6	3.8
9	3.8	4.55	3.0	[a]3.05	4.6	5.9	5.3	4.55	[a]3.65	4.85	3.5	3.7
10	3.8	4.55	3.0	3.1	4.7	5.8	5.35	4.6	[a]3.65	4.75	3.5	.....
11	3.8	4.55	3.0	3.1	4.65	5.8	5.35	[a]4.6	[a]3.65	4.65	3.5	3.65
12	3.8	4.55	[a]3.0	[a]3.1	4.65	5.8	5.3	4.59	3.65	4.5	[a]3.5	3.65
13	3.9	4.55	3.0	3.15	4.6	5.85	5.3	4.5	3.65	4.5	3.45	3.65
14	.....	4.55	3.1	3.15	4.6	5.85	5.2	4.5	3.6	[a]4.45	3.4	3.65
15	4.55	4.55	3.0	3.15	4.6	5.75	5.15	4.45	3.6	4.4	3.35	3.6
16	4.45	4.55	[a]2.95	3.15	4.5	5.7	5.05	4.4	3.65	4.3	3.3	3.55
17	4.45	4.55	2.9	3.1	4.55	5.6	5.05	4.3	3.65	[a]4.3	3.25	3.5
18	4.35	4.55	2.95	3.1	4.65	[a]5.5	5.0	4.25	3.65	4.25	3.3	3.4
19	4.25	.....	2.95	3.15	4.8	5.45	4.9	4.15	3.6	4.1	3.2	3.4
20	4.25	4.6	3.0	3.2	[a]5.0	5.35	4.85	4.05	3.6	4.0	3.15	3.35
21	4.15	4.6	2.95	3.25	5.3	5.35	4.85	4.0	3.55	3.9	3.15	3.0
22	4.0	4.65	3.0	3.25	5.35	5.55	4.85	4.0	3.4	3.85	3.15	3.0
23	4.0	4.7	2.95	3.30	5.3	5.5	4.85	4.0	3.45	3.8	3.2	2.95
24	4.15	4.7	2.95	3.50	5.15	5.4	4.85	4.0	3.5	3.8	3.2	3.05
25	4.15	.....	2.95	3.8	5.1	5.35	4.9	3.95	3.5	3.9	[a]3.15	3.1
26	4.2	4.5	3.0	[a]3.9	5.1	5.45	4.9	3.95	[a]3.5	3.9	[a]3.2	3.15
27	4.2	4.5	[a]3.0	4.04	5.05	5.35	4.95	[a]3.95	3.45	3.9	[a]3.2	3.15
28	4.15	4.55	3.0	4.4	5.05	[a]5.3	4.95	3.95	3.45	3.9	[a]3.2	3.15
29	4.15	.....	3.0	4.3	[a]5.1	5.25	4.9	3.95	3.5	3.9	[a]3.2	3.15
30	4.0	.....	2.95	[a]4.25	5.1	5.3	4.85	3.9	3.5	3.95	3.2	3.25
31	3.9	.....	2.95	.....	5.2	.....	4.85	3.9	.....	[a]3.95	.....	3.25

[a] Interpolated gage height.

NOTE.—River frozen during January, February, and December. Readings taken as follows: To water surface in a hole in the ice January 1–13, January 19 to February 7, and December 7–31. Water flowing over ice January 15–18, February 20 to March 1, December 2–4. River frozen solid to bottom at gage February 9–18. River open but partly gorged March 3–4. River clear March 5. Readings to ice December 1, 5, and 6.

Station rating table for St. Mary River near Cardston, Alberta, from September 13, 1902, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	100	3.70	410	4.90	1,370	6.00	3,165
2.60	109	3.80	460	5.00	1,490	6.10	3,380
2.70	121	3.90	515	5.10	1,620	6.20	3,605
2.80	136	4.00	575	5.20	1,755	6.30	3,835
2.90	153	4.10	640	5.30	1,900	6.40	4,075
3.00	174	4.20	710	5.40	2,055	6.50	4,325
3.10	198	4.30	785	5.50	2,215	6.60	4,585
3.20	225	4.40	870	5.60	2,385	6.70	4,855
3.30	255	4.50	960	5.70	2,565	6.80	5,135
3.40	288	4.60	1,055	5.80	2,755	6.90	5,425
3.50	325	4.70	1,155	5.90	2,955	7.00	5,725
3.60	365	4.80	1,260				

The above table is applicable only for open-channel conditions. It is based on 22 discharge measurements made during 1902–1905. It is well defined between gage heights 2.5 feet and 7 feet.

Estimated monthly discharge of St. Mary River near Cardston, Alberta, for 1905.

[Drainage area, 452 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	.....	.....	[a] 90	5,534	0.199	0.229
February	.....	.....	[a] 75	4,165	.166	.173
March	198	153	[b] 171	10,510	.378	.436
April	870	163	295	17,550	.653	.729
May	1,987	640	1,215	74,710	2.69	3.10
June	3,272	1,832	2,461	146,500	5.44	6.07
July	1,987	1,315	1,642	101,000	3.63	4.18
August	1,430	515	847	52,080	1.87	2.16
September	460	288	371	22,080	.821	.916
October	1,370	325	772	47,470	.171	.197
November	545	211	298	17,730	.659	.735
December	.....	.....	[a] 240	14,760	.531	.612
The year	.....	.....	706	514,100	1.43	19.54

[a] Frozen period estimated.
[b] Mean for 27 days taken as mean for entire month.

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., from which point it may be reached by regular stage. The nearest post-office is at Babb, Mont., 2 miles below.

The channel is straight for 500 feet above and 200 feet below the station. The left bank is high and rocky and not liable to overflow, though at high stages some water may pass in a small overflow channel just back of the cable support; the right bank is low and may overflow in a number of small channels which form a part of the old river bed. The bed of the stream is rocky, and the current is extremely swift during high water.

Discharge measurements are made by means of a cable, car and tagged wire, and low-water measurements are made by wading. The initial point for soundings was formerly at the left bank, but since September 2, 1904, when the cable was moved 50 yards upstream, it has been located on the right bank.

The gage is read once each day by Henry Henkel. The gage first established was washed away by high water in June, 1902, and the station was reestablished July 30, 1902. The new gage was located 1,800 feet above the first gage and above the cable station. It was again moved on September 27, 1902, to its present location, about 900 feet above the cable, as the second location was directly above a dam. The length of the wire from the marker to the end of the weight was 14.60 feet, and the distance from the zero of the rod to the outside of the pulley was 2.15 feet. This gage was washed out June 10, 1903, and replaced June 17, 1903, in practically its original position, by a gage having the same length of wire and the same position of pulley with reference to the scale zero as the former one. The length of the gage wire for the first part of 1905 was 14.57 feet. August 23, 1905, the wire was replaced by a chain, and the present chain length is 14.64 feet. The gage is referred to bench marks as follows: (1) A point chipped on a large bowlder 32.4 feet south of the gage; elevation above zero of gage, 12.52 feet. (2) Head of a 20-penny nail driven into the foot of a cottonwood tree 64.4 feet east of the gage; elevation above gage zero, 12.86 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 85, p 229; 100, pp 479–480; 130, p 28.
Discharge: 85, p. 229; 100, p 480; 130, p 29.
Discharge, monthly: 85, p 231; 100, p 482; 130, pp 30–31.
Gage heights: 85, p 230; 100, p 481; 130, p 29.
Rating tables: 85, p 230; 100, p 481; 130, p 30.

Discharge measurements of Swiftcurrent Creek near Babb, Mont., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 26	Stockman and Morse	57	99	5.35	3.40	530
May 29	H. M. Morse	.....	112	4.42	3.39	495
June 17	do	55	106	5.32	3.45	564
July 18	A. M. Crain	55	90	4.72	3.15	423
July 20	H. M. Morse	57	95	4.12	3.11	392
August 11	A. M. Crain	54	77	4.63	3.03	357
September 6	do	49	54	3.13	2.38	170
September 23	H. M. Morse	51	61	1.39	2.23	85
November 17	W. B. Freeman	.....	36	1.78	2.12	64

Daily gage height, in feet, of Swiftcurrent Creek near Babb, Mont., for 1905.

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

NOTE.—River frozen and readings to top of ice January 1 to February 25, inclusive, and November 26 to December 31, inclusive. Ice went out February 26.

Station rating table for Swiftcurrent Creek near Babb, Mont., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
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	4.40	1,255
2.40	130	3.10	385	3.80	800	4.50	1,335

The above table is applicable only for open-channel conditions. It is based on nine discharge measurements made during 1905, and extended parallel to 1904 curve. No measurements in 1905 being above 3.5 feet. It is well defined between gage heights 2.1 feet and 3.5 feet.

Estimated monthly discharge of Kennedy Creek near Babb, Mont., for 1905.

[Drainage area, 50 square miles.]

Month.	Mean discharge in second-feet.	Total in acre-feet.	Run-off.	
			Second-feet per square mile.	Depth in inches.
January	10	615	0.200	0.231
February	10	555	.200	.208
March	30	1,845	.600	.692
April	75	4,463	1.50	1.67
May	100	6,149	2.00	2.31
June	320	19,040	6.40	7.14
July	203	12,480	4.06	4.68
August	58	3,591	1.17	1.35
September	31	1,827	.614	.685
October	30	1,845	.600	.692
November	30	1,785	.600	.669
The period		54,200		

NOTE.—By interpolating between known gage readings, monthly mean discharges have been obtained for June, July, August, and September. The monthly means for January, February, March, April, May, October, and November are estimated.

MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in the St. Mary River basin in 1905 and show the seepage from St. Mary River.

Miscellaneous measurements in the St. Mary River drainage basin in 1905.

Date.	Stream.	Locality.	Width.	Gage height.	Area of section.	Mean velocity.	Discharge.
				Feet.	*Square feet.*	*Feet per second.*	*Second-feet.*
Sept. 23	Kennedy Creek	At mouth, Montana	16		11	2.00	22
July 20	St. Mary River	Babb, Mont.		2.30	311	4.23	1,316
Sept. 23	do	do	94	.87	138	2.30	317
Sept. 24	do	Just above mouth of Kennedy Creek, Montana.			129	2.66	343
Sept. 24	do	5½ miles below Kennedy Creek, Montana.			251	1.39	349
Sept. 24	do	Paisley dam site, Montana.			170	2.24	381
Sept. 25	do	One-fourth mile above International Line, Montana.			127	2.61	332
July 22	do	Kimball, Alberta[a]		3.35	413	3.41	1,408
Sept. 26	do	do.[b]			65	1.62	105
July 22	St. Mary canal	do.[c]			97	2.97	289
July 22	do	do.[d]			82	3.78	311
Sept. 25	do	do.[e]			98	2.84	278

[a] Measured above the head of the St. Mary canal at Canadian gaging station.
[b] Measured below the head of the St. Mary canal.
[c] Measured 2 miles below the head-gates.
[d] Measured 3 miles below the head-gates.
[e] Measured 1 mile below the head-gates.

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, still to a large extent awaiting settlement. 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 Cheyenne 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.

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.

The channel is straight for about 100 feet above and 150 feet below the station. The left bank is high and steep; the right bank is low and subject to overflow at times of high water. The bed of the stream is composed of silt and mud and is fairly permanent. There is but one channel at all stages.

Discharge measurements were originally made from the bridge to which the gage is attached, but owing to unfavorable conditions for accurate measurements the measuring section was changed June 10, 1904, to the footbridge at the Fargo waterworks, one-half mile upstream from the gage, except at unusually high stages, when measurements are made from the Northern Pacific Railway bridge, 15 rods below the gage. A movable timber and stay cable, enabling the meter to be held about 7 feet horizontally upstream from the footbridge, obviates the influence of the small piling piers. This equipment is stored in the pump house of the waterworks. The initial point for soundings at the footbridge is an electric-light pole on the right bank. The initial point at the railway bridge is the right end of the draw span.

The gage, which is read by H. R. Grasse, of the United States Weather Bureau, at Moorhead, Minn., is a vertical staff attached to the east side of the breakwater for the center pier of the bridge. The zero of the gage is 44.45 feet below the top of the plank walk of the bridge over the gage. The bench mark is a point on the extreme north end of the flat top of the concrete pier of the railway bridge at the initial point for soundings; elevation above zero of gage, 37.12 feet.

Information in regard to this station is contained in the following publications of the United States Geological Survey (WS=Water-Supply Paper; Bull=Bulletin):

Description: WS 85, p 237; 100, p 501; 130, pp 37–38.
Discharge: Bull 131, p 92; WS 85, p 238; 100, p 501; 130, p 38.
Discharge, monthly: WS 100, p 503; 130, p 40.
Gage heights: WS 85, p. 238; 100, pp 501–502; 130, pp 38–39.
Rating table: WS 100, p 502; 130, p 39.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 30	R. Richards	67	319	2.68	9.86	855
June 22	Chandler and Richards	108	535	1.95	9.84	1,044
July 29	Chandler and Hanna	110	563	1.98	10.19	1,115
August 22	R. Richards	114	650	2.02	10.90	1,317

Daily gage height in feet of Red River at Fargo, N. Dak., for 1905.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	7.7	9.1	7.8	9.4	9.9	10.2	10.0	9.6	8.9
2	.....	7.8	8.3	7.8	9.4	9.8	10.1	10.0	9.5	8.9
3	.....	8.4	8.6	7.9	9.3	9.7	10.1	9.9	9.5	9.0
4	.....	8.6	8.5	8.1	9.3	9.6	10.0	9.9	9.5	9.0
5	.....	8.5	8.3	8.3	9.5	9.8	10.0	9.9	9.4	9.0
6	.....	8.5	8.3	8.6	9.7	9.9	10.0	9.8	9.2	9.0
7	.....	8.6	8.4	8.8	9.8	10.0	9.9	9.8	9.2	9.0
8	.....	8.6	8.5	9.0	10.0	10.1	9.8	9.8	9.1	8.9
9	.....	8.6	8.5	9.2	9.9	10.2	9.9	9.8	9.0	8.9
10	.....	8.5	8.4	9.5	9.8	10.3	9.8	9.7	9.0	8.8
11	.....	8.5	8.3	10.3	9.8	10.3	9.7	9.7	9.0	8.8
12	.....	8.5	8.3	11.4	9.7	10.3	9.8	9.7	9.1	8.7
13	.....	8.5	8.2	13.3	9.8	10.4	9.9	9.6	9.2	8.7
14	.....	8.4	8.1	15.6	9.9	10.3	10.2	9.5	9.2	8.7
15	.....	8.3	8.0	17.0	9.9	10.3	10.3	9.3	9.2	8.7
16	.....	8.2	8.0	18.0	9.9	10.2	10.4	9.3	9.2	8.8
17	.....	8.1	8.0	18.4	9.9	10.2	10.9	9.3	9.2	8.7
18	.....	8.0	8.0	17.8	9.8	10.2	11.5	9.3	9.2	8.7
19	7.6	8.0	8.0	16.7	9.7	10.2	11.4	9.4	9.2	8.7
20	.....	8.0	8.0	14.7	9.8	10.1	11.2	9.6	9.2	8.7
21	.....	8.0	8.0	13.5	9.9	10.2	11.1	9.6	9.2	8.7
22	.....	8.1	7.9	12.4	9.9	10.1	11.0	9.7	9.2	8.7
23	.....	8.1	7.9	11.7	9.9	10.0	10.8	9.8	9.2	8.7
24	.....	8.0	7.9	11.5	10.0	10.0	10.8	9.8	9.1	8.7
25	7.6	8.0	7.9	11.0	10.0	10.0	10.6	9.8	9.0	8.7
26	7.6	8.0	7.9	10.8	9.9	10.0	10.5	9.8	9.0	8.7
27	7.6	8.2	7.9	10.5	9.9	9.8	10.5	9.8	9.0	8.8
28	7.6	8.5	7.9	10.3	9.9	10.0	10.4	9.8	9.0	8.7
29	.....	9.0	7.9	10.0	10.0	10.2	10.3	9.7	9.0	8.6
30	.....	9.0	7.8	9.5	10.0	10.2	10.2	9.7	9.0	.....
31	.....	9.5	.....	9.4	.....	10.3	10.1	.....	8.9	.....

NOTE.—River frozen January 1 to March 31; also November 30 to December 31. Gage heights are to water surface in a hole in the ice.

Station rating table for Red River at Fargo, N. Dak., from January 1, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
7.00	225	8.80	643	10.60	1,210	12.40	1,850
7.10	244	8.90	671	10.70	1,245	12.50	1,890
7.20	263	9.00	700	10.80	1,280	12.60	1,930
7.30	283	9.10	730	10.90	1,315	12.70	1,970
7.40	304	9.20	760	11.00	1,350	12.80	2,010
7.50	325	9.30	790	11.10	1,385	12.90	2,050
7.60	347	9.40	820	11.20	1,420	13.00	2,090
7.70	369	9.50	850	11.30	1,455	13.10	2,130
7.80	392	9.60	880	11.40	1,490	13.20	2,170
7.90	415	9.70	910	11.50	1,525	13.30	2,210
8.00	439	9.80	940	11.60	1,560	13.40	2,250
8.10	463	9.90	970	11.70	1,595	13.50	2,290
8.20	488	10.00	1,000	11.80	1,630	13.60	2,330
8.30	513	10.10	1,035	11.90	1,665	13.70	2,370
8.40	538	10.20	1,070	12.00	1,700	13.80	2,410
8.50	564	10.30	1,105	12.10	1,735	13.90	2,450
8.60	590	10.40	1,140	12.20	1,770	14.00	2,490
8.70	616	10.50	1,175	12.30	1,810		

The above table is applicable only for open channel conditions. It is based on discharge measurements made during 1901-1905. It is fairly well defined between gage heights 7.2 feet and 11 feet. The table has been extended beyond these limits, being based on one high-water measurement.

Estimated monthly discharge of Red River at Fargo, N. Dak., for 1905.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	730	392	480	28,560	0.080	0.089
May	4,250	392	1,641	100,900	.274	.316
June	1,000	790	937	55,760	.156	.174
July	1,140	880	1,032	63,460	.172	.198
August	1,525	910	1,131	69,540	.188	.217
September	1,000	790	908	54,030	.151	.168
October	880	671	751	46,180	.125	.144
November 1 to 29	700	590	641	36,870	.107	.115

NOTE.—No estimate for ice period.

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 channel is straight for 500 feet above and 150 feet below the Great Northern Railway bridge. The right bank is liable to overflow at high stages and is wooded; the left bank will overflow only at very high stages and for a short distance. The water at all stages will pass beneath the four-span bridge and its trestle approaches. The current has a moderate velocity. The bed of the stream is composed of sand and mud and is subject to some change. The water is usually heavily laden with sediment from Red Lake River, which enters one-half mile above the station.

Discharge measurements are made from the Great Northern Railway bridge, about one-fifth mile above the gage. The initial point for soundings is marked in red paint on the downstream guard rail at the left end of the left span.

The original gage is a vertical staff, attached to the north end of the breakwater of the middle bridge pier. The zero of this gage was placed 5.00 feet below the zero of the United States Army Engineers' gage, which is attached to the same breakwater. A standard chain gage, which was read during 1905 by Philip Hayes, has been established with the same datum as the vertical gage and is attached to the downstream side of the bridge. The length of the chain from the end of the weight to the marker is 50.44 feet. The gage is referred to bench marks as follows: (1) North corner of iron plates of turntable near the center of the middle pier of the Northern Pacific Railway bridge, on the north side, about 1 inch above the surface of the stone pier; elevation above gage datum, 43.95 feet. (2) Spike in a telegraph pole in the lumber yard southwest of the left end of the bridge, from which it is 200 feet distant; elevation above gage datum, 48.50 feet. The top of the pulley of the chain gage is 53.12 feet above gage datum. Gage datum is 45.58 feet above the city datum of Grand Forks, and is 777.9 feet above sea level.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 66, pp 11–12; 85, pp 235–236; 100, pp 494–495; 130, pp 40–41.
Discharge: 66, p 12; 85, p 236; 100, pp 495, 504; 130, p 41.
Discharge, monthly: 100, p 498; 130, p 43.
Gage heights: 66, p 12; 85, p 236; 100, p 496; 130, p 41.
Rating table: 100, p 497; 130, p 42.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 8	Wilcox and Turner	200	2,266	2.69	14.55	6,097
April 25	Richards and Hoskins	162	1,088	2.01	7.93	2,183
May 16	R. Richards	406	5,648	2.98	26.11	16,850
August 21	do	258	3,702	2.96	20.04	10,970

Daily gage height, in feet, of Red River at Grand Forks, N. Dak., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	7.2	12.4	7.4	13.2	13.7	14.6	12.4	11.3	9.1
2	.....	.....	7.6	13.0	7.8	13.0	13.9	14.1	12.2	11.2	8.7
3	.....	.....	8.0	14.2	7.6	12.7	13.5	13.8	12.2	11.2	8.45
4	.....	.....	8.5	16.2	7.75	12.4	13.1	13.4	12.6	11.0	8.45
5	.....	.....	9.0	15.8	7.9	12,2	12.8	13.9	12.8	10.9	8.4
6	.....	.....	9.45	17.5	8.45	12.3	12.5	14.0	12.8	10.6	9.1
7	6.4	.....	9.8	16.2	9.1	12.6	12.7	13.7	12.6	10.5	9.6
8	.....	.....	9.85	14.8	10.0	12.9	13.7	13.4	12.2	10.3	9.9
9	.....	.....	9.9	13.6	10.7	13.1	13.4	13.0	12.0	10.0	9.9
10	.....	.....	.....	12.9	11.2	13.0	13.2	12.9	11.6	10.0	9.5
11	.....	.....	.....	12.3	11.8	13.2	13.2	12.9	11.3	9.9	9.3
12	.....	.....	.....	11.6	13.9	13.0	13.0	12.8	11.1	9.7	9.0
13	.....	.....	.....	11.0	18.4	12.8	12.7	12.5	10.8	9.6	8.8
14	6.4	6.4	9.3	10.4	22.7	12.6	12.4	12.3	10.7	9.4	8.6
15	.....	.....	.....	9.9	25.2	12.4	12.4	12.6	10.8	9.5	8.8
16	.....	.....	.....	9.6	26.0	12.1	12.4	13.7	10.9	9.5	8.9
17	.....	.....	.....	9.3	25.9	11.9	13.2	14.7	11.4	9.5	8.9
18	.....	.....	.....	8.8	25.6	11.8	14.2	16.0	11.8	9.5	9.0
19	.....	.....	.....	8.4	25.2	11.6	14.4	18.0	11.9	9.6	8.9
20	.....	.....	.....	8.25	24.5	11.5	14.5	19.9	12.2	9.6	9.0
21	6.4	6.5	8.9	8.0	23.5	11.5	14.7	19.9	12.4	9.6	8.9
22	.....	.....	.....	8.0	22.2	11.5	14.7	19.0	12.6	9.8	8.9
23	.....	.....	.....	7.9	20.8	11.7	14.6	18.0	12.8	10.0	8.8
24	.....	.....	.....	7.75	19.0	12.0	14.2	16.7	12.6	10.1	9.0
25	.....	.....	.....	7.7	17.3	12.2	13.8	15.8	12.4	10.2	9.0
26	.....	.....	.....	7.9	16.4	12.3	13.6	15.4	12.1	10.2	9.2
27	.....	7.0	.....	7.6	15.4	12.6	13.7	15.0	11.9	10.3	8.8
28	.....	.....	10.3	7.5	14.7	12.6	13.8	14.4	11.8	10.1	.....
29	.....	.....	10.9	7.65	14.2	12.7	14.0	13.8	11.5	10.1	.....
30	.....	.....	11.25	7.7	14.0	12.8	15.1	13.3	11.4	9.6	.....
31	6.15	.....	11.7	.....	13.6	.....	15.0	12.8	.....	9.3	.....

NOTE.—River frozen entirely across January 1 to March 28; March 29 to April 6 ice breaking up. Gage heights are to water surface in a hole in the ice; thickness of ice, 1.6 to 2 feet. River frozen over during December; thickness of ice, 0.4 foot to 1.9 feet.

Station rating table for Red River at Grand Forks, N. Dak., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.00	1,250	9.70	3,120	13.40	5,510	19.20	10,230
6.10	1,295	9.80	3,180	13.50	5,580	19.40	10,410
6.20	1,340	9.90	3,240	13.60	5,650	19.60	10,590
6.30	1,385	10.00	3,300	13.70	5,725	19.80	10,770
6.40	1,430	10.10	3,360	13.80	5,800	20.00	10,950
6.50	1,475	10.20	3,420	13.90	5,875	20.20	11,130
6.60	1,520	10.30	3,480	14.00	5,950	20.40	11,310
6.70	1,565	10.40	3,540	14.10	6,025	20.60	11,490
6.80	1,610	10.50	3,600	14.20	6,100	20.80	11,670
6.90	1,655	10.60	3,660	14.30	6,175	21.00	11,850
7.00	1,700	10.70	3,720	14.40	6,250	21.20	12,030
7.10	1,750	10.80	3,780	14.50	6,325	21.40	12,210
7.20	1,800	10.90	3,840	14.60	6,400	21.60	12,390
7.30	1,850	11.00	3,900	14.70	6,475	21.80	12,570
7.40	1,900	11.10	3,965	14.80	6,550	22.00	12,750
7.50	1,950	11.20	4,030	14.90	6,625	22.20	12,930
7.60	2,000	11.30	4,095	15.00	6,700	22.40	13,110
7.70	2,050	11.40	4,160	15.20	6,860	22.60	13,290
7.80	2,100	11.50	4,225	15.40	7,020	22.80	13,470
7.90	2,150	11.60	4,290	15.60	7,180	23.00	13,650
8.00	2,200	11.70	4,355	15.80	7,340	23.20	13,830
8.10	2,250	11.80	4,420	16.00	7,500	23.40	14,010
8.20	2,300	11.90	4,485	16.20	7,660	23.60	14,200
8.30	2,350	12.00	4,550	16.40	7,820	23.80	14,400
8.40	2,405	12.10	4,615	16.60	7,980	24.00	14,600
8.50	2,460	12.20	4,680	16.80	8,140	24.20	14,800
8.60	2,515	12.30	4,745	17.00	8,300	24.40	15,000
8.70	2,570	12.40	4,810	17.20	8,460	24.60	15,200
8.80	2,625	12.50	4,880	17.40	8,620	24.80	15,400
8.90	2,680	12.60	4,950	17.60	8,790	25.00	15,600
9.00	2,735	12.70	5,020	17.80	8,970	25.20	15,820
9.10	2,790	12.80	5,090	18.00	9,150	25.40	16,040
9.20	2,845	12.90	5,160	18.20	9,330	25.60	16,260
9.30	2,900	13.00	5,230	18.40	9,510	25.80	16,480
9.40	2,955	13.10	5,300	18.60	9,690	26.00	16,700
9.50	3,010	13.20	5,370	18.80	9,870	27.00	17,800
9.60	3,065	13.30	5,440	19.00	10,050	28.00	18,900

The above table is applicable only for open channel conditions. It is based on 24 discharge measurements made during 1901–1905. It is well defined between gage heights 6 feet and 26 feet.

Estimated monthly discharge of Red River at Grand Forks, N. Dak., for 1905.

[Drainage area, 25,800 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April 7–30	7,660	1,950	3,288	156,500	0.127	0.113
May	16,700	1,900	8,138	500,400	.315	.363
June	5,370	4,225	4,826	287,200	.187	.209
July	6,780	4,810	5,847	259,500	.227	.262
August	10,860	4,745	6,564	403,600	.254	.293
September	5,090	3,720	4,507	268,200	.175	.195
October	4,095	2,900	3,345	205,700	.129	.149
November 1–27	3,240	2,405	2,734	151,800	.106	.106
The period				2,233,000		

NOTE.—No estimate for ice period.

OTTERTAIL RIVER NEAR FERGUS FALLS, MINN.

Ottertail River rises in Ottertail Lake, in west-central Minnesota, flows west, then south, then west, and enters Red River at Breckenridge, Minn.

The gaging station was established May 9, 1904. It is located at Three Mile Bridge, about 3½ miles northeast of Fergus Falls, Minn.

The channel is straight for about 150 feet above and 600 feet below the station. The current is medium at all stages. Both banks are high, wooded, and do not overflow. The bed of the stream is composed of clean gravel and small stones and is probably permanent except after extreme floods. There is one channel at ordinary stages, and possibly two at high water. As the chief source of supply is Ottertail Lake, sudden fluctuations in river height are not to be expected.

Discharge measurements are made from the single-span highway bridge to which the gage is attached. The initial point for soundings is the left end of the downstream hand rail.

The temporary gage, which was read during 1905 by R. G. Evensen, jr., is a vertical staff driven into the bank near the lower corner of the left abutment. The bench mark is a nail driven into the stone wing wall of the left abutment, downstream side about 4½ feet from the angle of the abutment and just behind the temporary gage; elevation above zero of gage, 5.56 feet.

A description of this station, gage height, and discharge data, and rating table are given in Water-Supply Paper No. 130, pp. 43–45.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second feet.*
March 31	Richards and Chandler	97	139	1.79	2.84	248
July 15	R. Richards	98	234	3.05	3.75	714
July 22	Hanna and Chandler	98	237	3.03	3.78	718

Daily gage height, in feet, of Ottertail River near Fergus Falls, Minn., for 1905.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.6	2.85	3.0	3.45	3.7	3.8	3.9	3.7	3.5
2	.....	.....	2.85	3.0	3.45	3.7	3.8	3.9	3.7	3.5
3	.....	.....	2.85	3.3	3.55	3.75	3.8	3.85	3.7	3.5
4	4.0	.....	2.9	3.3	3.55	3.8	3.8	3.85	3.7	3.5
5	.....	.....	2.9	3.3	3.6	3.85	4.0	3.85	3.7	3.5
6	.....	.....	2.9	3.3	3.6	3.85	4.0	3.85	3.7	3.5
7	.....	3.2	2.95	3.3	3.6	3.9	4.0	3.8	3.7	3.5
8	.....	.....	2.95	3.3	3.6	3.85	4.0	3.8	3.7	3.5
9	.....	.....	2.95	3.3	3.6	3.85	4.0	3.8	3.7	3.5
10	.....	.....	2.8	3.3	3.6	3.8	3.95	3.8	3.65	3.5
11	.....	3.1	2.8	3.6	3.55	3.8	3.95	3.8	3.65	3.5
12	.....	3.2	2.8	3.6	3.55	3.8	3.9	3.8	3.6	3.5
13	.....	3.2	2.9	3.6	3.6	3.8	3.85	3.85	3.6	3.5
14	.....	3.2	2.9	3.6	3.6	3.8	3.85	3.85	3.6	3.5
15	.....	3.15	3.0	3.6	3.6	3.8	3.85	3.85	3.6	3.5
16	.....	3.15	3.0	3.6	3.6	3.8	3.85	3.85	3.6	3.5
17	.....	3.2	3.0	3.55	3.62	3.8	3.9	3.85	3.6	3.5
18	.....	3.2	3.0	3.55	3.6	3.8	3.9	3.95	3.55	3.5
19	.....	3.2	3.0	3.55	3.6	3.75	3.9	3.95	3.55	3.5
20	3.9	3.2	3.0	3.5	3.6	3.75	3.9	3.95	3.55	3.5
21	.....	3.15	3.0	3.5	3.6	3.75	3.9	3.9	3.55	3.5
22	.....	3.1	3.0	3.5	3.6	3.9	3.9	3.9	3.55	3.5
23	.....	3.0	3.0	3.45	3.65	3.7	3.9	3.85	3.55	3.5
24	.....	2.9	3.0	3.45	3.7	3.7	3.85	3.85	3.55	3.5
25	3.7	2.9	3.0	3.45	3.7	3.7	3.85	3.8	3.55	3.5
26	.....	2.9	3.0	3.45	3.7	3.75	3.85	3.8	3.55	3.5
27	.....	2.9	3.0	3.45	3.7	3.75	3.85	3.75	3.55	3.55
28	.....	2.9	3.0	3.45	3.7	3.8	3.85	3.75	3.55	3.6
29	.....	2.9	3.0	3.45	3.7	3.8	3.85	3.7	3.55	3.65
30	.....	2.85	3.0	3.45	3.7	3.8	3.85	3.7	3.55	.....
31	.....	2.85	.....	3.45	.....	3.8	3.85	.....	3.55	.....

NOTE.—River frozen entirely across January 1–February 28; March 1–10, ice gradually disappeared; February 14, river frozen to the bottom in the middle. Gage heights are to water surface in a hole in the ice. The following comparative readings were also made:

Date.	Water surface.	Top of ice.	Thickness.
	Feet.	*Feet.*	*Feet.*
February 14	4.0	4.3	2.4
February 20	3.9	4.2	2.2
February 25	3.7	4.0	1.7
March 1	3.6	3.6	.8

River frozen November 30 to December 31.

Station rating table for Ottertail River near Fergus Falls, Minn., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.70	200	3.10	357	3.50	552	3.90	789
2.80	236	3.20	402	3.60	607	4.00	855
2.90	274	3.30	449	3.70	665	4.10	921
3.00	315	3.40	499	3.80	726	4.20	987

The above table is applicable only for open-channel conditions. It is based on eight discharge measurements made during 1904-5. It is well defined between gage heights 2.85 feet and 3.8 feet.

Estimated monthly discharge of Ottertail River near Fergus Falls, Minn., for 1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
March 11-31	402	255	340	14,160
April	315	236	292	17,380
May	607	315	516	31,730
June	665	526	613	36,480
July	789	665	719	44,210
August	855	726	778	47,840
September	822	665	750	44,630
October	665	580	614	37,750
November 1-29	636	552	558	32,100
The period				306,300

NOTE.—No estimate for ice period.

SHEYENNE RIVER NEAR HAGGART, N. DAK.

Sheyenne River rises in the eastern part of McLean County, N. Dak., flows, in a general way, east, then south, and then northeast, and enters Red River about 12 miles north of Moorhead, Minn.

The gaging 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 channel is straight for 30 feet above and 200 feet below the station, and the current is moderate. Both banks are steep and not liable to overflow except in unusual floods. The bed of the stream is of clay and shifts but slightly. There is one channel at all stages.

Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the end of the hand rail on the lower side of the bridge, right bank.

The gage, which was read during 1905 by John C. Haggart, consists of a vertical staff 17 feet long fastened to the piling pier at the middle of the bridge. The gage is referred to bench marks as follows: (1) A 12-penny nail driven into the base of the 11-inch elm tree 50 feet below the bridge on the right bank; elevation above gage zero, 17.05 feet. (2) A cross of fence staples, surrounded by brass-headed nails, on north side of 10-inch box elder tree, beside the east approach to the bridge, north side, the same being 23 feet east of the initial point for soundings; elevation above gage datum, 21.29 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 85, p 236; 100, p 498; 130, p 45.
Discharge: 85, p 236; 100, p 499; 130, p 46.
Discharge, monthly: 100, p 500; 130, p 47.
Gage heights: 85, p 237; 100, p 499; 130, p 46.
Rating table: 100, p 500; 130, p 47.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 30	R. Richards	53	175	1.13	6.60	198
June 22	Chandler and Richards	46	154	1.12	4.70	173
July 11	R. Richards	47	147	1.06	4.60	156
July 29	Hanna and Chandler	44	134	1.09	4.42	146
August 22	R. Richards	54	216	1.32	6.01	288

Daily gage height, in feet, of Sheyenne River near Haggart, N. Dak., for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.0	5.0	4.8	4.0	4.5	3.8	.....	3.9
2	.....	4.0	5.0	4.9	4.3	4.5	3.9	.....	3.9
3	6.5	3.9	4.9	4.5	4.0	4.6	3.9	.....	.....
4	6.0	4.2	4.9	6.6	4.0	4.4	4.0	.....	.....
5	5.8	4.5	4.9	5.6	4.2	4.3	4.0	.....	.....
6	5.6	5.0	4.7	5.0	4.7	4.5	3.9	.....	.....
7	5.4	6.1	4.9	5.0	4.9	4.3	3.9	.....	.....
8	5.5	5.9	4.9	4.0	5.7	4.4	3.8	.....	.....
9	5.7	5.6	5.0	3.8	5.9	4.4	3.9	.....	4.2
10	5.7	5.8	5.0	3.9	6.0	4.3	3.8	.....	.....
11	5.6	6.1	4.9	4.5	6.2	4.2	3.6	.....	.....
12	5.5	8.7	5.4	4.7	6.3	4.2	3.6	.....	.....
13	5.4	9.8	6.1	4.5	6.2	4.1	3.7	.....	.....
14	5.3	9.3	6.0	4.5	6.5	4.2	3.6	.....	.....
15	5.0	8.0	5.7	4.4	6.4	4.3	3.6	.....	.....
16	4.8	7.5	5.5	4.5	7.0	4.2	3.5	.....	.....
17	4.6	6.9	5.4	4.5	8.2	4.1	3.5	.....	.....
18	4.6	6.5	5.3	4.3	8.8	4.0	3.6	3.6	.....
19	4.7	6.4	5.0	4.8	8.4	4.3	3.7	3.7	.....
20	4.6	6.0	4.9	5.0	7.0	4.2	3.6	3.7	.....
21	4.5	5.9	4.9	4.5	6.5	4.1	3.5	3.7	.....
22	4.4	5.8	4.6	5.0	6.0	4.2	3.6	3.7	.....
23	4.35	5.8	4.5	5.5	5.7	4.0	3.7	3.8	.....
24	4.3	5.8	4.7	5.7	5.8	3.9	3.9	3.8	.....
25	4.2	5.7	4.7	5.4	6.0	3.9	3.6	3.8	.....
26	4.3	5.6	4.7	5.0	5.9	3.8	3.6	3.8	.....
27	4.2	5.5	4.8	4.7	5.5	3.9	3.5	3.9	.....
28	4.1	5.4	5.0	4.7	5.3	3.9	3.6	3.9	.....
29	4.1	5.3	5.0	4.3	5.0	3.8	3.6	3.9	.....
30	4.1	5.4	4.8	4.3	4.9	3.7	3.5	3.9	.....
31	.....	5.4	.....	4.2	4.6	.....	3.5	.....	.....

NOTE.—River frozen over January 1 to March 31, approximately, also December 1-31.

RED LAKE RIVER AT CROOKSTON, MINN.

Red Lake River rises in Red Lake, in northeastern Clearwater County, Minn., flows in a general westerly direction, and unites with Red River at Grand Forks. The distance from source to mouth in a straight line is 105 miles; by river it is over 200 miles. The total area of the watershed is 6,518 square miles.

The gaging station was established May 19, 1901. It is located at the bridge which connects Robert and St. Paul streets, Crookston, and which is known as the "Sampson Addition" bridge. It is about one-sixth mile west of the Great Northern Railway station.

The channel is straight for 250 feet above and 200 feet below the station. The right bank is low and is covered with brush. It is liable to overflow at very high stages, but there would be very little current in the flooded section owing to the trees and brush. The left bank is high, wooded, and not liable to overflow. The bed of the stream is sandy, free from vegetation, and shifts. The current is swift.

Discharge measurements are made from the lower side of the single-span bridge at which the gages are located. The initial point for soundings is the post of the hand rail, lower side, at the left end of the bridge, at a point where the diagonal member of the bridge truss meets the floor timbers.

The gages, of which there are three, were read during 1905 by J. E. Carroll, the city engineer. The low-water vertical gage is fastened to the piling of the left abutment under the bridge; it reads from zero to 9.6 feet. The high-water vertical gage is attached to the piling of the pier at the right end of the bridge; it reads from 7.5 to 15 feet. There is also a wire gage near the middle of the bridge, having the same datum. Its horizontal scale reads from 3 to 19 feet. The dam and power house of the city waterworks are located about 1,000 feet above the gage. The opening and closing of the sluices cause some variation in the flow, but the gage readings represent a close average of the daily river height. The gages are referred to bench marks as follows: (1) Top of hydrant at corner of St. Paul and Robert streets, 30 feet south of bridge; elevation above gage datum, 24.23 feet. (2) Top of hydrant 200 feet north of bridge, at corner of St. Paul and Woodlawn streets; elevation above gage datum, 27.46 feet. The gage datum has an elevation of 825 feet above sea level. The city datum of Crookston has an elevation of 4.10 feet above gage datum. The top of the rail of the main track at the Great Northern Railway station at Crookston has an elevation of 37.63 feet above gage datum.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 66, pp 10–11; 85, pp 234–235; 100, pp 491–492; 130, p 48.
Discharge: 66, p 11; 85, p 235; 100, p 492; 130, p 49.
Discharge, monthly: 100, p 494; 130, p 50.
Gage heights: 66, p 11; 85, p 235; 100, pp 492–493; 130, p 49.
Rating table: 100, p 493; 130, p 50.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 10	Wilcox and Chandler	178	849	2.95	7.06	2,505
July 24	Hanna and Chandler	183	923	3.20	7.66	2,957
August 19	R. Richards	194	1,439	3.37	9.93	4,846

Daily gage height, in feet, of Red Lake River at Crookston, Minn., for 1905.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.1	5.3	6.7	7.7	7.5	7.1	7.8	5.5	4.25
2	.....	7.25	5.25	6.45	7.0	7.45	7.2	7.7	5.5	4.1
3	.....	9.7	5.45	6.3	6.9	7.4	7.7	7.6	5.1	4.5
4	.....	9.0	5.55	6.5	6.65	8.2	8.0	7.45	5.0	4.8
5	.....	9.1	5.85	6.85	6.55	8.6	7.8	7.2	6.85	5.85
6	.....	8.9	6.2	6.85	7.05	8.2	7.6	7.0	6.65	6.65
7	.....	7.1	6.45	6.65	7.25	8.0	7.3	6.9	6.35	7.2
8	.....	6.7	6.75	6.35	7.0	7.6	7.25	6.8	6.3	6.6
9	.....	7.1	6.8	6.45	7.3	7.4	7.2	6.8	6.35	6.7
10	.....	6.8	7.05	7.0	7.0	7.4	7.15	6.7	6.2	6.4
11	.....	6.5	7.25	6.6	6.65	6.95	7.05	6.6	6.4	6.6
12	.....	6.1	9.8	6.5	6.65	6.8	6.85	6.5	6.1	6.3
13	.....	6.2	14.1	6.5	6.6	6.8	6.8	6.5	6.1	6.3
14	.....	6.05	13.2	6.25	6.55	6.8	6.65	6.5	6.0	5.9
15	.....	6.0	11.6	6.4	6.7	7.5	7.3	6.5	6.4	6.1
16	.....	5.8	10.6	5.9	8.6	7.2	8.1	6.5	6.45	6.0
17	.....	5.45	9.5	6.0	8.8	8.5	8.1	6.5	6.6	5.7
18	.....	5.4	9.6	6.55	9.2	10.0	8.2	6.4	6.15	6.0
19	.....	5.45	8.8	6.1	8.6	10.0	8.4	6.05	5.9	6.0
20	.....	4.95	8.5	5.7	9.2	9.4	8.7	5.85	6.0	6.0
21	.....	4.85	8.2	6.1	8.4	8.5	8.7	6.25	6.05	6.0
22	.....	5.0	8.0	6.05	8.2	8.2	8.4	6.85	5.9	5.5
23	.....	5.2	7.8	6.3	8.5	7.9	8.2	7.35	6.0	6.0
24	.....	5.4	7.4	6.3	7.5	7.5	8.0	6.75	6.2	5.7
25	5.2	5.1	7.4	6.55	7.15	7.2	7.9	6.9	6.5	6.0
26	5.8	5.4	7.3	6.45	7.1	7.1	7.9	6.9	6.0	6.2
27	6.4	4.9	7.0	6.5	7.2	7.1	7.9	6.65	4.75	6.0
28	6.9	5.4	6.9	6.7	8.2	7.1	7.8	6.2	4.1	6.0
29	7.4	5.35	6.95	6.75	9.3	7.0	7.8	6.1	3.85	6.0
30	7.8	4.9	6.3	7.8	8.4	6.9	7.7	6.35	4.4	6.7
31	7.0	.....	6.65	.....	7.8	6.9	.....	6.1	.....	6.65

NOTE.—River frozen entirely across January 1–March 2; March 3 to April 4 there was a gradually widening channel of open water. During December river frozen across except for narrow channel under gage.

Station rating table for Red Lake River at Crookston, Minn., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.90	600	5.70	1,530	8.00	3,255	11.60	6,265
4.00	640	5.80	1,600	8.20	3,415	11.80	6,435
4.10	680	5.90	1,670	8.40	3,575	12.00	6,605
4.20	720	6.00	1,740	8.60	3,735	12.20	6,775
4.30	765	6.10	1,810	8.80	3,895	12.40	6,945
4.40	810	6.20	1,880	9.00	4,055	12.60	7,115
4.50	855	6.30	1,950	9.20	4,225	12.80	7,285
4.60	905	6.40	2,020	9.40	4,395	13.00	7,455
4.70	955	6.50	2,095	9.60	4,565	13.20	7,625
4.80	1,005	6.60	2,170	9.80	4,735	13.40	7,795
4.90	1,055	6.70	2,245	10.00	4,905	13.60	7,965
5.00	1,110	6.80	2,320	10.20	5,075	13.80	8,135
5.10	1,165	6.90	2,395	10.40	5,245	14.00	8,305
5.20	1,220	7.00	2,470	10.60	5,415	14.20	8,475
5.30	1,280	7.20	2,620	10.80	5,585	14.40	8,645
5.40	1,340	7.40	2,775	11.00	5,755	14.60	8,815
5.50	1,400	7.60	2,935	11.20	5,925	14.80	8,985
5.60	1,465	7.80	3,095	11.40	6,095		

The above table is applicable only for open-channel conditions. It is based on 21 discharge measurements made during 1902–1905. It is well defined between gage heights 4 feet and 11.5 feet. The table has been extended beyond these limits, being based on one measurement at gage height 18.45 feet.

Estimated monthly discharge of Red Lake River at Crookston, Minn., for 1905.

[Drainage area, 5.525 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	4,650	1,030	1,990	118,400	0.360	0.402
May	8,390	1,250	3,199	196,700	.579	.668
June	5,095	1,530	2,078	123,600	.376	.420
July	4,310	2,132	2,950	181,400	.534	.616
August	4,905	2,320	3,035	186,600	.549	.633
September	3,815	2,208	3,012	179,200	.545	.608
October	3,095	1,635	2,264	139,200	.410	.473
November	2,358	582	1,676	99,730	.303	.338
The period				1,225,000		

NOTE.—No estimate for ice period.

PEMBINA RIVER NEAR NECHE, N. DAK.

Pembina River rises in the southern part of Manitoba, Canada, flows in a general southeasterly direction, and unites with Red River at Pembina, 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 channel is straight for 100 feet above and below the station. The right bank is densely wooded and the left is covered with brush. Both banks extend about 20 feet above the zero of the gage, and they are not liable to overflow except at very high stages. The bed of the stream, in which there are some sunken snags, is composed of sand and mud and may change slightly. About one-third of a mile below the gage there is a loose-rock dam 4 feet high. This raises the water 1 to 2 feet at the bridge, but as the dam is not tight the water may fall at low stages.

Discharge measurements are made from the single-span highway bridge 400 feet below the gage. The initial point for soundings is a point on the downstream hand rail, 3 feet from its right end. The bridge crosses the river obliquely, and to make allowance for this fact the hand rail has been divided into intervals of 10.4 feet. This is equivalent to 10-foot intervals of a cross section normal to the current.

The gage, which was read during 1905 by P. J. Horgan, is near the northeast corner of sec. 36, T. 164 N., R. 54 W. It consists of two sections of 1 by 6 inch plank. The lower section, reading from 0 to 5 feet, is driven into the bed of the stream, and its upper end is spiked to the bridge abutment timbers on the left bank. The upper section, reading from 5 to 24 feet, is spiked to the bridge pier on the right bank. The gage is referred to bench marks, as follows: (1) Top of horizontal timber on upstream side of right pier, near gage; it is marked with brass-headed nails and has an elevation of 23.70 feet above the zero of the gage. (2) West rail of the track at the rail joint at the crossing about 550 feet south of the gage; elevation above zero of gage, 26.54 feet. (3) Spike driven in north face of telephone pole inside the fence in the field west of the track and about 550 feet south of the gage; it is about 1½ feet above the ground and has an elevation of 24.28 feet above the zero of the gage. The elevation of the top of the 12 by 12 inch timber to which the low-water gage is fastened is 4.93 feet. The elevation of the zero of the gage above sea level, as determined by hand level from the railroad station at Neche, N. Dak., is 815 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 100, pp 488–489; 130, p 51.
Discharge: 100, p 489; 130, p. 52.
Discharge, monthly: 100, p 491.
Gage heights: 100, p 490; 130, p 52.
Rating table: 100, p 490.

Discharge measurements of Pembina River near Neche, N. Dak., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 10	R. Richards	72	288	1.76	5.71	507
April 24	Richards and Haskins	68	208	1.03	4.30	214
July 14	R. Richards	67	187	.93	3.95	174
July 28	Hanna and Chandler	64	153	.81	3.51	124
August 20	R. Richards	64	135	.68	3.20	92

Daily gage height, in feet, of Pembina River near Neche, N. Dak., for 1905.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	6.2	4.7	4.6	5.3	3.45	3.0	3.45	3.4
2	.....	6.3	4.6	4.6	5.1	3.45	3.0	3.45	3.4
3	.....	6.3	4.5	4.6	5.0	3.45	3.0	3.45	3.4
4	.....	8.2	4.4	4.6	4.9	3.45	2.95	3.5	3.45
5	.....	9.8	4.3	4.6	4.7	3.45	2.95	3.5	3.45
6	.....	9.5	4.2	4.6	4.5	3.4	3.0	3.45	3.45
7	.....	8.6	4.4	6.4	4.4	3.5	2.95	3.4	3.45
8	.....	7.5	4.8	6.2	4.4	3.6	2.95	3.45	3.45
9	.....	7.5	4.8	6.0	4.3	3.5	3.0	3.5	3.5
10	.....	7.5	5.0	9.0	4.3	3.4	3.05	3.5	3.5
11	.....	7.0	5.0	9.0	4.2	3.35	3.1	3.45	3.5
12	.....	6.5	5.9	9.0	4.1	3.3	3.15	3.5	3.5
13	.....	6.0	9.0	8.1	4.0	3.3	3.25	3.5	3.5
14	.....	5.4	8.6	6.6	4.0	3.25	3.3	3.5	3.55
15	.....	5.0	8.0	5.6	3.9	3.25	3.35	3.5	3.55
16	.....	5.0	7.4	5.3	3.9	3.25	3.35	3.5	3.5
17	.....	5.0	7.0	5.0	3.9	3.3	3.35	3.5	3.6
18	.....	5.0	6.2	5.0	3.9	3.3	3.4	3.5	3.5
19	.....	4.9	6.0	4.9	3.9	3.3	3.4	3.55	3.4
20	.....	4.9	5.8	4.9	3.9	3.25	3.35	3.55	3.3
21	.....	4.8	5.6	4.9	3.8	3.2	3.35	3.55	3.3
22	.....	4.8	5.5	5.0	3.8	3.15	3.35	3.5	3.3
23	6.0	4.8	5.3	5.0	3.8	3.1	3.35	3.5	3.3
24	6.0	4.8	5.0	4.9	3.75	3.05	3.35	3.3	3.3
25	6.1	4.8	4.8	5.1	3.7	3.0	3.3	3.4	3.25
26	6.4	4.8	4.9	5.4	3.7	3.0	3.4	3.7	3.2
27	6.7	4.8	4.9	5.5	3.6	3.0	3.4	3.5	.....
28	6.7	4.8	4.9	5.4	3.5	2.95	3.4	3.0	.....
29	6.7	4.8	4.8	5.4	3.5	2.95	3.45	3.1	.....
30	6.4	4.8	4.6	5.4	3.5	2.9	3.45	3.15	.....
31	6.4	.....	4.6	.....	3.45	2.95	.....	3.4	.....

NOTE.—River frozen over January 1 to March 22 and November 27 to December 31.

Station rating table for Pembina River near Neche, N. Dak., from February 26 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	70	4.30	233	5.60	454	6.90	714
3.10	80	4.40	248	5.70	473	7.00	735
3.20	91	4.50	263	5.80	492	7.20	777
3.30	102	4.60	279	5.90	511	7.40	919
3.40	113	4.70	295	6.00	530	7.60	862
3.50	125	4.80	311	6.10	550	7.80	906
3.60	137	4.90	328	6.20	570	8.00	950
3.70	150	5.00	345	6.30	590	8.20	994
3.80	163	5.10	363	6.40	610	8.40	1,040
3.90	176	5.20	381	6.50	630	8.60	1,086
4.00	190	5.30	399	6.60	651	8.80	1,132
4.10	204	5.40	417	6.70	672	9.00	1,180
4.20	218	5.50	435	6.80	693		

The above table is applicable only for open-channel conditions. It is based on five discharge measurements made during 1905. It is well defined between gage heights 3 feet and 4.3 feet. The table has been extended above gage height 5.7 feet.

Estimated monthly discharge of Pembina River near Neche, N. Dak., for 1905.

[Drainage area, 2,800 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 23-31	672	530	606	10,820	0.216	0.072
April	1,372	311	549	18,510	.196	.219
May	1,180	218	447	27,480	.160	.184
June	1,180	279	485	16,600	.173	.193
July	399	119	206	12,670	.074	.085
August	137	60	97	5,964	.035	.040
September	119	65	93.9	5,587	.034	.038
October	150	70	119	7,317	.042	.048
November 1-26	137	91	116	5,982	.041	.040
The period				110,900		

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.

MOUSE RIVER NEAR FOXHOLM, N. DAK.

This station was established June 22, 1904. 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 channel is straight for about 300 feet above and 500 feet below the station. The right bank is covered with brush and overflows at extreme high water, but only for a short distance. The left bank is a clean meadow; it overflows slightly during the ordinary spring floods, and in extreme floods to a depth of several feet for a distance of nearly half a mile. The bed of the stream is composed of silt and mud and does not shift. There is but one channel at ordinary stages; during higher stages the channel is broken by two rows of piles near each end of the bridge.

Discharge measurements are made from the downstream side of the single-span bridge, to which the gage is attached. The initial point for soundings is the left end of the downstream hand rail.

A vertical staff gage, which was read during 1905 by H. Heinen, is spiked to the downstream pile of a row that supports the bridge near the left bank. The bench mark is two 12-penny nails driven into the upstream face of the pile, to which the gage is attached; elevation above zero of gage, 4.92 feet. The elevation of the zero of the gage, as determined by hand level from a Reclamation Service stake, is 1,572 feet above sea level.

A description of this station and gage-height and discharge data are given in Water-Supply Paper No. 130, pp. 32–33.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 28	R. Richards	60	142	0.31	2.08	44
April 26 [a]	Chandler and Turner	43	41	.63	1.96	26
May 24	Richards and Chandler	64	187	.79	2.82	148
July 26 [a]	Hanna and Chandler	45	24	1.64	2.11	39
August 18 [a]	R. Richards	39	18	1.11	1.88	20

[a] Made at different sections.

Daily gage height, in feet, of Mouse River near Foxholm, N. Dak., for 1905.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.6	2.0	2.0	2.4	2.25	2.2	2.2	1.8	1.8
2	.....	3.6	2.0	1.9	2.4	2.2	2.2	2.2	1.8	1.8
3	.....	3.6	2.0	2.0	2.4	2.3	2.2	2.1	1.8	1.8
4	.....	3.7	2.0	2.1	2.4	2.3	2.2	2.0	1.8	1.8
5	.....	3.7	1.9	2.2	2.4	2.35	2.1	2.0	1.8	1.8
6	.....	3.7	1.8	2.1	2.4	2.4	2.1	1.9	1.8	1.8
7	.....	3.8	1.9	2.1	2.4	2.4	2.1	1.9	1.8	1.85
8	.....	3.9	2.0	2.1	2.45	2.45	2.1	1.8	1.8	1.9
9	.....	4.0	2.3	2.1	2.5	2.45	2.0	1.8	1.85	1.9
10	.....	3.9	2.1	2.2	2.5	2.45	2.0	1.7	1.9	1.9
11	.....	3.8	2.2	2.3	2.45	2.5	1.9	1.7	1.9	1.9
12	.....	3.8	2.3	2.4	2.4	2.55	1.9	1.6	1.9	1.9
13	.....	3.8	2.5	2.3	2.4	2.6	1.9	1.6	1.9	1.85
14	.....	3.8	2.3	2.35	2.3	2.6	2.1	1.6	1.9	1.85
15	.....	3.8	2.3	2.35	2.3	2.7	2.1	1.5	1.9	1.8
16	.....	3.7	2.2	2.4	2.3	2.7	2.0	1.5	1.9	1.8
17	.....	3.6	2.2	2.4	2.3	2.6	2.0	1.5	1.85	1.8
18	.....	3.5	2.2	2.4	2.3	2.5	1.9	1.5	1.8	1.75
19	.....	3.4	2.8	2.4	2.3	2.4	1.9	1.5	1.8	1.8
20	.....	3.3	2.4	2.4	2.3	2.3	1.9	1.5	1.8	1.8
21	.....	3.3	2.2	2.45	2.3	2.3	1.9	1.5	1.8	1.8
22	.....	3.2	2.0	2.45	2.3	2.2	1.8	1.5	1.7	1.9
23	.....	3.1	2.0	2.9	2.2	2.2	1.8	1.5	1.7	1.9
24	.....	3.0	2.2	2.8	2.2	2.2	1.8	1.5	1.7	1.9
25	.....	2.9	2.4	2.8	2.2	2.2	1.8	1.5	1.75	1.9
26	3.6	2.8	2.7	2.7	2.4	2.2	1.8	1.6	1.8	1.9
27	3.6	2.3	2.1	2.5	2.6	2.2	1.9	1.6	1.8	1.9
28	3.6	2.2	2.1	2.45	3.3	2.2	2.5	1.6	1.8	1.9
29	.....	2.1	2.1	2.3	3.3	2.2	2.4	1.7	1.8	.....
30	.....	2.05	2.0	2.2	3.3	2.2	2.4	1.8	1.8	.....
31	.....	2.1	.....	2.2	.....	2.2	2.3	.....	1.8	.....

NOTE.—River frozen over January 1 to March 15, approximately. Thickness of ice, 3 feet. Part of the time water was over the ice. River also frozen during December.

Station rating table for Mouse River near Foxholm, N. Dak., from June 23, 1904, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.50	3	1.80	14	2.10	40	2.30	66
1.60	5	1.90	21	2.20	52	2.40	80
1.70	9	2.00	30				

The above table is applicable only for open-channel conditions. It is based on nine discharge measurements made during 1904–1905. It is well defined between gage heights 1.8 feet and 3 feet. Above gage height 2.4 feet the rating curve is a tangent, the difference being 14.8 per tenth. Below 1.8 feet the table is not well defined.

Estimated monthly discharge of Mouse River near Foxholm, N. Dak., for 1904–1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1904.				
June 23-30	450	324	389	6,173
July	384	80	197	12,110
August	80	52	64.4	3,960
September	95	55	75.7	4,504
October	88	66	79.2	4,870
November 1-19	80	52	74.8	2,820
The period				34,440
1905.				
March 16-31	273	35	157	4,982
April	140	13	51.7	3,076
May	154	21	72.0	4,427
June	214	52	88.9	5,290
July	125	52	75.6	4,648
August	95	14	36.4	2,238
September	52	3	12.6	750
October	21	9	15.3	941
November 1-28	21	12	17.4	966
The period				27,320

NOTE.—No estimate for ice period.

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 channel is straight for 100 feet above and below the station. Both banks are high, covered with trees and shrubs, and will not overflow. The bed of the stream, which holds some snags and brush, is composed of sand and is fairly constant. The current has a moderate velocity.

Discharge measurements are made from the downstream side of the bridge at which the gage is located. The bridge makes an angle of 15°, with the normal to the direction of the current, and this fact must be taken into account in computing discharge measurements. The initial point for soundings is the zero mark on the downstream guard rail at the electric-light pole on the right bank.

The gage, which was read during 1905 by H. E. Wheeler, consists of a vertical staff, 20 feet long, nailed to a pile of the center pier of the bridge on the downstream side. The gage is referred to bench marks as follows: (1) Top of hydrant at the corner of the street, about 150 feet north of the gage; elevation above zero of gage, 21.83 feet. (2) Top of hydrant one block west of bench mark No. 1; elevation, 21.85 feet above zero of gage. (3) Top of rail of side track at the southwest corner of the roundhouse; elevation, 24.18 feet above zero of gage. (4) The top of the rail of the main track at the Great Northern Railway station has an elevation of 24.49 feet above the zero of the gage. As determined by connection with railroad levels, the zero of the gage has an elevation of 1,540 feet above sea level.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 100, pp 486–487; 130, p 34.
Discharge: 100, p 487; 130, p 34.
Discharge, monthly: 100, p 488.
Gage heights: 100, p 487; 130 p 34.
Rating table: 100, p 488.

Discharge measurements of Mouse River at Minot, N. Dak., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 27	Richards and Chandler	76	227	0.50	4.40	114
April 27	Chandler and Turner	70	195	.25	4.03	49
May 24	E. F. Chandler	77	223	.62	4.56	139
May 24[a]	do	54	89	1.36	4.45	122
July 26[a]	Hanna and Chandler	50	59	.81	4.60	48
August 18[a]	R. Richards	48	58	.62	4.01	36

[a] Made at different section.

Daily gage height, in feet, of Mouse River at Minot, N. Dak., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	.....	4.25	4.0	4.45	4.2	4.4	4.3	3.8	3.9
2	.....	.....	.....	4.25	4.0	4.45	4.2	4.4	4.3	3.8	3.9
3	.....	.....	.....	4.25	4.0	4.45	4.2	4.3	4.3	3.8	3.9
4	.....	.....	.....	4.25	4.05	4.45	4.2	4.3	4.25	3.8	3.9
5	.....	.....	4.4	4.2	4.05	4.45	4.15	4.3	4.15	3.8	3.9
6	.....	.....	4.4	4.2	4.05	4.45	4.15	4.3	4.15	3.8	3.9
7	.....	.....	4.4	4.15	4.05	4.4	4.15	4.3	4.1	3.8	3.9
8	.....	.....	4.35	4.15	4.05	4.4	4.15	4.25	4.0	3.8	3.9
9	.....	.....	4.35	4.15	4.05	4.4	4.15	4.2	4.0	3.8	3.9
10	.....	.....	4.3	4.15	4.05	4.4	4.15	4.15	4.0	3.8	3.9
11	.....	4.0	4.3	4.15	4.0	4.4	4.2	4.1	4.0	3.8	3.9
12	.....	.....	4.3	4.15	4.0	4.4	4.3	4.0	3.9	3.8	3.9
13	.....	.....	4.3	4.2	4.0	4.4	4.3	4.0	3.9	3.8	3.9
14	.....	.....	4.3	4.2	4.0	4.35	4.35	4.2	3.9	3.8	3.9
15	.....	.....	4.3	4.25	4.0	4.35	4.35	4.4	3.9	3.9	3.9
16	.....	.....	4.3	4.25	4.0	4.3	4.35	4.4	3.9	3.9	3.9
17	.....	.....	4.3	4.25	4.05	4.3	4.35	4.3	3.9	3.9	3.9
18	.....	.....	4.3	4.25	4.05	4.3	4.4	4.2	3.9	3.9	3.9
19	.....	.....	4.4	4.2	4.05	4.3	4.4	4.15	3.9	3.9	4.0
20	.....	.....	4.4	4.2	4.05	4.3	4.4	4.15	3.8	3.9	4.0
21	.....	4.0	4.4	4.2	4.05	4.35	4.35	4.1	3.8	3.9	4.0
22	.....	.....	4.4	4.15	4.1	4.35	4.35	4.1	3.8	3.9	4.0
23	.....	.....	4.4	4.15	4.4	4.35	4.35	4.05	3.8	3.9	4.0
24	.....	.....	4.4	4.1	4.45	4.3	4.35	4.0	3.8	3.9	4.0
25	.....	.....	4.4	4.1	4.5	4.3	4.3	4.0	3.8	3.9	4.0
26	.....	.....	4.4	4.0	4.5	4.3	4.3	4.0	3.8	3.9	4.0
27	4.0	4.0	4.4	4.0	4.5	4.25	4.25	4.0	3.8	3.9	4.0
28	.....	.....	4.35	4.0	4.5	4.25	4.2	4.0	3.8	3.9	4.0
29	.....	.....	4.35	4.0	4.5	4.25	4.2	4.2	3.8	3.9	.....
30	.....	.....	4.3	4.0	4.5	4.2	4.2	4.4	3.8	3.9	.....
31	.....	.....	4.25	.....	4.5	.....	4.3	4.4	.....	3.9	.....

NOTE.—River frozen over January 1 to March 4. Thickness of ice, 1 foot. Gage heights are to water surface in hole in ice. River also frozen during December.

Station rating table for Mouse River at Minot, N. Dak., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.00	40	4.90	202	5.80	364	6.70	526
4.10	58	5.00	220	5.90	382	6.80	544
4.20	76	5.10	238	6.00	400	6.90	562
4.30	94	5.20	256	6.10	418	7.00	580
4.40	112	5.30	274	6.20	436	7.20	620
4.50	130	5.40	292	6.30	454	7.40	660
4.60	148	5.50	310	6.40	472	7.60	700
4.70	166	5.60	328	6.50	490	7.80	740
4.80	184	5.70	346	6.60	508	8.00	780

The above table is applicable only for open channel conditions. It is based on five discharge measurements made during 1905. It is well defined between gage heights 4 feet and 4.6 feet. The table has been extended beyond these limits. This curve is very unsatisfactory. Conditions at the station are unusual. 1904 measurements indicate a reverse in the discharge curve.

Estimated monthly discharge of Mouse River at Minot, N. Dak., for 1905.

[Drainage area, 8,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 5-31	112	85	103	5,516	.012	.012
April	85	40	68.8	4,094	.0082	.0090
May	130	40	69.3	4,261	.0082	.010
June	121	76	104	6,188	.012	.013
July	112	67	87.9	5,405	.010	.012
August	112	40	75.1	4,618	.0089	.011
September	94	4	31.3	1,862	.0037	.0041
October	22	4	13.9	855	.0017	.0020
November 1-28	40	22	28.4	1,577	.0034	.0035
The period				34,380		

DES LACS RIVER AT FOXHOLM, N. DAK.

Des Lacs River, the chief upper tributary of the Mouse, rises in the lake of the same name in northern Ward County, N. Dak., and flows southeastward, uniting with the Mouse about 10 miles above Minot.

The gaging station was established June 23, 1904. It is located at the highway bridge at Foxholm, N. Dak., a station of the Minneapolis, St. Paul and Sault Ste. Marie Railway.

The channel is straight for 75 feet above and 25 feet below the station. There is but one channel at ordinary stages. During high water it is divided by the pile piers of the bridge. The right bank is high, covered with brush, and does not overflow; the left bank is covered with brush, and at high floods the water may pass across a neck a few rods east of the bridge. The bed of the stream is composed of mud and silt and is slightly shifting. The current is sluggish at low stages.

Discharge measurements are made from the downstream side of the bridge, to which the gage is attached. The initial point for soundings is the right end of the downstream hand rail.

A staff gage, which was read during 1905 by Thomas H. Kinney, is nailed to the downstream side of the first pier from the left bank. The pier is composed of rows of piles parallel to the bank of the stream. The gage is referred to bench marks as follows: (1) Group of four spikes driven into the pile beside the gage rod; elevation above zero of gage, 10.00 feet. (2) Cluster of nails driven flush in the center of the top of a 12-inch post standing about 1 foot high, located approximately 34 feet south and 350 west of the southwest corner of bridge floor and hand rail; elevation above gage zero, 20.53 feet. (3) Top of rail of main track of "Soo" Railway at road crossing about 500 feet southwest of bridge. Elevation of zero of gage, as obtained by hand level from the railroad, is 1,633 feet above sea level.

A description of his station, gage height and discharge data, and rating table are given in Water-Supply Paper No. 130, pp. 35–37.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 28	R. Richards	17	30	0.32	2.64	9.5
April 26	E. F. Chandler	14	5	.57	1.98	2.9
May 24	R. Richards	14	6	.77	2.04	4.5
July 26	Hanna and Chandler	12	3	1.49	2.45	4.6
August 18[a]	R. Richards	12	3	.80	2.02	2.5

[a] Made at different section.

Daily gage height, in feet, of Des Lacs River at Foxholm, N. Dak., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	3.7	2.35	1.95	1.9	1.8	2.0	1.85	1.8	1.75	1.9
2	.....	.....	3.6	2.3	1.95	1.9	1.8	9.0	1.85	1.8	1.75	1.9
3	.....	.....	3.4	2.25	1.95	1.9	1.8	4.5	1.8	1.8	1.75	1.9
4	.....	2.3	3.2	2.25	1.95	1.9	1.8	3.1	1.8	1.8	1.75	1.9
5	.....	.....	3.5	2.25	1.95	1.95	1.75	3.0	1.8	1.8	1.75	1.9
6	.....	.....	3.3	2.2	2.0	2.0	1.75	3.0	1.8	1.8	1.8	1.9
7	2.3	.....	3.2	2.2	1.95	2.5	1.75	3.0	1.8	1.8	1.9	1.9
8	.....	.....	3.2	2.2	1.95	2.1	1.75	2.7	1.8	1.8	2.0	1.9
9	.....	.....	2.8	2.2	1.95	2.15	1.75	2.7	1.8	1.8	2.0	1.9
10	.....	.....	2.9	2.2	1.95	2.2	1.75	2.65	1.8	1.8	2.0	1.9
11	.....	2.3	3.0	2.1	2.0	2.2	1.75	2.5	1.8	1.8	2.0	1.9
12	.....	.....	3.0	2.1	2.1	2.15	1.75	2.5	1.8	1.8	2.0	1.9
13	.....	2.3	.....	2.1	2.1	2.15	1.75	2.5	1.8	1.8	2.0	1.9
14	2.3	.....	.....	2.0	2.1	2.1	3.8	2.5	1.8	1.8	1.95	1.9
15	.....	.....	3.0	2.0	2.1	2.1	3.6	2.4	1.8	1.8	1.95	1.9
16	.....	.....	.....	2.0	2.1	2.1	2.0	2.3	1.8	1.8	1.95	1.9
17	.....	.....	2.8	2.0	2.1	2.15	2.0	2.1	1.8	1.8	1.95	.....
18	.....	.....	2.5	2.0	2.2	2.1	2.0	2.0	1.8	1.8	1.95	.....
19	.....	.....	2.6	2.0	2.15	2.1	2.0	2.0	1.8	1.8	1.95	.....
20	.....	2.8	2.6	2.0	2.1	2.0	2.0	2.0	1.8	1.8	1.9	.....
21	2.3	.....	2.6	2.0	2.05	2.0	2.35	1.9	1.8	1.8	1.9	.....
22	.....	3.1	2.6	2.0	2.0	1.95	2.35	1.9	1.8	1.8	1.9	.....
23	.....	.....	2.65	2.0	2.0	1.95	2.35	1.9	1.8	1.8	1.95	.....
24	.....	3.1	2.7	2.0	2.0	1.95	2.35	1.9	1.8	1.8	1.95	.....
25	.....	3.2	2.75	2.0	2.0	1.95	2.3	1.9	1.8	1.8	1.95	.....
26	.....	3.6	2.9	2.0	1.95	1.9	2.1	1.9	1.8	1.8	1.9	.....
27	.....	3.8	2.85	2.0	1.95	1.9	2.0	1.9	1.8	1.8	1.9	.....
28	2.3	3.9	2.6	2.0	1.95	1.85	2.0	1.9	1.8	1.8	1.9	.....
29	.....	.....	2.65	1.95	1.95	1.8	2.0	1.9	1.8	1.8	1.9	.....
30	.....	.....	2.5	1.95	1.95	1.8	2.0	1.9	1.8	1.8	1.9	.....
31	.....	.....	2.4	.....	1.95	.....	2.0	1.9	.....	1.8	.....	.....

NOTE.—River frozen over January 1 to February 26; also March 7 to 19. Gage heights are to water surface in hole cut in ice. Thickness of ice, 1 to 1.8 feet.

Station rating table for Des Lacs River at Foxholm, N. Dak., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.80	1	2.50	8	3.20	22	3.90	44
1.90	2	2.60	10	3.30	25	4.00	48
2.00	3	2.70	12	3.40	28	4.10	52
2.10	4	2.80	14	3.50	31	4.20	56
2.20	5	2.90	16	3.60	34	4.30	60
2.30	6	3.00	18	3.70	37	4.40	64
2.40	7	3.10	20	3.80	40	4.50	68

The above table is applicable only for open channel conditions. It is based on 10 discharge measurements made during 1904–1905. It is fairly well defined between gage heights 2 feet and 4 feet.

Estimated monthly discharge of Des Lacs River at Foxholm, N. Dak., for 1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
March (18 days)	37	7	17.3	618
April	6.5	2.5	3.9	232
May	5	2.5	3.1	191
June	8	1	3.1	184
July	40	.5	4.8	295
August	250	2	16.5	1,014
September	1.5	1	1.0	60
October	1	1	1.0	61
November	3	1	2.0	119
December 1–16	2	2	2.0	64
The period				2,838

NOTE.—No estimate for ice period.

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, 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 Alleghany Mountains.

The total area drained by the Mississippi and its tributaries is 1,240,000 square miles. It includes wholly or in part thirty States, besides a small area in the Dominion of Canada.

The eastern outline of the basin 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.

Topographically the country included within the Mississippi basin presents all varieties of form. Mountain and prairie, arid plain, and alluvial bottom land teeming with vegetation are all 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, and from one of the smallest of these, 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.

MISSISSIPPI RIVER NEAR SAUK RAPIDS, MINN.

This station was established April 23, 1903. 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 channel is straight for 4,000 feet above the station and 600 feet below. Both banks are high and not subject to overflow. The bed consists of sand and gravel and is somewhat shifting. There is but one channel at all stages. The channel has a width of 625 feet at low water and about 700 feet at high stages. The current is of medium swiftness.

Discharge measurements are made from a boat running on a cable, which is securely fastened to trees on each side of the river. The point to which soundings are referred is a nail head in the root of a tree on the left bank, to which the cable is fastened.

The gage, which was read during 1905 by Frank McCrea, is a vertical timber fastened to a post driven into the bed on the left side of the river. It is referred to bench marks as follows: (1) Top of a large, pointed rock, 150 feet upstream from the gage and 10 feet from the water's edge; elevation above zero of gage, 18.58 feet. (2) A §-inch iron stake, driven on the left shore between the cable and bench mark No. 1; elevation above zero of gage, 14.22 feet. (3) On root of a small elm tree, on left bank of river, just below cable; elevation, 18.29 feet above gage zero. A short distance above the old gage is a large rock with a vertical face at an elevation of 14.45 feet above the zero of the gage. Observations of the river height can be made by determining distances from the top of this rock to the water surface.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann=Annual Report; WS=Water-Supply Paper):

Description: WS 98, pp 173–174; 128, p 18.
Discharge: Ann 22, iv, p 219; WS 98, p 174; 128, p 19.
Gage heights: WS 98, pp 174–175; 128, p 19.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
January 3	R. Richards	560	1,813	1.44	11.29	2,619
April 5	do	582	3,889	2.19	13.60	8,523

Daily gage height, in feet, of Mississippi River near Sauk Rapids, Minn., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.2	11.25	.....	11.35	11.45	13.45	18.1	14.25	13.85	12.85	12.5	12.2
2	11.2	11.25	11.5	11.3	11.45	13.35	17.9	14.25	13.85	12.9	12.4	.....
3	11.3	11.25	11.65	11.8	12.2	13.2	17.6	14.25	13.85	13.0	12.5	.....
4	11.2	11.25	11.7	12.4	13.2	13.1	18.2	14.25	13.85	12.95	12.6	.....
5	11.25	11.25	.....	13.6	14.0	13.9	18.8	14.35	13.85	12.9	12.4	.....
6	11.25	11.25	.....	14.0	14.4	14.5	19.8	14.5	13.85	12.8	12.5	13.15
7	11.25	11.25	11.65	14.3	14.45	14.7	20.1	14.6	13.8	12.75	12.55	.....
8	11.25	11.25	.....	14.1	14.5	14.7	20.2	14.8	13.75	12.75	12.55	.....
9	11.4	11.25	.....	13.8	14.6	14.8	20.1	14.8	13.7	12.6	12.5	.....
10	11.3	11.25	.....	13.5	14.9	14.9	19.6	15.2	13.65	12.55	12.45	.....
11	11.25	11.25	11.6	13.4	15.8	14.9	19.2	15.2	13.5	12.5	12.35	13.1
12	11.2	.....	.....	13.4	16.3	15.0	18.6	15.2	13.65	12.35	12.35	.....
13	11.25	.....	11.4	13.2	16.2	15.2	18.2	15.1	13.6	12.2	12.25	.....
14	11.25	.....	.....	13.0	16.5	15.4	19.8	15.05	13.6	12.0	12.3	.....
15	11.25	.....	.....	12.85	16.5	15.6	17.5	15.2	13.65	12.0	12.25	.....
16	11.25	.....	.....	12.85	16.5	16.1	17.2	15.3	13.65	12.0	12.25	.....
17	11.25	.....	.....	12.7	16.0	16.8	16.8	15.1	13.6	12.45	12.2	.....
18	11.25	11.2	.....	12.65	15.5	17.0	16.6	15.0	13.8	12.5	12.2	13.3
19	11.25	.....	11.2	12.65	15.4	17.2	16.4	14.9	14.2	12.6	12.1	.....
20	11.25	.....	.....	12.4	15.0	17.6	16.4	14.8	14.2	12.75	12.1	.....
21	11.25	.....	.....	12.35	15.0	17.6	16.2	14.7	14.2	12.95	12.05	.....
22	11.25	11.35	.....	12.2	15.0	17.4	16.1	15.0	14.2	12.95	12.05	.....
23	11.3	.....	11.65	12.05	15.25	17.2	16.0	14.7	14.2	13.0	12.15	.....
24	11.25	.....	11.65	11.8	15.3	17.3	15.8	14.35	14.0	13.1	12.5	.....
25	11.25	.....	11.4	11.6	15.2	17.3	15.6	14.45	13.7	13.15	13.0	.....
26	11.25	.....	11.4	11.45	15.0	18.2	15.4	14.5	13.5	13.1	12.9	12.9
27	11.25	11.4	11.55	11.3	14.6	18.2	15.1	14.4	13.35	13.05	13.0	.....
28	11.25	.....	11.6	11.2	14.3	18.3	14.9	14.2	13.2	13.0	12.45	.....
29	11.25	.....	11.6	11.25	14.2	18.3	14.7	14.2	13.0	12.95	12.05	.....
30	11.25	.....	11.5	11.4	13.7	18.2	14.45	14.0	12.9	12.8	12.0	.....
31	11.25	.....	11.4	.....	13.6	.....	14.2	13.95	.....	12.85	.....	.....

NOTE.—River frozen over January 1 to March 23; also December 1-31. Gage heights are to water surface in a hole in the ice.

MISSISSIPPI RIVER AT ANOKA, MINN.

This station was established May 8, 1905. It is located at a highway bridge three-fourths of a mile southwest of Anoka.

The channel is straight for about 1 mile above the station and for about one-half mile below, and is broken by four bridge piers. The right and left banks are clean and slope gently upward to a height of 25 feet above gage zero; they are not subject to overflow. The bed of the stream is composed of gravel and is probably nearly constant, except as affected by sunken logs, which cover the bed occasionally at some points. There is one channel at all stages. The current is medium.

Discharge measurements are made from the lower side of the steel highway bridge, to which the gage is attached. The initial point for soundings is the end of the bridge hand rail on the left bank, lower side.

The gage is composed of a 6-inch timber, 12 feet long, bolted to the lower side of the first stone pier of the bridge from the left bank. The gage was read during 1905 by Walter A. Griffith. This gage is attached to the same pier and at the same height as the United States engineers' gage placed there in 1896.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
May 8	E. F. Chandler	762	5,046	2.96	3.08	14,950
July 21	R. Richards	785	6,585	4.13	4.98	27,180
August 1	E. F. Chandler	772	4,674	3.33	2.97	15,570
August 15	do	774	5,089	3.22	3.26	16,400

Daily gage height, in feet, of Mississippi River at Anoka, Minn., for 1905.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.65	6.6	3.0	2.6	2.25	2.0	4.45
2	.....	2.4	6.6	3.0	2.55	2.15	1.8	4.45
3	.....	2.2	6.6	3.0	2.5	2.15	1.75	4.45
4	.....	2.2	6.7	3.0	2.4	2.05	1.75	4.45
5	.....	3.0	6.9	2.95	2.4	2.05	1.75	4.35
6	.....	3.2	7.5	2.95	2.4	2.0	1.75	4.4
7	.....	3.5	8.2	3.0	2.4	1.9	1.75	4.6
8	.....	3.7	8.7	3.05	2.4	1.9	1.9	4.6
9	3.1	3.9	8.8	3.05	2.35	1.9	1.9	5.65
10	3.45	4.0	8.6	3.05	2.35	1.9	1.9	5.2
11	3.8	4.0	8.4	3.05	2.3	1.9	1.9	.....
12	4.45	4.0	8.0	3.2	2.2	1.55	1.9	.....
13	5.4	4.0	7.8	3.25	2.2	1.55	1.75	.....
14	5.7	4.0	7.5	3.25	2.2	1.55	1.75	.....
15	6.1	4.0	6.7	3.25	2.25	1.55	1.6	.....
16	6.2	4.3	6.3	3.4	2.35	1.55	1.55	.....
17	6.6	4.6	6.0	3.9	2.25	1.55	1.55	4.6
18	6.4	5.3	5.6	3.85	2.5	1.55	1.55	.....
19	6.05	5.8	5.45	[a] 3.7	2.8	1.55	1.4	.....
20	5.55	5.9	5.0	3.6	3.0	1.55	1.4	.....
21	5.2	5.95	5.0	3.8	3.15	2.2	1.4	.....
22	5.05	5.9	4.9	3.65	3.0	2.2	1.4	.....
23	4.9	5.8	[a] 4.8	3.4	2.95	2.2	1.3	.....
24	4.8	5.7	4.7	3.4	3.1	2.4	1.6	.....
25	4.5	5.8	4.45	3.4	3.1	2.4	1.8	.....
26	4.35	6.05	4.0	3.15	3.1	2.4	2.0	.....
27	3.95	6.4	3.85	3.3	2.6	2.6	2.0	.....
28	3.65	6.6	3.65	3.25	2.6	2.6	2.0	2.25
29	3.5	[a] 6.6	3.55	3.0	2.4	2.4	2.45	.....
30	3.2	6.6	3.5	2.9	2.35	2.4	4.45	.....
31	2.95	.....	3.3	2.7	.....	2.3	.....	.....

[a] Gage heights interpolated.

NOTE.—River frozen part way across December 10–31.

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 on the small tributaries are many dams, built for the purpose of holding and flushing logs into the main river.

RUM RIVER NEAR ANOKA, MINN.

This station was established May 8, 1905. It is located at the highway bridge 6½ miles due north of Anoka, the distance by road being 7½ miles.

The channel is straight for 400 feet above and 300 feet below the station, broken by one pier at ordinary stages and by two piers at high stages. The right bank is composed of brush, and will overflow at ordinary floods. The left bank is a road, graded to the bridge abutment, and will not overflow. Grassy flats above and below the bridge will be covered by high floods. The bed of the stream is composed of sand and silt and is probably nearly constant. The current is sluggish at medium stages.

Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the center of the circular iron pier on the lower side of the bridge on the left bank. On account of the obliquity of the bridge, distances of 10.5 feet are marked along the bridge and considered as 10 feet.

The standard chain gage is located at the middle of the bridge span. The length of the chain from the end of the weight to the marker is 20.65 feet. The gage was read during 1905 by Henry E. Faherty.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
May 8	E. F. Chandler	150	1,130	1.80	14.46	2,035
July 22	R. Richards	149	905	1.15	12.80	1,036
August 2	E. F. Chandler	148	768	.93	11.91	715
August 15	do	148	783	.86	11.78	670

Daily gage height, in feet, of Rum River near Anoka, Minn., for 1905.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	12.1	14.2	11.9	11.95	12.45	13.4	14.25
2	.....	11.9	14.1	11.95	11.9	12.6	13.15	14.1
3	.....	11.9	14.15	12.0	12.4	12.5	12.95	.....
4	.....	12.0	14.25	11.9	12.6	12.3	12.8	.....
5	.....	12.2	14.4	12.0	12.4	12.25	12.95	.....
6	.....	12.1	14.75	11.9	12.6	12.2	13.15	.....
7	.....	14.0	15.2	11.95	12.5	12.1	13.2	.....
8	14.5	14.8	15.5	11.95	12.5	12.05	13.35	.....
9	14.7	15.2	15.9	11.95	12.4	12.0	13.35	.....
10	15.2	15.7	16.4	11.9	12.2	12.3	13.45	.....
11	15.45	16.0	17.0	11.9	12.1	12.7	13.4	14.2
12	15.4	16.1	17.4	11.8	12.15	12.5	13.3	.....
13	15.4	16.0	17.4	11.75	12.2	12.45	13.4	.....
14	15.45	15.8	17.0	11.75	12.3	12.4	13.1	.....
15	15.7	15.4	15.9	11.8	12.2	12.5	13.0	.....
16	16.6	15.4	15.3	11.8	12.6	12.85	12.95	.....
17	17.2	15.3	14.35	12.2	12.5	12.95	12.9	.....
18	17.3	15.3	13.8	13.1	13.1	13.25	12.85	13.65
19	17.1	15.35	13.4	13.2	13.5	13.6	12.8	.....
20	16.8	15.35	13.1	13.25	13.8	13.85	12.7	.....
21	16.5	15.4	12.9	13.4	14.1	14.0	12.7	.....
22	16.3	15.45	12.8	13.55	14.15	14.15	12.65	.....
23	15.8	15.5	12.6	13.3	14.3	14.0	12.7	.....
24	15.4	15.45	12.2	13.15	13.95	13.95	12.9	.....
25	14.9	15.45	11.95	13.0	13.7	14.1	13.0	.....
26	14.7	15.3	12.1	12.8	13.45	14.15	13.1	.....
27	14.15	15.1	12.2	12.6	13.1	14.05	13.4	.....
28	13.7	14.4	12.15	12.3	12.8	13.8	13.6	13.25
29	13.2	14.2	12.15	12.2	12.6	13.65	13.9	.....
30	12.7	14.2	11.4	12.05	12.5	13.5	14.4	.....
31	12.3	.....	11.8	12.0	.....	13.45	.....	.....

NOTE.—River frozen over during December. Gage heights are to water surface in a hole in the ice. Thickness of ice, 0.7 to 1 foot.

Station rating table for Rum River near Anoka, Minn., from May 8 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
11.00	474	12.30	838	13.60	1,450	15.80	3,180
11.10	492	12.40	874	13.70	1,510	16.00	3,370
11.20	512	12.50	910	13.80	1,570	16.20	3,560
11.30	534	12.60	950	13.90	1,635	16.40	3,760
11.40	558	12.70	990	14.00	1,700	16.60	3,960
11.50	584	12.80	1,035	14.20	1,840	16.80	4,160
11.60	612	12.90	1,080	14.40	1,985	17.00	4,370
11.70	642	13.00	1,130	14.60	2,135	17.20	4,580
11.80	672	13.10	1,180	14.80	2,295	17.40	4,790
11.90	704	13.20	1,230	15.00	2,460	17.60	5,010
12.00	736	13.30	1,280	15.20	2,630	17.80	5,230
12.10	770	13.40	1,335	15.40	2,810	18.00	5,450
12.20	804	13.50	1,390	15.60	2,990		

The above table is applicable only for open-channel conditions. It is based on four very consistent discharge measurements made during 1905. It is well defined between gage heights 11.7 feet and 14.5 feet. Above 14.5 feet table is based on product of area and velocity curves extended.

Estimated monthly discharge of Rum River near Anoka, Minn., for 1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
May 8–31	4,685	838	2,817	134,100
June	3,465	704	2,313	137,600
July	4,790	558	2,045	125,700
August	1,420	657	876	53,860
September	1,910	704	1,089	64,800
October	1,805	736	1,205	74,090
November	1,985	970	1,216	72,360
The period				662,500

NOTE.—No estimate for ice period.

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. 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 channel is straight for 1,000 feet above and 2,000 feet below the station, with a width of about 300 feet at low water and 350 feet at high stages. There is but one channel at all stages. The left bank is low and liable to overflow for a distance of 50 to 75 feet from the gage. The right bank is a steep, rocky bluff. The bed of the stream is composed of sand, gravel, and blue earth, and may shift somewhat at high water. The current velocity is moderate, though somewhat sluggish near the banks at low stages.

Discharge measurements are made from a small rowboat running on a cable. The initial point for soundings is a spike in the base of the willow tree to which the small cable is attached on the right bank.

The gage, which was read during 1905 by George E. Blake, is a vertical timber fastened to a post, which is driven into the river bed a few feet from the right bank. The bench mark is on a 20-inch cottonwood tree on the right bank a short distance above the station and about 30 feet from the water's edge; its elevation is 14.78 feet above the zero of the gage.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 99, pp. 15–16; 130, pp 53–54.
Discharge: 99, p 16; 130, p 54.
Gage heights: 99, p 17; 130, pp 54–55.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 3	R. Richards	295	1,400	2.34	4.98	3,282
May 10	E. F. Chandler	294	1,042	2.35	4.16	2,454
June 18	R. Richards	310	2,517	3.25	8.60	8,179
September 12	do	285	877	1.54	2.78	1,347

Daily gage height, in feet, of Minnesota River near Mankato, Minn., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.9	1.9	3.95	5.1	2.85	5.95	6.2	5.25	3.2	2.8	2.75	4.0
2	1.8	1.9	4.15	5.15	2.85	5.8	7.5	5.1	3.15	2.75	2.65	8.05
3	1.8	1.9	4.4	5.0	2.9	5.65	7.8	5.0	3.1	2.7	2.7	7.8
4	1.85	1.9	5.4	4.95	3.25	5.5	8.8	4.8	3.05	2.65	2.65	7.4
5	1.85	1.9	5.6	5.1	3.8	5.35	9.4	4.65	3.0	2.65	2.75	7.3
6	1.8	1.9	6.0	5.15	3.9	5.2	10.6	4.5	2.95	2.55	3.1	7.5
7	1.8	1.9	5.8	5.15	3.85	5.05	11.7	4.45	2.85	2.55	3.2	7.3
8	1.8	1.9	5.4	5.1	3.7	4.8	12.2	4.3	2.85	2.55	3.4	7.0
9	1.8	1.9	5.2	5.0	3.65	4.7	12.5	4.2	2.8	2.5	3.5	6.7
10	1.8	1.9	4.7	4.8	4.1	4.6	12.0	4.1	2.75	2.65	3.5	6.1
11	1.8	1.9	4.1	4.6	5.05	4.5	11.8	4.0	2.75	2.55	3.5	6.0
12	1.9	2.0	4.0	4.4	6.0	4.45	11.2	3.85	2.75	2.5	3.5	5.9
13	1.9	2.05	4.3	4.25	6.3	4.3	11.7	3.7	2.7	2.45	3.45	5.8
14	1.9	2.05	3.5	4.1	7.0	4.25	10.2	3.7	2.65	2.5	3.45	5.5
15	1.9	2.1	3.7	4.0	8.0	4.1	9.8	3.7	2.75	2.7	3.4	5.35
16	1.9	2.1	3.85	3.8	9.2	4.15	9.3	3.7	2.7	2.75	3.35	5.1
17	1.9	2.1	3.9	3.8	9.8	4.3	9.0	3.5	2.75	2.75	3.25	4.95
18	1.9	2.1	4.0	3.7	10.0	4.2	8.7	3.7	2.75	2.8	3.25	4.85
19	1.9	2.1	.....	3.6	9.9	4.3	8.4	3.7	4.45	2.7	3.2	4.6
20	1.9	2.1	.....	3.5	9.8	4.25	8.1	3.6	3.75	2.8	3.2	4.5
21	1.9	2.0	.....	3.4	9.6	4.2	7.8	3.55	3.5	2.8	3.15	4.45
22	1.9	2.0	.....	3.25	9.2	4.05	7.6	3.5	3.45	2.85	3.1	4.4
23	1.9	2.3	.....	3.2	8.8	4.0	7.3	3.4	3.35	2.9	3.05	4.1
24	1.9	2.4	.....	3.2	8.2	3.95	7.0	3.85	3.25	2.9	3.4	3.85
25	1.9	3.0	.....	3.1	7.8	4.75	6.8	3.7	3.05	2.85	3.6	3.9
26	1.9	3.5	.....	3.1	7.4	5.6	6.6	3.55	2.95	2.85	3.75	3.9
27	1.9	3.7	.....	3.0	7.4	6.1	6.3	3.5	2.95	2.8	3.8	3.85
28	1.9	4.4	.....	2.95	6.6	6.2	6.0	3.5	2.9	2.8	5.05	3.8
29	1.9	.....	.....	2.9	6.4	5.9	5.9	3.45	2.85	2.8	5.6	3.7
30	1.9	.....	.....	2.85	6.2	5.8	5.6	3.4	2.8	2.8	4.4	3.6
31	1.9	.....	.....	.....	6.05	.....	5.4	3.25	.....	2.75	.....	3.6

NOTE.—Ice conditions January 1 to February 28, also December 1-31. Gage heights are to water surface.

Station rating table for Minnesota River near Mankato, Minn., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.00	840	3.50	1,805	5.00	3,310	7.80	7,010
2.10	885	3.60	1,890	5.20	3,550	8.00	7,300
2.20	935	3.70	1,980	5.40	3,790	8.20	7,600
2.30	985	3.80	2,070	5.60	4,030	8.40	7,900
2.40	1,040	3.90	2,165	5.80	4,270	8.60	8,200
2.50	1,095	4.00	2,260	6.00	4,530	8.80	8,500
2.60	1,155	4.10	2,360	6.20	4,790	9.00	8,800
2.70	1,215	4.20	2,460	6.40	5,050	9.20	9,100
2.80	1,280	4.30	2,560	6.60	5,330	9.40	9,400
2.90	1,345	4.40	2,660	6.80	5,610	9.60	9,710
3.00	1,415	4.50	2,760	7.00	5,890	9.80	10,030
3.10	1,485	4.60	2,870	7.20	6,170	10.00	10,350
3.20	1,560	4.70	2,980	7.40	6,450	10.20	10,670
3.30	1,640	4.80	3,090	7.60	6,730	10.40	10,990
3.40	1,720	4.90	3,200				

The above table is applicable only for open channel conditions. It is based on four discharge measurements made during 1905. It is well defined between gage heights 2.8 feet and 8.6 feet. The table has been extended beyond these limits. On account of changes at gaging section, measurements of previous years were not considered applicable. This table gives 25 per cent increase over 1903 table for low stages and 5 to 15 per cent decrease for high stages.

Estimated monthly discharge of Minnesota River near Mankato, Minn., for 1905.

[Drainage area, 13,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
March 1–18	4,530	1,805	2,874	102,600	0.214	0.143
April	3,490	1,312	2,369	141,000	.177	.198
May	10,350	1,312	5,435	334,200	.406	.468
June	4,790	2,212	3,205	190,700	.239	.267
July	14,350	3,790	8,452	519,700	.631	.728
August	3,610	1,600	2,232	137,200	.167	.192
September	2,710	1,185	1,452	86,400	.108	.120
October	1,345	1,068	1,223	75,200	.091	.105
November	4,030	1,185	1,784	106,200	.133	.148
The period	.....	.....	.....	1,693,000	.....	.....

NOTE.—No record March 19–31. No estimate for ice period.

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.

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 channel is straight above and below the station. The right bank is protected by a high masonry wall; the left bank is low, but the water is confined by an earthern embankment. The bed of the stream is composed of gravel, with a few rocks, and is permanent. There is one channel, broken by one pier, at all stages, the width being 450 feet at low water and 500 feet at flood stages. The current is fairly swift.

Discharge measurements are made from a two-span highway bridge. The initial point for soundings is a point marked by two nails in the footway at the right end of the bridge.

A standard chain gage, which was read during 1905 by Joseph E. Kimpton, is fastened to the downstream side of the highway bridge. The length of the chain from the end of the weight to the marker is 30.69 feet. The bench mark is a nail in the top of a 6-inch white-oak stump which is attached to a tree, still standing, located about 200 feet east of the road and 200 feet south of the river; elevation above zero of gage, 20.09 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 83, p 166; 98, p 177; 128, p 20.
Discharge: 83, p 166; 98, p 178; 128, p 21.
Discharge, monthly: 98, p 180; 128, p 22.
Gage heights: 83, p 167; 98, pp 178–179; 128, p 21.
Rating tables: 98, pp 179–180; 128, p 22.

Discharge measurements of Chippewa River near Eau Claire, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
May 24	S. K. Clapp	200	4,400	3.66	8.80	16,110
June 14	M. S. Brennan	427	5,131	3.83	10.72	19,660
July 12	do	355	3,585	2.09	6.55	7,489
August 12	do	335	3,062	1.29	5.00	3,948

Daily gage height, in feet, of Chippewa River near Eau Claire, Wis., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	12.0	6.8	6.3	6.8	6.8	6.5	5.15	5.7	4.75
2	4.36	.....	.....	10.2	5.8	6.8	7.4	5.75	6.2	5.55	6.15	5.15
3	.....	.....	.....	11.2	5.9	6.5	6.3	4.35	5.3	7.8	5.45	4.8
4	.....	.....	.....	10.5	6.5	8.2	6.2	4.35	6.1	5.55	5.75	5.65
5	.....	4.8	4.2	10.4	7.5	12.1	6.9	4.75	6.8	4.9	5.65	4.45
6	.....	.....	.....	10.8	6.6	19.2	10.4	5.1	6.5	4.9	5.75	5.4
7	.....	.....	.....	10.2	7.3	.....	10.6	5.25	6.1	7.5	6.1	5.4
8	.....	.....	.....	9.8	7.6	19.6	11.3	5.05	5.65	5.0	6.3	5.9
9	4.4	.....	4.5	9.2	7.3	17.3	10.1	5.3	5.75	4.85	6.05	5.85
10	.....	.....	.....	8.9	8.8	14.5	7.0	5.9	5.1	4.8	6.1	5.35
11	.....	.....	.....	8.7	7.8	13.0	8.1	4.9	4.9	5.5	6.5	5.3
12	.....	.....	4.3	7.4	7.9	12.6	6.9	5.45	5.35	7.9	5.5	5.3
13	.....	5.3	4.3	5.75	7.5	11.5	6.9	5.1	6.9	6.2	5.7	5.3
14	.....	.....	4.25	5.65	9.5	10.0	7.2	5.35	5.85	5.9	5.8	5.25
15	4.8	.....	4.1	6.1	10.7	9.4	7.1	5.7	5.4	5.25	5.2	5.0
16	.....	.....	4.5	5.75	12.2	8.8	7.6	4.45	5.55	6.4	6.2	4.6
17	.....	.....	4.5	6.2	12.9	8.7	6.8	4.45	7.7	7.35	5.5	4.7
1	.....	5.36	4.65	7.0	12.0	10.2	6.5	5.6	10.7	7.8	6.0	4.8
19	.....	.....	4.4	5.6	10.6	12.2	6.6	5.25	7.0	7.9	5.5	4.7
20	.....	.....	4.45	5.45	10.2	11.3	6.7	7.4	10.1	8.95	5.45	4.7
21	.....	.....	4.55	5.4	9.2	10.5	6.0	7.3	10.8	8.5	5.4	4.65
22	4.67	.....	5.5	5.4	8.6	9.1	6.4	8.9	10.3	8.65	4.6	4.85
23	.....	.....	6.2	5.05	8.6	9.0	5.7	5.85	9.2	8.35	5.2	4.55
24	.....	.....	7.1	5.3	8.0	8.8	6.1	6.2	8.4	7.9	5.0	4.6
25	.....	4.95	7.8	5.3	8.1	8.2	5.75	6.4	6.5	7.55	5.2	4.1
26	.....	.....	8.9	6.3	7.5	7.3	5.55	8.3	8.5	7.2	5.7	4.8
27	.....	.....	10.4	5.5	7.7	7.5	4.9	5.3	6.0	7.1	6.05	4.6
28	.....	.....	11.8	4.8	7.0	8.7	4.45	5.0	6.0	7.0	5.7	4.65
29	5.17	.....	13.2	5.05	7.1	7.8	5.3	7.8	7.9	6.6	5.7	4.55
30	.....	.....	13.6	4.85	7.2	5.75	4.45	6.2	6.2	6.5	5.0	4.7
31	.....	.....	12.9	.....	6.9	.....	4.35	6.2	.....	6.4	.....	4.7

NOTE.—River frozen entirely across at gage January 1 to February 28; March 1 to 17, ice gradually disappeared. Thickness of ice, 2 to 2.5 feet. Gage heights are to water surface in a hole in the ice.

Station rating table for Chippewa River near Eau Claire, Wis., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.50	750	5.40	4,830	7.60	10,290	11.40	22,410
3.60	960	5.50	5,050	7.80	10,870	11.60	23,160
3.70	1,170	5.60	5,280	8.00	11,450	11.80	23,950
3.80	1,380	5.70	5,510	8.20	12,030	12.00	24,750
3.90	1,590	5.80	5,740	8.40	12,610	12.20	25,550
4.00	1,800	5.90	5,970	8.60	13,200	12.40	26,350
4.10	2,010	6.00	6,200	8.80	13,800	12.60	27,150
4.20	2,220	6.10	6,430	9.00	14,400	12.80	27,950
4.30	2,430	6.20	6,660	9.20	15,000	13.00	28,750
4.40	2,640	6.30	6,900	9.40	15,620	13.20	29,560
4.50	2,850	6.40	7,140	9.60	16,260	13.40	30,390
4.60	3,070	6.50	7,380	9.80	16,920	13.60	31,240
4.70	3,290	6.60	7,630	10.00	17,600	13.80	32,110
4.80	3,510	6.70	7,880	10.20	18,280	14.00	33,000
4.90	3,730	6.80	8,130	10.40	18,960	14.20	33,900
5.00	3,950	6.90	8,390	10.60	19,640	14.40	34,800
5.10	4,170	7.00	8,650	10.80	20,320	14.60	35,700
5.20	4,390	7.20	9,180	11.00	21,000	14.80	36,600
5.30	4,610	7.40	9,720	11.20	21,690	15.00	37,500

The above table is applicable only for open-channel conditions. It is based on 15 discharge measurements made during 1904–5. It is well defined between gage heights 5 feet and 13 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Chippewa River near Eau Claire, Wis., for 1905.

[Drainage area, 6,740 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 18–31	31,240	2,640	13,510	2.00	1.04
April	24,750	3,510	10,180	1.51	1.68
May	28,350	5,740	12,670	1.88	2.17
June	60,520	5,625	20,370	3.02	3.26
July	22,050	2,535	8,626	1.28	1.48
August	14,100	2,535	5,867	.870	1.00
September	20,320	3,730	8,970	1.33	1.48
October	14,250	3,510	8,041	1.19	1.37
November	7,380	3,070	5,437	.807	.900
December	5,970	2,010	3,821	.567	.654

NOTE.—No estimate for ice period.

FLAMBEAU RIVER NEAR LADYSMITH, WIS.

Flambeau River rises in the lake of the same name in western Vilas County, Wis., flows southwestward, and unites with the Chippewa in the southern part of Gates County.

The gaging station was established February 13, 1903. It is located three-fourths of a mile south of the Minneapolis, St. Paul and Sault Ste. Marie Railway station, three-fourths of a mile south of Ladysmith, and one-half mile below the dam of the Menasha Pulp Company.

The channel is straight for 500 feet above and below the station. The right bank is low, but the overflow passes beneath the bridge. The left bank is high and is covered with trees. The gaging section is broad and shallow, with a bed of small bowlders, gravel, and sand, and is not liable to shift. The stream is divided into three channels by bridge piers. The channel is somewhat obstructed by log jams during the rafting season.

Discharge measurements are made from a three-span highway bridge. The initial point for soundings is at the right end of the bridge.

A standard chain gage, which was read during 1905 by Leonard McCandless and C. A. Phillips, is fastened to the upstream side of the right span. The length of the chain from the end of the weight to the marker is 25.40 feet. The bench mark is a cut on a rivet head on the post to which the pulley of the chain gage is attached; elevation, 36.28 feet above the gage datum.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 98, pp 180–181; 128, pp 22–23.
Discharge: 98, p 181; 128, p 23.
Discharge, monthly: 98, p 183; 128, p 25.
Gage heights: 98, pp 181–182; 128, p 24.
Rating tables: 98, p 182; 128, p 24.

Discharge measurements of Flambeau River near Ladysmith, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 8	S. K. Clapp	129	1,537	3.49	18.27	5,367
May 23	do	357	1,292	2.69	17.60	3,474
June 14	M. S. Brennan	354	1,232	2.67	17.35	3,288
July 12	do	353	1,015	2.54	16.80	2,576
August 12	do	345	623	1.84	15.66	1,144
September 23	F. W. Hanna	353	1,404	3.02	17.75	4,236

Daily gage height, in feet, of Flambeau River near Ladysmith, Wis., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	18.8	16.8	17.4	17.7	15.8	16.9	16.55	16.4	16.15
2	.....	.....	.....	18.4	16.8	16.25	17.6	15.9	16.6	16.55	16.25	15.9
3	.....	.....	.....	19.0	16.8	16.4	17.5	15.8	16.9	16.35	16.15	15.85
4	.....	16.4	16.8	19.2	17.0	16.8	17.6	15.7	17.0	16.25	16.05	16.2
5	.....	.....	.....	18.9	17.3	17.8	18.6	15.75	17.0	16.2	16.2	15.95
6	.....	.....	.....	18.4	17.6	18.7	19.0	15.35	16.9	16.15	16.15	16.1
7	16.3	.....	.....	18.4	17.6	19.6	19.2	15.35	16.6	15.8	16.2	16.45
8	.....	.....	.....	18.2	17.4	19.3	18.8	15.3	16.7	15.95	16.15	16.15
9	.....	.....	.....	18.1	17.1	18.9	18.5	15.5	16.5	15.8	16.05	16.25
10	.....	.....	.....	17.8	17.4	18.7	18.2	15.3	16.4	15.95	15.95	16.25
11	.....	16.5	16.0	17.4	17.5	18.6	17.4	15.4	16.2	15.55	16.05	15.9
12	.....	.....	.....	17.2	17.8	18.6	17.0	15.55	16.2	16.2	16.3	15.8
13	.....	.....	.....	17.2	17.8	17.6	17.0	15.4	16.25	16.15	16.3	15.9
14	16.6	.....	.....	18.2	18.0	17.5	17.0	15.32	16.25	16.1	16.2	15.7
15	.....	.....	.....	18.1	18.3	17.6	16.7	15.45	16.45	16.4	16.1	15.7
16	.....	.....	.....	17.6	18.2	17.7	16.6	15.6	16.8	16.75	16.25	16.2
17	.....	.....	.....	17.2	18.4	18.0	16.35	15.55	17.1	16.75	16.05	16.4
18	.....	16.7	16.9	16.55	18.6	19.7	16.35	15.9	17.05	17.0	15.9	15.7
19	.....	.....	.....	16.55	18.6	19.6	16.4	16.8	17.7	17.65	15.9	15.95
20	.....	.....	.....	16.45	18.4	19.4	16.15	16.9	17.8	17.2	15.85	15.45
21	16.7	.....	.....	16.55	18.0	19.1	16.1	17.1	18.2	17.65	15.9	15.65
22	.....	.....	.....	17.0	18.0	18.9	16.2	16.9	18.4	17.35	15.7	15.65
23	.....	.....	.....	16.3	17.4	18.6	15.9	16.6	17.8	17.45	15.75	15.6
24	.....	.....	16.8	16.35	18.0	18.4	15.5	16.45	17.6	17.3	15.6	15.7
25	.....	16.6	16.45	16.15	17.6	18.0	15.9	16.8	17.3	17.1	16.0	15.75
26	.....	.....	16.35	16.05	17.4	18.0	15.75	16.35	17.2	16.95	16.6	16.1
27	.....	.....	16.25	17.4	17.2	18.0	15.8	16.25	16.8	16.85	16.1	15.6
28	16.6	.....	17.1	17.4	18.0	17.7	15.8	16.8	16.8	16.8	16.6	16.0
29	.....	.....	17.9	17.0	17.8	17.7	15.75	17.0	16.7	16.7	16.15	15.9
30	.....	.....	18.2	16.8	17.6	17.7	15.7	17.2	16.2	16.55	15.9	16.15
31	.....	.....	18.6	.....	17.4	.....	15.55	17.0	.....	16.3	.....	16.1

NOTE.—River frozen nearly across January 1-31, and entirely across February 1 to March 23. March 11-23 there was water on the ice. Gage heights are to water surface in a hole in the ice. The following comparative readings were also made:

Date.	Water surface.	Top of ice.	Thickness.
	Feet.	*Feet.*	*Feet.*
January 7	16.3	16.4	0.7
January 14	16.6	16.8	1.3
January 21	16.7	16.9	1.4
January 28	16.6	16.9	1.5
February 4	16.4	16.9	1.7
February 11	16.5	16.9	1.7
February 18	16.7	17.1	2.0
February 25	16.6	16.9	1.8
March 4	16.8	17.8	1.8

Station rating table for Flambeau River near Ladysmith, Wis., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
15.00	600	16.20	1,735	17.40	3,510	18.50	5,770
15.10	670	16.30	1,855	17.50	3,700	18.60	5,980
15.20	745	16.40	1,980	17.60	3,890	18.70	6,190
15.30	825	16.50	2,110	17.70	4,090	18.80	6,400
15.40	910	16.60	2,245	17.80	4,300	18.90	6,610
15.50	1,000	16.70	2,385	17.90	4,510	19.00	6,820
15.60	1,090	16.80	2,530	18.00	4,720	19.20	7,240
15.70	1,185	16.90	2,680	18.10	4,930	19.40	7,680
15.80	1,285	17.00	2,835	18.20	5,140	19.60	8,120
15.90	1,390	17.10	2,995	18.30	5,350	19.80	8,560
16.00	1,500	17.20	3,160	18.40	5,560	20.00	9,000
16.10	1,615	17.30	3,330				

The above table is applicable only for open channel conditions. It is based on discharge measurements made during 1903-1905. It is not very well defined.

Estimated monthly discharge of Flambeau River near Ladysmith, Wis., for 1905.

[Drainage area, 2,120 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 24-31	5,980	1,795	3,384	1.60	0.476
April	7,240	1,558	3,867	1.82	2.03
May	5,980	2,530	4,090	1.93	2.22
June	8,340	1,795	5,223	2.46	2.74
July	7,240	1,000	2,950	1.39	1.60
August	3,160	825	1,669	.787	.907
September	5,560	1,735	2,839	1.34	1.50
October	3,990	1,045	2,305	1.09	1.26
November	2,245	1,090	1,616	.762	.850
December	2,045	955	1,449	.683	.787

NOTE.—No estimate for ice period.

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, measured at the mouth of the river, 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 per 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 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 channel is straight for 500 feet above and below the station. The right bank is high, alluvial, and clean; the left is high, rocky, and covered with scattered trees. Neither bank is liable to overflow. The bed of the stream is composed of gravel and rock, is free from vegetation, and is permanent. There is only one channel at high water, but there may be two at low stages. The current is swift at all times.

Discharge measurements are made from the downstream side of the single-span bridge to which the gage is attached. The initial point for soundings is the inner face of the left abutment.

A standard chain gage, which was read once each day during 1905 by A. Bissell, is fastened to the bridge on the downstream side. The length of the chain from the end of the weight to the end of the chain proper is 29.01 feet. The gage is referred to bench marks as follows: (1) The highest point on a bowlder about 30 feet from the river and the same distance from the highway on the left bank; elevation above gage datum, 23.00 feet. (2) Top of the bottom of the downstream chord at the gage pulley; elevation above gage datum, 24.73 feet. (3) Top of bridge seat at the downstream right abutment; elevation above datum of gage, 23.55 feet.

Discharge measurements of Black River at Neillsville, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 7	Hanna and Clapp	192	1,021	3.25	7.70	3,279
May 24	S. K. Clapp	165	471	2.18	4.95	1,024
June 13	M. S. Brennan	192	945	3.15	7.26	2,978
July 11	do	161	392	1.56	4.25	612
August 11	do	151	242	.93	3.30	225
September 25	F. W. Hanna	163	419	1.86	4.35	780

Daily gage height, in feet, of Black River at Neillsville, Wis., for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.4	3.7	4.4	2.7	3.3	3.5	3.7	4.0
2	.....	3.4	3.3	4.4	2.6	3.2	3.5	3.5	4.2
3	.....	4.1	3.2	4.9	2.6	3.5	3.4	3.5	3.8
4	.....	5.3	7.7	6.5	2.6	3.4	3.4	3.5	3.7
5	.....	5.2	14.2	8.4	2.9	3.6	3.0	3.5	3.8
6	8.2	4.9	19.8	8.0	2.7	3.2	3.0	3.7	3.5
7	7.7	5.0	16.5	6.8	4.2	3.1	3.1	4.1	3.5
8	6.9	4.6	11.5	5.9	4.0	3.0	2.7	4.1	3.4
9	6.2	4.6	8.8	5.3	4.0	2.9	2.4	3.9	3.3
10	6.0	5.9	7.6	4.7	3.5	2.8	3.1	3.8	3.4
11	5.7	6.6	8.6	4.2	3.3	2.7	3.0	3.7	3.4
12	5.5	6.7	8.0	3.8	3.3	2.8	3.0	3.7	3.5
13	5.1	6.2	7.1	3.9	3.3	2.7	3.0	3.6	3.4
14	4.8	10.7	6.2	4.0	3.3	2.7	3.0	3.5	3.4
15	4.6	10.1	5.5	4.8	3.2	4.3	4.0	3.4	3.5
16	4.3	9.2	5.8	4.5	3.0	6.0	4.9	3.4	3.4
17	3.9	8.7	11.2	4.0	2.9	6.0	5.4	3.4	3.3
18	3.8	8.2	10.7	3.8	3.0	6.1	5.5	3.4	3.0
19	4.2	6.6	8.6	4.2	3.0	8.6	5.6	3.4	3.0
20	3.9	6.0	7.0	4.3	3.0	8.3	6.6	3.3	3.2
21	3.2	5.3	6.0	4.0	3.2	7.5	6.9	3.2	3.1
22	3.1	5.1	5.2	3.8	3.5	6.3	6.5	3.2	3.1
23	3.1	4.9	4.5	3.3	3.4	5.8	5.9	3.2	3.3
24	3.5	4.7	4.1	3.1	3.6	4.7	5.5	3.5	3.5
25	3.4	4.3	3.9	3.1	3.4	4.2	5.0	4.2	3.5
26	3.4	4.2	3.7	3.0	3.3	3.9	4.6	4.6	3.5
27	3.4	4.1	3.5	2.9	3.2	3.8	4.4	4.5	3.4
28	3.4	3.9	3.3	2.9	3.0	3.7	4.1	4.3	3.4
29	3.4	3.9	3.3	2.8	3.4	3.6	3.9	3.9	3.4
30	3.4	3.8	3.5	2.8	3.5	3.8	3.7	3.7	3.5
31	.....	3.8	.....	2.7	3.3	.....	3.6	.....	3.5

NOTE.—No ice record at this station.

Station rating table for Black River at Neillsville, Wis., from April 6 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	150	4.80	990	6.60	2,310	8.40	4,120
3.10	177	4.90	1,055	6.70	2,395	8.50	4,230
3.20	205	5.00	1,120	6.80	2,480	8.60	4,340
3.30	235	5.10	1,185	6.90	2,570	8.70	4,460
3.40	267	5.20	1,250	7.00	2,660	8.80	4,580
3.50	301	5.30	1,315	7.10	2,750	8.90	4,700
3.60	338	5.40	1.385	7.20	2,850	9.00	4,820
3.70	379	5.50	1,455	7.30	2,950	9.10	4,940
3.80	424	5.60	1,525	7.40	3,050	9.20	5,060
3.90	473	5.70	1,600	7.50	3,150	9.30	5,180
4.00	525	5.80	1,675	7.60	3,250	9.40	5,300
4.10	579	5.90	1,750	7.70	3,350	9.50	5,420
4.20	635	6.00	1,825	7.80	3,460	9.60	5,540
4.30	692	6.10	1,905	7.90	3,570	9.70	5,660
4.40	750	6.20	1,985	8.00	3,680	9.80	5,780
4.50	810	6.30	2,065	8.10	3,790	9.90	5,900
4.60	870	6.40	2,145	8.20	3,900	10.00	6,020
4.70	930	6.50	2,225	8.30	4,010		

The above table is applicable only for open channel conditions. It is based on six discharge measurements made during 1905. It is well defined between gage heights 3.3 feet and 7.7 feet. Beyond the limits of the table the discharge is only approximate.

Estimated monthly discharge of Black River at Neillsville, Wis., for 1905.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
April 6–30	3,900	177	1,036
May	6,910	267	1,768
June	23,060	205	3,840
July	4,120	80	884
August	635	60	229
September	4,340	80	918
October	2,570	20	750
November	870	205	392
December	635	150	292

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 lying 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 semiprairie 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.

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 laraely made up of sand, gravel, and bowlders.

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.

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 channel is straight from the dam to the bridge and for about 400 feet below. It is about 300 feet wide at low stages and 400 feet at high water. Both banks are high and do not overflow. The velocity is rapid and the surface rough. The station is so near the dam that at high stages the velocity is affected. It is possible that the bed of the stream may be subject to slight change, though it is of rock and gravel and is very rough. Prairie River enters about one-half mile above the station, and there is an island about 600 feet below.

Discharge measurements are made from the two-span highway bridge, to which the chain gage is fastened. Each span of the bridge is 175 feet in length. The initial point for soundings is a nail marked "0" in the footboard at the left end of the bridge opposite the center of the iron hand-rail post.

The gage was read during 1905 by A. F. Lueck. Originally a vertical gage was fastened to the mill abutment. June 17, 1903, a chain gage was established on the bridge and made to read the same as the old gage at the mill. It is fastened to the guard timber on the downstream side, and the zero is marked by a brass screw driven into the guard timber. The fall of the water from the old gage to the new is 2.70 feet when the water is at high stage. The length of the chain from the end of the weight to the marker is 23.68 feet. The bench mark is a cross cut in the sandstone rock in the bridge seat of the abutment nearest the city; its elevation above the zero of the gage is 16.25 feet. This bench mark is 18.28 feet below the United States bench mark located at the corner of the engine house opposite the city hall.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 83, p 170; 98, pp 190-191; 128, pp 25-26.
Discharge: 83, p 170; 98, p 191; 128, p 26.
Discharge, monthly: 128, p 28.
Gage heights: 83, p 170; 98, p 192; 128, p 27.
Rating table: 128, p 27.

Discharge measurements of Wisconsin River at Merrill, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 10	S. K. Clapp	334	2,189	3.84	7.80	8,396
May 26	do	324	1,679	2.69	6.25	4,519
June 10	M. S. Brennan	334	2,334	4.06	8.17	9,478
July 10	do	332	1,596	2.73	6.48	4,357

Daily gage height, in feet, of Wisconsin River at Merrill, Wis., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.2	5.25	5.35	8.9	5.15	5,8	7.4	5.05	6.1	6.2	6.2	5.2
2	4.95	5.0	5.35	8.8	5.7	5.7	7.3	5.45	6.2	6.0	6.3	5.7
3	5.2	4.9	5.2	9.2	6.2	5.9	7.5	5.35	6.15	6.2	5.6	5.6
4	5.7	5.15	5.4	8.9	6.1	5.5	7.6	5.35	6.7	6.0	5.25	5.8
5	5.35	5.5	5.25	8.8	6.25	7.6	8.0	5.95	6.7	6.05	5.8	5.4
6	5.4	5.35	5.35	8.8	6.4	10.4	8.2	6.1	6.25	6.0	5.35	5.25
7	5.2	5.15	5.55	8.8	6.45	10.0	7.7	6.85	6.0	5.3	5.1	5.55
8	5.45	5.25	5.15	8.2	7.2	9.0	7.8	6.0	6.25	5.3	5.55	5.55
9	5.15	5.1	5.2	8.6	6.7	9.0	8.0	6.25	6.1	4.3	5.45	5.35
10	5.05	5.4	5.65	7.8	6.45	8.4	7.2	6.4	6.3	4.9	5.9	5.75
11	5.35	5.2	5.45	7.4	6.95	8.5	6.85	6.05	6.15	6.15	5.8	5.7
12	5.5	4.95	5.05	7.2	7.2	8.4	7.05	5.75	6.3	6.8	5.15	5.55
13	5.5	5.2	5.45	7.4	6.9	7.8	6.2	6.0	6.65	6.45	5.3	5.6
14	5.9	5.25	4.7	7.0	7.4	7.8	6.3	6.15	6.4	6.55	5.0	5.6
15	6.0	5.15	4.7	6.9	7.6	7.6	6.8	5.9	6.05	5.9	5.2	5.35
16	5.95	5.5	4.95	7.2	7.6	8.1	6.5	6.05	6.4	6.15	5.65	5.7
17	5.75	5.7	5.05	7.4	7.8	10.4	6.3	5.9	6.6	5.85	5.7	6.15
18	5.85	5.65	5.25	7.0	7.8	10.6	6.55	6.4	6.45	6.25	5.75	5.5
19	5.65	5.55	5.25	6.45	7.5	10.6	5.05	6.25	6.9	6.65	5.85	5.6
20	5.15	5.35	5.25	6.45	7.3	9.6	5.65	6.2	7.35	6.85	5.45	5.65
21	5.15	4.3	5.5	6.45	7.0	9.2	6.45	5.9	6.7	6.7	5.75	5.75
22	5.6	5.2	4.95	6.05	6.75	8.6	6.0	6.8	7.3	6.7	5.75	5.75
23	5.8	5.75	4.95	5.95	6.8	8.5	5.5	6.5	6.9	6.8	5.75	5.45
24	6.05	5.8	5.35	5.6	6.4	8.0	5.4	4.8	6.8	6.15	5.6	5.55
25	6.15	5.6	4.55	5.75	6.45	7.6	5.2	5.55	6.5	6.3	5.7	5.9
26	5.85	5.15	5.75	6.2	6.3	6.9	5.1	6.35	6.25	6.7	5.2	6.25
27	5.85	5.65	6.05	5.9	6.35	7.6	5.65	6.4	6.55	6.55	4.8	5.9
28	5.25	5.35	7.4	5.65	6.35	7.5	5.8	6.25	6.15	6.9	5.15	5.6
29	5.1	.....	8.0	5.95	6.25	6.75	5.6	5.75	5.95	6.5	5.65	5.85
30	5.05	.....	8.6	5.45	6.25	7.05	5.75	6.0	6.45	5.7	5.5	5.7
31	5.15	.....	8.5	.....	6.0	.....	4.3	6.8	.....	5.8	.....	5.4

NOTE.—No ice record at this station.

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 general direction of the channel is straight for 2,000 feet above and below the station. The width at ordinary stages is about 325 feet, broken by one pier. The right bank is high and rocky; the left overflows, making the width of the channel from 500 to 600 feet. During the spring flood of 1903 the water overflowed the turnpike. The right side of the bed of the stream is rocky, but the remainder is sandy and is liable to shift. The velocity is rapid and rather poorly distributed on account of the ice breaker above the middle pier and the variation in the width of the channel just above the bridge. Yellow River flows into the Wisconsin about 4 miles below the station. There are islands both above and below the station, but they are several hundred feet away.

Discharge measurements are made from the two-span highway bridge to which the gage is attached. The initial point for soundings is a point over the right abutment, marked zero with paint.

A standard chain gage, which was read during 1905 by W. F. Bingman, is fastened to the upstream side of the bridge. The length of the chain from the end of the weight to the marker is 26.87 feet. The gage is referred to bench marks as follows: (1) A nail in the top of a red-oak stump, 2.5 feet in diameter, about 60 feet south of the center of the roadbed and about 50 feet from the river at ordinary stages; elevation above zero of gage, 12.99 feet. (2) A nail in the root of a large cottonwood tree 280 feet south of the bridge and about 80 feet from the river; elevation above gage zero, 11.90 feet. (3) A cross on a large sandstone rock 70 feet south of the center of the roadway and 15 feet west of the water's edge on the west bank of the river; elevation above zero of gage, 20.36 feet. Bench marks Nos. 1 and 2 are on the east side of the river.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 83, p 169; 98, p 187; 128, pp 28–29.
Discharge: 83, p 169; 98, p 188; 128, p 29.
Discharge, monthly: 98, p 190; 128, p 31.
Gage heights: 83, p 169; 98, pp 188–189; 128, p 30.
Rating table: 98, pp 189–190; 128, p 30.

Discharge measurements of Wisconsin River near Necedah, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 4	S. K. Clapp	.....	5,777	5.07	12.33	29,290
May 25	do	317	4,137	3.23	7.65	13,350
June 12	M. S. Brennan	437	6,017	4.99	12.90	30,050
August 9	do	314	3,486	2.40	6.85	9,268

Daily gage height, in feet, of Wisconsin River near Necedah, Wis., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	13.3	5.95	6.5	7.3	5.5	5.9	6.0	5.8	5.4
2	.....	.....	.....	13.3	6.1	6.4	7.3	5.3	6.0	5.7	5.5	5.1
3	.....	.....	.....	12.8	6.1	6.4	7.5	5.2	6.2	5.6	5.3	5.1
4	.....	6.0	5.7	12.4	6.0	6.3	7.5	5.2	6.0	5.5	5.4	5.3
5	.....	.....	.....	11.9	6.0	7.7	7.5	5.6	6.1	5.4	5.5	5.6
6	.....	.....	.....	11.6	6.5	8.3	8.1	5.3	6.1	5.4	5.4	5.8
7	6.0	.....	.....	11.8	6.6	11.0	8.6	5.4	6.55	5.4	5.4	6.8
8	.....	.....	.....	11.9	6.7	12.5	9.1	6.6	6.2	5.4	5.4	6.5
9	.....	.....	.....	11.4	6.9	15.0	8.7	6.9	5.7	5.2	5.5	6.2
10	.....	.....	.....	10.6	7.0	17.0	8.3	7.1	5.6	5.3	5.5	8.6
11	.....	.....	6.15	9.9	7.0	16.0	7.6	6.7	5.5	5.0	5.6	8.8
12	.....	.....	.....	9.3	7.5	13.0	7.4	6.5	5.3	4.9	5.5	8.4
13	.....	6.0	.....	9.0	8.3	11.9	7.0	6.7	5.4	4.7	5.5	7.7
14	6.0	.....	.....	8.6	8.5	11.5	6.6	6.4	5.5	4.7	5.5	7.7
15	.....	.....	.....	8.4	8.3	11.2	6.7	6.2	5.5	5.1	5.3	7.6
16	.....	.....	.....	8.0	8.6	10.4	6.5	5.9	5.3	5.1	5.3	7.6
17	.....	.....	.....	7.8	9.3	9.7	6.3	6.0	5.4	5.3	5.1	7.8
18	.....	.....	.....	7.5	9.8	9.5	6.5	5.9	5.5	5.3	5.2	7.3
19	.....	.....	.....	7.1	9.8	9.6	6.3	5.8	6.9	5.6	5.2	7.3
20	.....	6.0	.....	6.7	9.7	11.2	6.3	5.6	7.4	5.6	5.3	7.3
21	6.1	.....	5.0	6.6	9.3	12.4	6.3	5.5	8.2	5.8	5.2	7.2
22	.....	.....	5.0	6.6	8.8	12.3	6.1	5.7	8.4	6.3	4.9	7.1
23	.....	.....	5.0	6.5	8.3	11.0	5.9	5.7	8.4	6.7	4.9	7.1
24	.....	.....	5.3	6.4	8.0	9.8	5.7	5.5	7.8	7.0	4.9	6.8
25	.....	6.0	5.6	6.3	7.7	8.8	5.75	5.7	7.2	6.8	4.8	6.3
26	.....	.....	6.8	6.0	7.2	8.3	6.0	5.9	6.8	6.7	5.1	6.3
27	.....	.....	7.1	6.15	7.1	8.0	5.5	5.3	6.5	6.6	5.1	7.1
28	6.0	.....	8.3	6.0	7.0	7.8	5.1	5.0	6.0	6.4	5.5	6.5
29	.....	.....	9.3	5.95	6.7	7.4	5.3	5.8	5.9	6.2	5.3	6.4
30	.....	.....	10.7	5.9	6.8	7.0	5.1	5.7	6.0	6.2	5.4	6.3
31	.....	.....	.....	.....	6.6	.....	5.3	5.7	.....	6.0	.....	6.1

NOTE.—River frozen over January 1 to March 20. Gage heights are to water surface in a hole in the ice. Thickness of ice, 2 to 2.5 feet. No ice record for December.

Station rating table for Wisconsin River near Necedah, Wis., from January 1, 1904, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.00	1,800	5.50	5,130	7.00	9,400	9.80	17,800
4.10	2,000	5.60	5,380	7.20	10,000	10.00	18,400
4.20	2,200	5.70	5,640	7.40	10,600	10.50	19,900
4.30	2,400	5.80	5,900	7.60	11,200	11.00	21,400
4.40	2,600	5.90	6,170	7.80	11,800	11.50	23,610
4.50	2,810	6.00	6,440	8.00	12,400	12.00	25,860
4.60	3,020	6.10	6,720	8.20	13,000	12.50	28,230
4.70	3,240	6.20	7,010	8.40	13,600	13.00	30,750
4.80	3,460	6.30	7,300	8.60	14,200	13.50	38,450
4.90	3,690	6.40	7,600	8.80	14,800	14.00	46,200
5.00	3,920	6.50	7,900	9.00	15,400	15.00	61,800
5.10	4,150	6.60	8,200	9.20	16,000	16.00	77,500
5.20	4,390	6.70	8,500	9.40	16,600	17.00	93,300
5.30	4,630	6.80	8,800	9.60	17,200	18.00	109,200
5.40	4,880	6.90	9,100				

The above table is applicable only for open-channel conditions. It is based on 23 discharge measurements made during 1902–1905. It is well defined between gage heights 4.5 feet and 10.5 feet. The table has been extended beyond these limits. 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, which causes the discharge to increase at a greater rate per foot.

Estimated monthly discharge of Wisconsin River near Necedah, Wis., for 1905.

[Drainage area, 5,800 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 21-30	20,500	3,920	9,037	1.56	0.58
April	35,370	6,170	15,790	2.72	3.04
May	17,800	6,305	11,060	1.91	2.20
June	93,300	7,300	23,320	4.02	4.48
July	15,700	4,150	8,711	1.50	1.73
August	9,700	3,920	6,099	1.05	1.21
September	13,600	4,630	7,419	1.28	1.43
October	9,400	3,240	5,748	.991	1.14
November	5,900	3,460	4,667	.805	.898
December	14,800	4,150	8,888	1.53	1.76

NOTE.—No estimate for ice period.

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 2,304 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 at the highway bridge just above the Chicago, Milwaukee and St. Paul Railway bridge and near the Dearborn stone quarry.

The channel is straight for about 400 feet above and below the station, but the river makes abrupt turns at both ends of this section. Both banks are high and not subject to overflow. The bed of the stream is solid rock and sand and is permanent. The channel is broken by one pier and the current velocity is moderate. There is a dam at Waubeck, 4 miles above the station, and another at Anamosa, the same distance below.

Discharge measurements are made from the two-span highway bridge, which has a length of 225 feet. The initial point for soundings is the end of the lower chord on the upstream side of the bridge at the left bank.

A standard chain gage, which was read during 1905 by Frank Dearborn, is attached to the guard rail on the upstream side of the bridge. The length of the chain from the end of the weight to the marker is 36.40 feet. The gage is referred to bench marks as follows: (1) The east end of the south rail west of the first switch east of the railroad station at Stone City; elevation, 815.08 feet above sea level and 38.75 feet above gage datum. (2) A cross on the northwest corner of the middle pier of the highway bridge at which the station is located; elevation, 31.09 feet above gage datum and 807.42 feet above sea level. The center of the gage pulley has an elevation of 35.58 feet above gage datum and 811.91 feet above sea level. The top of the lower chord, upstream side, at the first cross girder east of the pier, is 31.75 feet above gage datum. The elevations of the bench marks above sea level have been determined by the Chicago, Milwaukee and St. Paul Railway levels.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 99, p 19; 130, pp 55–56.
Discharge: 99, p 20; 130, p 56.
Discharge, monthly: 99, p 21; 130, p 58.
Gage heights: 99, p 20; 130, p 57.
Rating table: 99, p 20; 130, p 58.

Discharge measurements of Wapsipinicon River at Stone City, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 25	M. S. Brennan	170	1,514	3.12	9.81	4,718
April 27	do	143	521	1.11	3.95	679
May 23	Hanna and Hoyt	148	750	2.22	5.74	1,667
June 22	F. W. Hanna	148	711	2.18	5.48	1,547
July 18	Hanna and Clapp	140	420	1.35	3.64	568
August 9	F. W. Hanna	118	276	.73	2.87	202
September 25	M. S. Brennan	138	328	.88	3.08	289
October 24	do	140	363	1.00	3.30	364

Daily gage height, in feet, of Wapsipinicon River at Stone City, Iowa, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	3.05	5.4	3.6	4.6	4.4	3.2	3.33	2.76	2.92	4.75
2	.....	2.54	3.1	5.0	3.55	5.8	4.2	3.26	3.2	2.72	2.9	4.35
3	.....	.....	3.18	4.8	3.5	6.3	4.1	3.22	3.12	2.72	2.83	.....
4	.....	.....	3.45	4.7	3.42	5.4	5.5	3.14	3.06	2.72	2.8	.....
5	.....	.....	3.9	4.5	3.35	5.05	6.2	3.05	3.02	2.72	2.92	.....
6	2.3	.....	3.65	4.3	3.35	4.75	6.5	3.0	2.95	2.7	3.1	4.3
7	.....	.....	3.9	4.2	3.55	4.45	6.8	2.98	2.92	2.68	3.44	.....
8	.....	.....	4.1	4.1	3.55	4.2	5.6	2.9	2.9	2.66	3.55	.....
9	.....	.....	4.95	3.95	3.42	4.05	5.05	2.84	2.86	2.64	3.64	.....
10	.....	.....	5.4	3.9	3.55	4.0	4.8	2.76	2.86	2.62	3.52	.....
11	.....	2.42	6.2	3.75	3.9	3.8	4.2	2.65	2.82	2.64	3.48	.....
12	2.3	.....	7.0	3.7	5.3	3.7	4.35	2.58	2.78	2.61	3.38	.....
13	.....	.....	7.8	3.7	6.2	3.6	4.4	2.52	2.75	2.58	3.3	3.1
14	.....	.....	8.1	3.65	6.3	3.6	4.3	2.48	2.72	2.6	3.2	.....
15	.....	.....	8.3	3.6	7.1	3.5	3.8	2.6	2.8	2.63	3.15	.....
16	.....	.....	8.0	3.55	7.6	3.45	3.7	3.04	2.73	2.61	3.1	.....
17	.....	.....	7.8	3.4	7.9	3.4	3.55	3.36	2.71	2.82	3.08	.....
18	.....	.....	7.3	3.34	8.2	4.35	3.65	3.45	2.72	3.15	3.03	.....
19	2.42	.....	8.7	3.3	7.8	4.9	3.6	3.4	3.0	3.13	3.0	.....
20	.....	.....	9.1	3.32	7.4	4.4	3.6	3.32	2.98	3.4	2.96	3.02
21	.....	2.45	11.0	3.38	6.8	4.7	4.1	3.2	3.6	3.46	2.93	.....
22	.....	.....	11.7	4.0	6.5	5.5	5.2	3.6	3.6	3.42	2.9	.....
23	.....	.....	12.3	3.8	5.8	5.6	6.1	3.12	3.35	3.35	2.91	.....
24	.....	.....	10.8	3.7	5.4	5.4	5.4	3.1	3.15	3.31	2.9	.....
25	.....	.....	9.9	3.8	5.1	5.2	4.4	3.04	3.02	3.22	2.98	.....
26	.....	2.8	8.8	3.85	4.7	5.2	3.95	2.96	2.9	3.15	3.02	2.74
27	2.48	2.78	8.4	3.95	4.3	5.1	3.7	3.85	2.82	3.15	3.04	.....
28	.....	2.8	7.6	3.9	4.1	4.9	3.6	4.05	2.9	3.08	3.25	.....
29	.....	.....	7.0	3.8	4.0	4.65	3.45	3.9	2.8	3.03	3.4	.....
30	.....	.....	6.4	3.65	4.25	4.5	3.33	3.7	2.8	3.0	5.3	.....
31	.....	.....	5.8	.....	4.4	.....	3.25	3.5	.....	3.0	.....	.....

NOTE.—River frozen over January 1 to March 15. Also December 1-31. Gage heights are to water surface in a hole cut in the ice. Thickness of ice, 0.9 foot to 1.9 feet during January and February. Average thickness for December, 0.4 foot.

Station rating table for Wapsipinicon River at Stone City, Iowa, from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.00	40	3.30	370	4.60	1,020	6.60	2,270
2.10	50	3.40	417	4.70	1,075	6.80	2,410
2.20	63	3.50	467	4.80	1,130	7.00	2,550
2.30	78	3.60	518	4.90	1,185	7.20	2,690
2.40	95	3.70	570	5.00	1,240	7.40	2,835
2.50	115	3.80	620	5.20	1,350	7.60	2,985
2.60	137	3.90	670	5.40	1,470	7.80	3,140
2.70	162	4.00	720	5.60	1,600	8.00	3,300
2.80	189	4.10	770	5.80	1,730	8.50	3,700
2.90	218	4.20	820	6.00	1,860	9.00	4,100
3.00	250	4.30	870	6.20	1,990	9.50	4,500
3.10	286	4.40	920	6.40	2,130	10.00	4,900
3.20	326	4.50	970				

The above table is applicable only for open-channel conditions. It is based on 16 discharge measurements made during 1904–5. It is well defined between gage heights 2.7 feet and 5.7 feet. The table has been extended beyond these limits, being based on one measurement at 9.8 feet. Below 2.7 feet the table is uncertain.

Estimated monthly discharge of Wapsipinicon River at Stone City, Iowa, for 1905.

[Drainage area, 1,308 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 16–31	6,740	1,730	3,953	3.02	1.80
April	1,470	370	689	.527	.588
May	3,460	394	1,396	1.07	1.23
June	2,060	417	1,044	.798	.890
July	2,410	348	995	.761	.877
August	745	111	330	.252	.290
September	518	165	251	.192	.214
October	447	133	235	.180	.208
November 1 to 29	539	189	306	.234	.252

NOTE.—No estimate for ice period.

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 (10,973 square miles), 5,653 square miles are in Wisconsin and 5,320 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.

ROCK RIVER AT ROCKTON, ILL.

This station was established May 13, 1903. It is located at the village highway bridge, one-half mile from the Chicago, Milwaukee and St. Paul Railway station, 1 mile below the dam, and three-fourths of a mile below the junction of Pecatonica River with Rock River.

The channel is straight for 2,000 feet above and 1,000 feet below the station, is about 565 feet wide between bridge abutments, and is broken by four piers. The bed of the stream is composed of rocks and gravel. The current is swift. There are small islands a short distance above and immediately below the station.

Discharge measurements are made from the upstream side of the five-span highway bridge to which the gage is attached. The initial point for soundings is the face of the abutment on the left end of the bridge.

The chain gage, which was read during 1905 by O. T. Bartholomew, is located on the first span from the left end of the bridge, downstream side. The length of the chain is 26.45 feet. The gage is referred to bench marks as follows: (1) A hammered cross on the top stone of the left abutment, about 1 foot from the bridge shoe and 1 foot from the south edge; elevation above gage datum, 16.85 feet. (2) Top of west end of south rail of railroad track, 250 feet north of the north end of the bridge, at a point where the sidewalk on the west side of the street crosses the track; elevation above gage datum, 16.49 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey, as follows:

Description: 98, pp 193, 195–196; 128, pp 31–32.
Discharge: 98, pp 194, 196; 128, p 32.
Discharge, monthly: 98, p 195; 128, p 34.
Gage heights: 98, pp 194, 196; 128, p 33.
Rating table: 98, p 195; 128, p 33.

Discharge measurements of Rock River at Rockton, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 23	Brennan and Hanna	516	4,650	3.82	10.37	17,770
April 29	M. S. Brennan	503	1,524	3.52	4.42	5,361
June 29	do	503	1,530	3.37	4.44	5,152
August 28	do	482	1,012	3.28	3.20	3,324
September 15	do	460	860	3.24	2.88	2,783

Daily gage height, in feet, of Rock River at Rockton, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.0	a 3.1	4.0	10.1	4.2	4.3	4.3	2.8	2.8	2.3	2.6	3.5
2	3.8	3.2	5.0	9.4	4.1	4.25	4.3	2.75	2.95	2.05	2.6	3.5
3	4.55	a 3.2	5.4	8.9	3.8	4.2	4.3	2.7	3.85	2.2	2.7	3.0
4	3.9	3.15	6.2	8.7	3.8	4.2	4.1	2.65	3.4	2.2	2.6	3.2
5	3.65	3.15	6.1	8.4	3.6	4.3	4.0	3.15	3.5	2.15	2.65	3.1
6	3.45	3.1	5.8	8.3	3.65	5.0	3.9	3.1	3.45	2.2	3.0	3.15
7	3.3	3.25	5.7	8.1	3.6	4.85	4.0	3.0	3.4	2.15	2.9	3.05
8	3.5	3.25	5.5	7.8	3.55	4.9	4.05	3.0	3.4	2.1	3.1	3.05
9	3.5	3.25	5.5	7.6	3.4	5.1	3.95	2.75	3.3	1.9	3.1	3.0
10	4.2	3.25	6.4	7.4	3.55	5.3	3.95	2.7	3.3	2.0	3.15	3.0
11	4.0	3.3	6.2	7.2	3.95	5.2	4.0	2.65	3.4	2.0	3.0	3.1
12	4.1	3.3	5.6	6.8	5.8	5.4	4.05	2.6	3.15	2.1	2.8	2.95
13	3.75	3.4	5.6	6.5	6.0	5.4	4.2	2.5	3.05	2.05	2.8	2.85
14	3.85	3.15	5.5	6.3	6.4	5.4	4.2	2.8	2.9	2.1	3.0	2.95
15	4.0	3.2	5.3	6.0	7.0	5.3	4.1	2.65	2.9	2.05	2.75	2.75
16	3.7	3.2	5.2	5.8	7.3	5.3	4.0	2.6	2.8	2.05	2.7	2.7
17	3.8	3.25	5.0	5.6	6.9	5.3	3.7	2.7	2.75	2.2	2.7	2.75
18	3.5	3.35	7.1	5.3	6.5	5.4	3.55	2.45	2.9	2.5	2.7	2.5
19	3.35	3.35	8.2	5.2	6.3	5.3	3.35	2.61	2.7	4.1	2.7	2.65
20	3.3	3.15	8.0	4.9	6.4	5.1	3.4	3.3	2.55	4.3	2.75	2.6
21	3.15	3.3	8.6	5.2	5.9	5.2	3.3	3.1	2.5	4.0	2.65	2.6
22	3.2	3.35	9.2	5.3	5.6	5.2	3.2	2.75	2.5	3.85	2.7	2.6
23	3.05	3.5	10.2	5.1	5.3	5.3	3.1	2.7	2.5	3.6	2.75	2.6
24	3.1	3.35	10.8	4.9	5.1	5.2	3.1	2.7	2.5	3.45	2.7	2.65
25	3.15	3.3	11.1	4.7	4.7	5.0	3.1	2.65	2.3	3.4	2.7	2.3
26	3.25	3.5	11.4	4.5	4.75	4.7	2.8	3.1	2.5	3.35	2.5	2.65
27	3.2	3.4	11.4	4.5	4.7	4.6	2.8	3.1	2.45	3.2	2.5	2.8
28	3.1	3.65	11.0	4.45	4.6	4.55	2.85	3.3	2.4	3.2	2.75	2.6
29	3.2	.....	11.0	4.35	4.6	4.4	3.1	3.3	2.3	3.05	3.15	3.05
30	3.0	.....	10.9	4.1	4.5	4.2	3.1	3.0	2.35	3.05	3.1	4.6
31	3.0	.....	10.7	.....	4.5	.....	2.95	2.85	.....	2.95	.....	3.5

a Gage heights interpolated.

NOTE.—Ice conditions uncertain during January and February. Partial ice conditions during December. Discharge applied as for open channel.

Station rating table for Rock River at Rockton, Ill., from January 1, 1904, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.00	1,350	3.00	2,775	3.90	4,365	4.80	6,180
2.10	1,470	3.10	2,935	4.00	4,555	4.90	6,400
2.20	1,600	3.20	3,105	4.10	4,745	5.00	6,620
2.30	1,740	3.30	3,280	4.20	4,940	5.10	6,840
2.40	1,880	3.40	3,455	4.30	5,140	5.20	7,070
2.50	2,025	3.50	3,635	4.40	5,345	5.30	7,300
2.60	2,170	3.60	3,815	4.50	5,550	5.40	7,540
2.70	2,320	3.70	3,995	4.60	5,760	5.50	7,780
2.80	2,470	3.80	4,180	4.70	5,970	5.60	8,020
2.90	2,620						

The above table is applicable only for open-channel conditions. It is based on 22 discharge measurements made during 1903-5. 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.

Estimated monthly discharge of Rock River at Rockton, Ill., for 1905.

[Drainage area, 6,150 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January[a]	5,655	2,775	3,716	0.604	0.696
February[a]	3,905	2,935	3,250	.528	.550
March	22,520	4,555	12,890	2.10	2.42
April	19,270	4,745	10,050	1.63	1.82
May	12,270	3,455	6,748	1.10	1.27
June	7,540	4,940	6,491	1.06	1.18
July	5,140	2,470	3,916	.637	.734
August	3,280	1,952	2,538	.413	.476
September	4,272	1,740	2,642	.430	.480
October	5,140	1,240	2,411	.392	.452
November	3,020	2,025	2,463	.400	.446
December[a]	5,760	1,740	2,722	.443	.511
The year	22,520	1,240	4,986	.811	11.04

[a] See footnote for gage height table.

ROCK RIVER AT STERLING, ILL.

This station was established January 5, 1905. It is located on the new highway bridge in Sterling, Ill., about one-half mile below the dam of the Sterling Manufacturing Company.

The channel is straight for 1,000 feet above and 2,000 feet below the station. Both banks are high, alluvial, and not liable to overflow. The island between the two channels is partly submerged at very high water, but the road grade does not overflow. The bed of the stream is composed of gravel, is free from vegetation, and is permanent. There are two channels at all stages, each broken by the piers of the bridges. The current is swift.

Discharge measurements are made from the upstream side of the five-span bridge over the right channel and three-span structure over the left channel. The initial points for soundings are the inner faces of the concrete walls at the right ends of the upstream girders of the bridges in each channel.

A standard chain gage, which was read during 1905 by C. A. Staples, is placed on each channel. The length of the chain for the right (north) channel is 31.82 feet from the end of the weight to the outside edge of the ring; that for the left (south) channel is 32.10 feet. The gage in the right channel is referred to four bench marks as follows: (1) Extreme downstream corner of downstream wing of right abutment of bridge over right channel; elevation above gage datum, 20.78 feet. (2) Top of the girder at the gage pulley on the right channel; elevation above gage datum, 31.33 feet. (3) Extreme downstream corner of downstream wing of left abutment of bridge over left channel; elevation, 20.66 feet above gage datum. (4) Top surface of the girder at the gage pulley on the right channel; elevation, 31.11 feet above gage datum. The datum of the gage on the left channel is 0.48 foot below that on the right channel.

Discharge measurements of Rock River (north channel) at Sterling, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 11[a]	Hanna and Clapp	566	2,668	2.65	8.90	7,082
March 24	Hanna and Brennan	602	3,649	3.91	10.71	14,270
April 28	M. S. Brennan	536	1,608	2.74	7.09	4,398
June 16	F. W. Hanna	554	1,792	2.90	7.46	5,206
August 11	do	549	881	1.91	5.80	1,681
September 15	do	550	1,007	2.10	6.05	2,118

[a] One channel blocked with ice.

Daily gage height, in feet, of Rock River (north channel) at Sterling, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.05	7.25	10.7	7.05	6.95	6.85	6.05	5.9	5.7	5.98	5.93
2	.....	7.05	7.25	10.1	6.95	6.95	6.8	6.03	6.0	5.69	5.94	5.98
3	.....	7.05	9.3	9.9	6.9	6.9	6.8	5.84	6.05	5.6	5.92	6.05
4	.....	7.0	10.0	9.6	6.9	6.9	6.75	5.78	6.2	5.53	5.9	6.05
5	.....	7.0	9.8	9.4	6.55	6.9	6.7	5.73	6.3	5.51	5.84	6.1
6	6.5	7.0	9.7	9.1	6.5	8.7	6.7	5.7	6.3	5.49	5.8	6.05
7	6.6	7.0	9.6	9.0	6.3	8.6	6.65	5.76	6.4	5.42	5.77	6.1
8	6.9	6.9	9.3	8.9	6.25	7.8	6.6	5.84	6.5	5.42	5.74	6.1
9	7.1	6.9	9.3	8.7	6.25	7.8	6.65	5.82	6.6	5.4	5.74	6.1
10	7.8	6.9	9.3	8.7	6.4	7.8	6.65	5.8	6.7	5.4	5.73	6.0
11	7.8	6.9	9.2	8.5	9.8	7.9	6.65	5.78	6.65	5.38	5.71	6.0
12	7.1	7.0	8.0	8.3	10.6	7.7	6.65	5.76	6.6	5.36	5.72	5.98
13	7.1	7.0	7.9	8.3	10.4	7.8	6.65	5.84	6.6	5.36	5.7	5.98
14	7.1	7.0	7.9	8.2	10.2	7.7	6.7	5.82	6.6	5.34	5.7	5.98
15	7.1	7.0	7.9	8.1	9.7	7.6	6.75	5.78	6.55	5.3	5.74	5.94
16	7.1	7.0	7.9	7.7	9.7	7.45	6.7	5.77	6.5	5.28	5.7	5.92
17	7.1	7.0	8.5	7.7	9.7	7.7	6.6	5.75	6.4	5.22	5.68	5.81
18	7.1	7.0	9.2	7.6	9.9	7.6	6.55	5.64	6.4	5.18	5.66	5.81
19	6.65	7.05	11.6	7.5	8.9	7.4	6.55	5.45	6.35	5.17	5.68	5.8
20	7.1	7.05	11.6	7.5	8.7	7.45	6.5	5.5	6.3	5.23	5.7	5.78
21	7.1	7.05	9.8	7.5	8.5	7.25	6.35	5.6	6.25	5.3	5.73	5.76
22	7.1	7.05	9.8	7.55	8.0	7.2	6.2	5.67	6.15	6.35	5.74	5.72
23	7.1	7.1	9.8	7.5	7.8	7.2	6.15	5.72	6.0	6.5	5.78	5.72
24	7.1	7.1	10.7	7.5	7.2	7.15	6.15	5.76	5.95	6.5	5.79	5.74
25	7.05	7.1	10.9	7.5	7.1	7.1	6.15	5.78	5.88	6.3	5.82	5.71
26	7.2	7.2	11.0	7.5	7.0	7.0	6.1	5.78	5.86	6.3	5.82	5.72
27	7.2	7.2	11.0	7.5	7.0	6.95	5.99	5.84	5.76	6.3	5.81	5.72
28	7.2	7.2	10.9	7.2	7.05	6.9	5.96	5.48	5.72	6.25	5.8	5.7
29	7.0	.....	10.8	7.1	7.05	6.9	5.97	5.91	5.7	6.15	5.85	5.8
30	7.0	.....	10.7	7.05	7.05	6.85	5.9	5.91	5.68	6.0	5.9	5.82
31	7.0	.....	10.7	.....	6.95	.....	6.1	5.9	.....	6.0	.....	5.8

NOTE.—Channel frozen over January 10 to March 7.

Station rating table for Rock River (north channel) at Sterling, Ill., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.10	560	6.50	3,060	7.90	6,295	9.60	10,930
5.20	710	6.60	3,270	8.00	6,550	9.80	11,530
5.30	860	6.70	3,485	8.10	6,810	10.00	12,140
5.40	1,020	6.80	3,700	8.20	7,070	10.20	12,760
5.50	1,180	6.90	3,920	8.30	7,330	10.40	13,380
5.60	1,340	7.00	4,145	8.40	7,590	10.60	14,000
5.70	1,510	7.10	4,375	8.50	7,850	10.80	14,620
5.80	1,680	7.20	4,605	8.60	8,110	11.00	15,240
5.90	1,860	7.30	4,835	8.70	8,380	11.20	15,860
6.00	2,050	7.40	5,070	8.80	8,650	11.40	16,480
6.10	2,245	7.50	5,310	8.90	8,920	11.60	17,100
6.20	2,445	7.60	5,550	9.00	9,200	11.80	17,720
6.30	2,645	7.70	5,795	9.20	9,760	12.00	18,340
6.40	2,850	7.80	6,045	9.40	10,340		

The above table is applicable only for open-channel conditions. It is based on five discharge measurements made during 1905. It is well defined between gage heights 5.8 feet and 10.7 feet. This station is very accurately rated for 1905.

Discharge measurements of Rock River (south channel) at Sterling, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 11	Hanna and Clapp	286	1,534	2.38	9.13	3,645
March 24	Hanna and Brennan	300	2,186	3.63	10.98	7,934
April 28	M. S. Brennan	290	1,020	2.67	7.28	2,723
June 16	F. W. Hanna	284	1,068	2.89	7.59	3,087
August 11	do	272	589	2.21	5.76	1,300
September 15	do	278	635	2.01	6.04	1,274

Daily gage height, in feet, of Rock River (south channel) at Sterling, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.6	7.25	10.9	7.25	7.05	6.9	6.0	6.0	5.67	5.95	6.0
2	.....	6.6	7.25	10.3	7.1	6.8	6.9	5.98	6.1	5.66	5.9	6.05
3	.....	6.6	9.3	10.1	7.0	6.75	6.9	5.81	6.05	5.58	5.88	6.15
4	.....	6.6	10.0	9.8	7.0	6.8	6.85	5.78	6.2	5.51	5.85	6.15
5	6.4	6.0	10.5	9.6	6.6	6.8	6.8	5.72	6.3	5.49	5.82	6.15
6	6.5	6.0	10.5	9.4	6.5	8.85	6.8	5.7	6.3	5.45	5.78	6.2
7	6.6	6.0	9.0	9.3	6.3	8.6	6.75	5.76	6.4	5.37	5.72	6.2
8	6.4	6.5	9.0	9.3	6.3	7.5	6.75	5.84	6.5	5.35	5.7	6.2
9	6.9	6.45	9.0	9.0	6.3	7.45	6.7	5.82	6.6	5.33	5.72	6.2
10	6.6	6.5	9.0	9.0	6.4	7.45	6.7	5.8	6.7	5.32	5.7	6.1
11	7.1	6.5	9.0	8.8	10.3	7.6	6.7	5.78	6.7	5.32	5.68	6.1
12	7.1	6.3	8.4	8.6	10.9	7.8	6.7	5.72	6.65	5.3	5.7	6.1
13	7.1	6.15	8.4	8.6	10.8	8.0	6.7	5.76	6.65	5.31	5.69	6.1
14	7.15	6.1	8.3	8.5	10.6	7.9	6.75	5.77	6.65	5.3	5.68	6.05
15	7.4	6.9	8.3	8.4	9.9	7.8	6.8	5.74	6.6	5.15	5.7	6.05
16	7.4	6.1	8.2	7.9	9.9	7.7	6.8	5.7	6.55	4.95	5.65	6.0
17	7.4	6.1	8.5	7.9	9.9	7.6	6.7	5.68	6.5	4.88	5.64	5.91
18	7.4	6.1	9.3	7.8	9.5	7.6	6.6	5.59	6.45	4.85	5.6	5.95
19	7.0	6.05	11.8	7.7	9.0	7.6	6.6	5.54	6.4	4.85	5.62	5.9
20	6.75	6.05	11.8	7.6	8.9	7.6	6.5	5.61	6.35	5.19	5.64	5.88
21	6.75	6.05	10.8	7.7	8.6	7.55	6.25	5.7	6.3	5.28	5.65	5.88
22	6.7	6.05	10.6	7.7	8.2	7.4	6.15	5.75	6.2	6.3	5.65	5.84
23	6.8	6.1	10.6	7.7	8.0	7.4	6.15	5.79	6.05	6.5	5.68	5.83
24	6.8	6.1	11.4	7.7	7.55	7.35	6.15	5.82	5.97	6.5	5.7	5.9
25	6.75	6.1	11.2	7.7	7.5	7.25	6.15	5.9	5.9	6.3	5.72	5.89
26	6.8	7.05	11.3	7.7	7.45	7.2	6.1	5.92	5.82	6.3	5.72	5.9
27	6.8	7.2	11.2	7.7	7.4	7.1	5.95	5.98	5.74	6.3	5.72	5.88
28	6.8	7.2	11.2	7.4	7.3	7.05	5.95	6.0	5.7	6.25	5.72	5.86
29	6.6	.....	11.0	7.3	7.3	7.0	5.95	6.0	5.68	6.15	5.94	5.95
30	6.6	.....	10.9	7.25	7.3	6.95	5.85	6.0	5.66	5.98	5.97	5.96
31	6.6	.....	11.0	.....	7.0	.....	6.05	6.0	.....	5.95	.....	5.96

NOTE.—Channel frozen over January 15 to March 7.

Station rating table for Rock River (south channel) at Sterling, Ill., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.00	600	6.50	1,875	8.00	3,600	9.80	6,080
5.10	670	6.60	1,975	8.10	3,730	10.00	6,400
5.20	745	6.70	2,075	8.20	3,860	10.20	6,720
5.30	820	6.80	2,180	8.30	3,990	10.40	7,040
5.40	895	6.90	2,290	8.40	4,120	10.60	7,360
5.50	975	7.00	2,400	8.50	4,250	10.80	7,680
5.60	1,055	7.10	2,510	8.60	4,380	11.00	8,000
5.70	1,140	7.20	2,620	8.70	4,510	11.20	8,320
5.80	1,225	7.30	2,730	8.80	4,640	11.40	8,640
5.90	1,310	7.40	2,850	8.90	4,780	11.60	8,960
6.00	1,400	7.50	2,970	9.00	4,920	11.80	9,280
6.10	1,490	7.60	3,090	9.20	5,200	12.00	9,600
6.20	1,585	7.70	3,210	9.40	5,480	12.20	9,930
6.30	1,680	7.80	3,340	9.60	5,780	12.40	10,270
6.40	1,775	7.90	3,470				

The above table is applicable only for open channel conditions. It is based on five discharge measurements made during 1905. It is well defined between gage heights 5.7 feet and 11 feet. This station is very accurately rated for 1905.

Estimated monthly discharge of Rock River[a] at Sterling, Ill., for 1905.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
March 8-31	26,380	10,155	18,010
April	22,150	6,935	11,570
May	21,840	4,225	10,340
June	13,090	6,048	8,043
July	6,100	3,128	4,892
August	3,548	2,107	2,861
September	5,560	2,582	4,167
October	4,935	1,160	2,614
November	3,367	2,497	2,820
December	3,830	2,786	3,265

[a] North and south channels combined.

NOTE.—No estimate for ice period.

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 12,410 square miles, 4,470 square miles of this being tributary to it above its junction with Cedar River at Columbus Junction. Cedar River drains 7,597 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, and from the standpoint of power development the Iowa River system is important.

IOWA RIVER AT IOWA CITY, IOWA.

This station was established June 1, 1903. It is located on the county bridge, directly west of the university grounds.

The channel is straight for about 1,600 feet above and below the station, is 316 feet wide between abutments, and is broken by one pier. The bed of the stream is of soft material, except near the bridge pier, and is slightly shifting. The right bank is high, somewhat rocky, and is not liable to overflow; the left does not overflow, owing to the road embankment. Both banks are covered with willows above ordinary high-water mark, which interfere with flood measurements. The current is moderately swift.

Discharge measurements are made from the upstream side of the two-span highway bridge at the foot of Burlington street, about 1,000 feet below the bridge at which the gage is located. The bridge is not quite at right angles to the direction of the current. The initial point for soundings is the inner face of the right abutment, at the west end of the bridge, and is marked zero on the bridge floor.

A standard chain gage, which was read during 1905 by Arthur G. Smith, was substituted on September 15, 1903, for the gage installed at the time of the establishment of the station, the length of chain being the same, 24.43 feet. On June 8, 1904, the length of the chain was changed to 26.48 feet, the gage datum remaining the same. The gage is referred to bench marks as follows: (1) Nail driven into base of an elm tree standing 16 feet northwest of bridge on which gage is located; elevation, 18.96 feet above gage datum, 61.01 feet above city datum, and 668.35 feet above sea level. (2) On the top stone just north of and against the northwest railing post of the bridge at which the gage is located; elevation, 22.67 feet above gage datum, 64.72 feet above city datum, and 672.06 feet above sea level. The city bench mark used for reference is on the north side of the base of a maple tree, one block east and one block and 40 feet south of the bridge at which the gage is located; elevation, 22.53 feet above gage datum, 64.58 feet above city datum, and 671.92 feet above sea level. The elevation above sea level was obtained from the levels of the Chicago, Rock Island and Pacific Railway. The bottom of the top handrail just above the pulley center has an elevation of 26.73 feet above gage datum.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 99, pp 24–25; 130, p 59.
Discharge: 99, p 25; 130, p 60.
Discharge: monthly: 99, p 27; 130, p 61.
Gage heights: 99, pp 25–26; 130, p 60.
Rating table: 99, p 26; 130, p 61.

Discharge measurements of Iowa River at Iowa City, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 26	M. S. Brennan	314	2,456	2.59	6.47	6,372
April 20	do	192	895	1.31	.82	1,176
May 22	Hanna and Hoyt	307	2,508	2.78	6.81	6,982
June 21	F. W. Hanna	206	1,239	1.98	2.35	2,458
July 17	Hanna and Clapp	193	1,040	1.53	1.10	1,590
August 8	F. W. Hanna	179	809	1.03	.15	833
September 26	M. S. Brennan	180	737	.88	− .28	646

Daily gage height, in feet, of Iowa River at Iowa City, Iowa, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	0.5	3.25	1.4	4.1	3.6	0.35	−0.35	−0.95	−0.05	0.9
2	.....	.....	.9	2.95	1.35	3.8	2.05	.45	− .4	− .95	− .05	.5
3	.....	.....	1.35	2.8	1.2	3.6	1.8	.45	− .6	− .9	.0	.5
4	.....	− 0.9	3.5	2.5	1.1	3.5	2.65	.15	− .65	− .9	.0	− .2
5	.....	.....	2.7	2.3	.9	3.15	2.9	.2	− .7	−1.0	.1	.0
6	.....	.....	1.9	2.3	.8	2.9	2.8	.25	− .8	− .95	1.0	.5
7	−1.4	.....	1.6	2.25	.65	2.6	2.65	.2	− .8	− .9	1.5	.6
8	.....	.....	1.65	2.25	.5	2.25	2.45	.15	− .75	−1.1	2.05	1.0
9	.....	.....	2.7	2.25	.55	2.15	2.4	.1	− .85	−1.05	1.6	.8
10	.....	.....	4.4	2.1	.85	7.6	2.35	.0	− .85	−1.05	1.5	1.3
11	.....	−1.1	4.4	1.95	4.4	5.4	1.9	− .1	− .8	−1.0	1.4	.5
12	.....	.....	4.9	1.8	6.2	4.7	2.0	− .3	− .8	−1.3	1.4	.8
13	.....	.....	4.4	1.55	6.4	4.8	1.65	− .4	−1.0	−1.05	1.1	.7
14	−1.1	.....	3.2	1.35	6.4	4.0	1.45	− .4	−1.1	− .8	1.1	.6
15	.....	.....	2.45	1.15	7.1	2.6	1.25	.4	− .85	− .75	1.0	.5
16	.....	.....	2.7	2.05	6.8	2.2	1.2	.35	− .95	− .5	.9	.3
17	.....	.....	3.35	.95	6.3	2.05	1.15	.35	− .9	− .2	.8	.0
18	.....	− .9	2.4	.85	6.0	2.3	1.15	.2	− .9	2.05	.8	− .1
19	.....	.....	3.8	.8	6.4	3.05	.9	.0	− .2	1.75	.5	.0
20	.....	.....	6.3	.9	6.6	3.0	1.15	− .2	− .3	1.5	.5	.2
21	−1.2	.....	3.8	2.1	6.8	2.5	2.6	− .35	.1	1.4	.5	− .3
22	.....	.....	4.6	1.6	6.8	2.15	3.0	.0	.5	1.0	.3	− .5
23	.....	.....	5.6	1.85	7.4	2.1	3.15	− .45	.4	.7	.3	.3
24	.....	.....	6.4	1.8	8.0	2.25	2.9	− .2	.05	.6	.6	− .2
25	.....	1.0	6.5	1.8	7.8	2.25	2.15	− .1	− .2	.2	.7	− .7
26	.....	.....	6.4	2.1	7.1	1.95	1.5	− .2	− .25	.1	.8	.1
27	−1.1	− .4	6.1	1.95	6.0	1.55	1.15	.0	− .5	.1	.8	[a] − .2
28	.....	.....	5.1	1.7	5.2	1.35	.95	.5	− .6	.0	1.5	− .3
29	.....	.....	4.8	1.6	5.4	1.2	.85	.4	− .7	− .1	1.0	− .2
30	.....	.....	4.0	1.45	4.8	1.0	.65	.0	− .7	.0	.8	.0
31	.....	.....	3.6	.....	4.4	.....	.5	− .2	.....	.0	.....	.0

[a] Gage height interpolated.

NOTE.—River frozen January 1 to February 28, approximately. Gage heights are to water surface in a hole cut in the ice. The following comparative readings were also made:

Date.	Water surface.	Top of ice.	Thickness of ice.
	Feet.	*Feet.*	*Feet.*
January 7	−1.4	−1.3	0.7
January 14	−1.1	−1.05	.6
January 21	−1.2	−1.2	.8
January 28	−1.1	−1.0	1.2
February 4	− .9	− .7	1.2
February 11	−1.1	−1.0	1.3
February 18	− .9	− .7	1.2

Partial ice conditions during December.

Station rating table for Iowa River at Iowa City, Iowa, from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−1.50	230	0.30	916	2.20	2,190	7.00	7,150
−1.40	252	0.40	971	2.40	2,350	7.50	7,820
−1.30	276	0.50	1,028	2.60	2,520	8.00	8,540
−1.20	302	0.60	1,087	2.80	2,700	8.50	9,290
−1.10	330	0.70	1,148	3.00	2,890	9.00	10,040
−1.00	360	0.80	1,210	3.20	3,080	9.50	10,800
−0.90	392	0.90	1,274	3.40	3,270	10.00	11,600
−0.80	426	1.00	1,340	3.60	3,460	10.50	12,400
−0.70	462	1.10	1,410	3.80	3,650	11.00	13,220
−0.60	499	1.20	1,480	4.00	3,840	11.50	14,070
−0.50	538	1.30	1,550	4.20	4,030	12.00	14,920
−0.40	579	1.40	1,620	4.40	4,220	12.50	15,770
−0.30	622	1.50	1,690	4.60	4,410	13.00	16,640
−0.20	666	1.60	1,760	4.80	4,600	13.50	17,540
−0.10	712	1.70	1,830	5.00	4,800	14.00	18,440
0.00	760	1.80	1,900	5.50	5,350		
0.10	810	1.90	1,970	6.00	5,900		
0.20	862	2.00	2,040	6.50	6,500		

The above table is applicable only for open-channel conditions. It is based on 25 discharge measurements made during 1903–1905. It is well defined between gage heights −1.5 feet and +2.4 feet. The table has been extended beyond these limits, being based on three measurements near 7 feet and one near 14 feet gage height.

Estimated monthly discharge of Iowa River at Iowa City, Iowa, for 1905.

[Drainage area, 3,317 square miles.]

Month.	Discharge in second-feet			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	6,500	1,028	3,695	1.11	1.28
April	3,128	1,210	1,973	.595	.664
May	8,540	1,028	4,710	1.42	1.64
June	7,960	1,340	2,916	.879	.981
July	3,460	1,028	2,013	.607	.700
August	1,028	558	793	.239	.276
September	1,028	330	532	.160	.178
October	2,078	276	743	.224	.258
November	2,078	538	1,229	.371	.414
December	1,550	462	902	.272	.314

NOTE.—No estimate for January and February. Discharge for December applied as for open channel.

CEDAR RIVER AT CEDAR RAPIDS, IOWA.

Cedar River, called also, in part of its course, Red Cedar River, rises in the southwestern part of Dodge County, Minn., flows southeastward across eastern Iowa to the northern part of Muscatine County, then turns abruptly to the southwest, and joins Iowa River in northern Louisa County.

The gaging 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 channel is straight for 800 feet above and below the station, is regular in cross section, and is about 400 feet wide. The right bank is high and will overflow at extreme stages only; the left is an earth embankment and will seldom overflow. At the First Avenue Bridge the channel is straight both above and below for several hundred feet, and is divided into five parts by the five-span Pratt truss bridge, its length between abutments being 714 feet. The banks are high and not liable to overflow. The bed of the stream is of rock and gravel and is permanent. The current is strong and direct.

Discharge measurements were originally made from a cable and car at a point just above the gage. At low stages the discharge at the cable station can be measured by wading. Since 1903 discharge measurements have been made from the upstream side of the First Avenue Bridge, about one-half mile upstream from the gage. The initial point for soundings is the inner upstream face of the left abutment. For the purpose of comparing soundings, the distance of the water surface below the top surface of the downstream hand rail at a point 1 foot west of the nineteenth hand rail post from the left abutment is measured.

The gage, which was read during 1905 by R. S. Toogood, consists of an inclined timber, graduated to read to vertical tenths and half-tenths feet. It is fastened to the right bank by posts set in the ground. The gage is referred to bench marks as follows: (1) A city bench mark at Williams & Hunting's office, on the north corner of Fifth avenue and West First street, marked by a triangle on the stone just north of the first iron post from the corner of the building; elevation above sea level, as determined by the city of Cedar Rapids from the level of the Northwestern Railway, 746.6 feet; elevation above gage datum, 23.57 feet. (2) Bolt driven into masonry foundation of east face of Iowa Windmill and Pump Company's building, on west bank of river, just north of Seventh avenue; elevation above sea level, 740.05 feet; elevation above gage datum, 17.02 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 99, pp 21-22; 130, p 62.
Discharge: 99, p 22; 130, p 63.
Discharge, monthly: 99, p 24; 130, p 64.
Gage heights: 99, p 23; 130, p 63.
Rating table: 99, p 23; 130, p 64.

Discharge measurements of Cedar River at Cedar Rapids, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 25	M. S. Brennan	643	3,775	3.94	7.09	14,860
April 27	do	595	1,395	2.04	3.95	2,845
May 23	Hanna and Hoyt	621	2,778	3.54	5.80	9,820
June 22	F. W. Hanna	632	2,656	3.32	5.58	8,806
July 18	Hanna and Clapp	599	1,596	2.18	4.05	3,473
August 9	F. W. Hanna	568	1,127	1.49	3.45	1,680
September 25	M. S. Brennan	566	1,086	1.28	3.31	1,393

Daily gage height, in feet, of Cedar River at Cedar Rapids, Iowa, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	3.45	3.55	4.9	3.75	5.1	4.05	3.65	3.45	3.25	3.3	3.2
2	3.0	3.5	3.55	4.7	3.7	5.6	4.35	3.65	3.4	3.2	3.3	3.15
3	3.4	3.6	3.55	4.65	3.75	5.5	4.6	3.55	3.35	3.2	3.3	3.0
4	3.2	3.45	3.6	4.55	3.7	5.2	4.7	3.7	3.35	3.15	3.3	2.9
5	3.25	3.45	4.05	4.45	3.65	4.9	4.8	3.6	3.3	3.15	3.4	2.9
6	3.3	3.5	3.95	4.45	3.6	4.65	5.0	3.7	3.3	3.15	3.65	3.0
7	3.3	3.55	4.2	4.5	3.55	4.45	5.4	3.6	3.25	3.15	3.9	3.2
8	3.2	3.55	4.85	4.5	3.5	4.3	5.4	3.5	3.25	3.1	3.8	3.55
9	3.1	3.6	5.3	4.4	3.55	4.3	5.3	3.45	3.25	3.1	3.7	3.7
10	3.3	3.55	6.2	4.35	3.6	4.3	5.1	3.4	3.25	3.05	3.65	3.65
11	3.4	3.5	7.0	4.3	4.6	4.2	4.9	3.4	3.2	3.05	3.65	3.5
12	3.3	3.5	6.8	4.2	5.2	4.05	4.8	3.4	3.2	3.1	3.6	3.35
13	3.35	3.55	6.3	4.1	5.0	4.5	4.7	3.35	3.2	3.1	3.6	3.35
14	3.3	3.55	5.7	4.0	5.4	4.4	4.4	3.4	3.25	3.1	3.55	3.3
15	3.25	3.6	5.4	3.9	5.7	4.5	4.3	3.45	3.25	3.1	3.55	3.25
16	3.4	3.55	5.15	3.9	6.1	4.55	4.2	3.6	3.25	3.25	3.5	3.2
17	3.3	3.6	5.4	3.85	6.3	4.8	4.1	3.6	3.25	3.4	3.5	3.15
18	3.35	3.7	5.8	3.8	7.0	4.7	4.05	3.6	3.25	3.4	3.45	3.2
19	3.4	3.75	6.4	3.85	7.8	5.1	3.95	3.5	3.35	3.65	3.45	3.25
20	3.45	3.8	6.7	3.8	7.9	5.2	4.65	3.5	3.65	3.55	3.4	3.2
21	3.4	3.75	7.4	3.95	7.1	5.5	4.7	3.4	3.65	3.55	3.4	3.2
22	3.45	3.7	8.3	4.05	6.4	5.6	4.4	3.3	3.5	3.55	3.4	3.3
23	3.4	3.65	9.0	4.0	5.8	5.8	4.2	3.35	3.45	3.55	3.35	3.35
24	3.35	3.65	8.2	4.0	5.4	5.7	4.05	3.3	3.4	3.55	3.35	3.3
25	3.3	3.6	7.0	3.95	5.1	5.4	3.9	3.35	3.3	3.55	3.4	3.3
26	3.3	3.6	6.4	3.95	4.9	4.8	3.8	3.6	3.3	3.5	3.45	3.25
27	3.35	3.6	6.0	3.95	4.7	4.5	3.75	3.7	3.25	3.45	3.45	3.2
28	3.4	3.55	5.8	3.9	4.65	4.3	3.7	3.65	3.3	3.4	3.65	3.25
29	3.4	.....	5.6	3.85	4.65	4.15	3.75	3.55	3.25	3.4	3.85	3.2
30	3.45	.....	5.4	3.8	4.6	4.15	3.7	3.5	3.25	3.35	3.6	3.2
31	3.45	.....	5.1	.....	4.8	.....	3.65	3.45	.....	3.3	.....	3.1

NOTE.—River frozen part way across January 1 to March 9, inclusive, also December 1-31.

Station rating table for Cedar River at Cedar Rapids, Iowa, from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	880	4.20	3,820	5.40	8,190	7.20	15,330
3.10	1,050	4.30	4,150	5.50	8,570	7.40	16,150
3.20	1,230	4.40	4,490	5.60	8,950	7.60	16,970
3.30	1,425	4.50	4,840	5.70	9,340	7.80	17,790
3.40	1,635	4.60	5,190	5.80	9,730	8.00	18,610
3.50	1,855	4.70	5,550	5.90	10,120	8.20	19,450
3.60	2,090	4.80	5,920	6.00	10,510	8.40	20,290
3.70	2,335	4.90	6,290	6.20	11,310	8.60	21,130
3.80	2,595	5.00	6,670	6.40	12,110	8.80	21,970
3.90	2,875	5.10	7,050	6.60	12,910	9.00	22,810
4.00	3,170	5.20	7,430	6.80	13,710	9.20	23,670
4.10	3,490	5.30	7,810	7.00	14,510	9.40	24,530

The above table is applicable only for open-channel conditions It is based on 26 discharge measurements made during 1902–1905. It is well defined between gage heights 3 feet and 7.2 feet.

Estimated monthly discharge of Cedar River at Cedar Rapids, Iowa, for 1905.

[Drainage area, 6,317 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 10-31	22,810	7,050	12,210	1.93	1.58
April	6,290	2,595	3,702	.586	.654
May	18,200	1,855	7,030	1.11	1.28
June	9,730	3,330	6,002	.950	1.06
July	8,190	2,212	4,585	.726	.837
August	2,335	1,425	1,819	.288	.332
September	2,212	1,230	1,479	.234	.261
October	2,212	965	1,453	.230	.265
November	2,875	1,425	1,908	.302	.337

NOTE.—No estimate for ice period.

RED CEDAR RIVER AT JANESVILLE, IOWA.

This station was established April 26, 1905. It is located on the Illinois Central Railroad bridge at Janesville, Iowa, about one-fourth mile below the highway bridge.

The channel is straight for 1,000 feet above and below the station. Both banks are high, clean, and not subject to overflow. The bed of the stream is composed of gravel and is permanent. The current is swift. Two old piers, which have been torn down, may cause some inaccuracy in measurements at very low water, but there are several good sections near by where measurements can be made by wading.

Discharge measurements are made from the upstream side of the two-span highway bridge to which the gage is attached. The initial point for soundings is the inner upstream face of the left abutment.

A standard chain gage, which was read once each day during 1905 by J. E. Davis, is fastened to the upstream side of the left span of the bridge, 150 feet from the left abutment. The length of the chain from the end of the weight to the last copper link is 25.77 feet. The gage is referred to bench marks as follows: (1) A cross on the east end of the northeast coping of the east abutment; elevation above gage datum, 24.30 feet. (2) Center of the gage pulley; elevation above zero of gage, 25.57 feet.

Discharge measurements of Red Cedar River at Janesville, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 26	M. S. Brennan	150	210	2.49	1.14	522
May 24	Hanna and Hoyt	178	419	2.94	2.35	1,230
June 22	F. W. Hanna	219	1,033	3.25	5.50	3,358
July 19	Hanna and Clapp	183	529	3.36	3.00	1,775
September 23	M. S. Brennan	153	199	2.00	1.02	397
October 29	do	155	203	1.91	1.03	388

Daily gage height, in feet, of Red Cedar River at Janesville, Iowa, for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.0	2.6	2.3	1.2	1.1	1.0	0.9	2.7
2	.....	1.0	2.5	2.6	1.3	1.1	1.0	.9	3.3
3	.....	1.0	2.2	2.3	1.3	1.1	1.0	.9	3.3
4	.....	1.0	2.0	3.5	1.2	1.1	1.0	.9	3.3
5	.....	1.0	1.8	3.9	1.2	1.1	1.0	1.0	3.3
6	.....	1.0	1.7	3.9	1.2	1.0	.9	1.1	3.2
7	.....	1.0	1.6	3.9	1.1	1.0	.9	1.1	3.1
8	.....	.9	1.5	3.6	1.1	1.0	.9	1.0	2.8
9	.....	.9	1.5	3.9	1.1	1.0	.9	1.1	2.7
10	.....	1.1	1.4	3.4	1.1	1.0	1.0	1.1	2.5
11	.....	2.3	1.8	2.9	1.1	1.0	.9	1.1	2.3
12	.....	4.2	3.1	2.5	1.1	1.0	.9	1.1	2.1
13	.....	2.4	3.9	2.4	1.1	1.0	.9	1.1	1.9
14	.....	2.4	3.7	2.1	1.4	1.0	.9	1.1	1.7
15	.....	3.9	3.9	2.0	1.4	1.0	1.0	1.1	1.7
16	.....	5.6	2.8	2.0	1.3	1.0	.9	1.0	1.7
17	.....	7.6	2.6	1.8	1.2	1.1	1.1	1.0	1.7
18	.....	6.5	3.4	1.6	1.2	1.1	1.2	1.0	1.7
19	.....	4.9	5.3	3.2	1.1	1.2	1.1	1.0	1.7
20	.....	4.0	6.3	2.0	1.1	1.2	1.1	1.0	1.5
21	.....	3.4	6.7	1.6	1.1	1.2	1.2	1.0	1.5
22	.....	2.9	6.2	1.5	1.1	1.1	1.2	1.0	.....
23	.....	2.6	4.7	1.5	1.0	1.1	1.2	.9	.....
24	.....	2.3	3.5	1.4	1.2	1.1	1.2	1.0	.....
25	.....	2.2	2.8	1.3	1.7	1.0	1.2	1.1	.....
26	.....	2.0	2.4	1.3	1.3	1.0	1.1	1.1	.....
27	1.1	1.9	2.1	1.3	1.3	1.0	1.1	1.0	.....
28	1.1	1.8	1.9	1.3	1.3	1.0	1.1	1.2	.....
29	1.1	2.4	1.8	1.3	1.3	1.0	1.0	1.3	.....
30	1.0	2.3	1.8	1.2	1.3	1.0	1.0	1.0	.....
31	.....	2.9	.....	1.2	1.2	.....	.9	.....	.....

NOTE.—River frozen entirely across during December.

Station rating table for Red Cedar River at Janesville, Iowa, from April 26 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	180	1.90	935	3.30	1,880	5.40	3,420
0.60	210	2.00	1,000	3.40	1,950	5.60	3,570
0.70	245	2.10	1,065	3.50	2,020	5.80	3,720
0.80	285	2.20	1,130	3.60	2,090	6.00	3,870
0.90	330	2.30	1,195	3.70	2,160	6.20	4,030
1.00	380	2.40	1,260	3.80	2,230	6.40	4,190
1.10	435	2.50	1,325	3.90	2,300	6.60	4,350
1.20	495	2.60	1,390	4.00	2,370	6.80	4,510
1.30	555	2.70	1,460	4.20	2,520	7.00	4,670
1.40	615	2.80	1,530	4.40	2,670	7.20	4,830
1.50	675	2.90	1,600	4.60	2,820	7.40	4,990
1.60	740	3.00	1,670	4.80	2,970	7.60	5,150
1.70	805	3.10	1,740	5.00	3,120	7.80	5,310
1.80	870	3.20	1,810	5.20	3,270	8.00	5,470

The above table is applicable only for open-channel conditions. It is based on six discharge measurements made during 1905. It is fairly well defined between gage heights 1 foot and 3 feet. The table has been extended beyond these limits. Below 1 foot and above 4 feet the table is very uncertain.

Estimated monthly discharge of Red Cedar River at Janesville, Iowa, for 1905.

[Drainage area, 1,840 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
May	5,150	330	1,434	0.779	0.898
June	4,430	615	1,694	.921	1.03
July	2,300	495	1,199	.652	.752
August	805	380	503	.273	.315
September	495	380	410	.223	.249
October	495	330	397	.216	.249
November	555	330	402	.218	.243

NOTE.—No estimate for ice period.

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 14,720 square miles. Above the mouth of the Raccoon its drainage area is 6,462 miles, while that of the Raccoon at its confluence with the Des Moines is 3,677 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. It is located at the "Swede Town" bridge, the only highway bridge in Fort Dodge.

The channel is straight for 1,000 feet above and below the station. Both banks are fairly high, clean, and do not overflow. The bed of the stream is composed of sand, gravel, and mud, is free from vegetation, and is permanent. The current is fairly swift.

Discharge measurements are made from the downstream side of the two-span bridge to which the gage is fastened. The initial point for soundings is the downstream inner face of the right abutment.

A standard chain gage, which was read during 1905 by Andrew J. Moe, is attached to the floor of the downstream footway of the bridge. The length of the chain from the end of the weight to the last copper link is 35.72 feet. The gage is referred to bench marks as follows: (1) A painted line on the west abutment; elevation, 9.11 feet. (2) Floor of the bridge at the initial point for soundings; elevation, 35.54 feet. (3) Center of pulley of gage; elevation, 35.54 feet. All elevations are above datum of gage.

Discharge measurements of Des Moines River at Fort Dodge, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 22	M. S. Brennan	266	948	2.00	4.10	1,895
May 24	Hoyt and Hanna	276	1,462	3.00	5.81	4,388
June 29	F. W. Hanna	250	727	1.59	3.40	1,147
July 19	Hanna and Clapp	276	1,277	2.89	5.36	3,692
August 7	F. W. Hanna	260	830	1.86	3.80	1,545
September 23	M. S. Brennan	255	754	1.64	3.48	1,238

Daily gage height, in feet, of Des Moines River at Fort Dodge, Iowa, for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.1	6.6	3.95	4.05	3.3	3.9	3.05	3.7
2	.....	3.0	6.7	4.3	4.35	3.1	3.7	3.0	4.05
3	.....	2.9	6.4	4.55	4.1	2.9	3.5	2.95	4.0
4	.....	2.9	6.2	4.55	4.0	2.85	3.4	2.95	3.9
5	.....	2.8	5.9	4.7	3.9	2.7	3.3	3.1	3.9
6	.....	2.9	5.8	4.9	3.8	2.7	3.25	3.4	3.9
7	.....	2.8	5.5	5.0	3.8	2.6	3.2	3.9	3.9
8	.....	2.9	5.2	5.1	3.75	2.55	3.05	4.15	3.95
9	.....	2.9	4.9	5.45	3.7	2.55	3.0	4.25	3.95
10	.....	3.4	4.65	5.75	3.6	2.5	3.05	4.3	4.0
11	.....	3.8	4.55	6.0	3.45	2.45	2.95	4.4	3.9
12	.....	4.9	4.5	6.2	3.3	2.5	2.85	4.4	3.85
13	.....	4.9	4.35	6.2	3.2	2.4	2.85	4.35	3.95
14	.....	5.7	4.1	6.1	3.2	2.4	2.9	4.3	3.9
15	.....	6.0	4.0	6.0	3.15	2.4	3.15	4.25	4.8
16	.....	6.6	3.8	5.8	3.1	2.4	3.1	4.1	.....
17	.....	7.0	3.6	5.65	3.05	2.5	3.15	4.0	.....
18	.....	7.0	3.5	5.55	3.05	2.4	3.2	3.9	.....
19	.....	6.9	3.6	5.45	3.0	2.5	3.3	3.8	.....
20	.....	6.8	4.0	5.3	[a]3.0	2.6	3.4	3.7	.....
21	.....	6.8	4.2	5.2	3.0	2.8	3.5	3.6	.....
22	.....	6.6	4.2	5.1	2.95	3.05	3.6	3.5	.....
23	4.0	6.2	3.9	5.0	2.9	3.5	3.6	3.45	.....
24	3.8	5.9	3.8	4.85	3.75	4.05	3.6	3.7	.....
25	3.5	5.7	3.55	4.75	3.5	4.45	3.6	3.85	.....
26	3.5	5.45	3.5	4.7	3.5	4.9	3.6	4.0	.....
27	3.5	5.3	3.35	4.6	3.35	5.0	3.5	4.15	.....
28	3.4	5.2	3.3	4.5	3.3	4.85	3.35	4.35	.....
29	3.3	6.2	3.5	4.4	3.3	4.6	3.3	4.45	.....
30	3.2	6.3	3.7	4.3	3.4	4.2	[a]3.2	3.85	.....
31	.....	6.3	.....	4.25	3.5	.....	3.1	.....	.....

[a] Gage heights interpolated.

Station rating table for Des Moines River at Fort Dodge, Iowa, from April 23 to December 31, 1905.

Gage height.	Discharge.	Gage height	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.40	430	3.50	1,255	4.60	2,545	5.70	4,225
2.50	490	3.60	1,350	4.70	2,690	5.80	4,380
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

The above table is applicable only for open channel conditions. It is based on six discharge measurements made during 1905. It is well defined between gage heights 3.4 feet and 5.8 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Des Moines River at Fort Dodge, Iowa, for 1905.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
April 23–30	1,780	985	1,289
May	6,460	685	3,428
June	5,890	1,070	2,553
July	5,010	1,722	3,321
August	2,205	755	1,237
September	3,140	430	1,066
October	1,665	720	1,081
November	2,338	792	1,642
December 1–15	2,835	1,450	1,763

DES MOINES RIVER AT DES MOINES, IOWA.

This station was established May 24, 1905. It is located at the Interurban Bridge at Des Moines, Iowa, near the suburb of Highland Park.

The channel is straight for 500 feet above and below the station. Both banks are fairly high, wooded, and overflow during floods. The bed of the stream is composed of sand and silt and is slightly shifting. There is but one channel at all stages, broken by the piers of the bridge, all the water passing between the abutments. The current is moderately swift.

Discharge measurements are made from the downstream side of the three-span bridge, with trestle at both ends, to which the gage is attached. The initial point for soundings is the inner face of the left trestle abutment.

A standard chain gage, which was read during 1905 by Frank Peterson, is fastened to the binding tie of the downstream side of the bridge. The length of the chain from the end of the weight to the marker is 30.30 feet. August 8 a new chain gage was installed. It was located in the same place as the old gage. The chain length was increased to 30.70 feet, the gage datum remaining the same. The gage is referred to bench marks as follows: (1) Top surface of south side of tubular pier at left end of bridge; elevation above gage datum, 24.44 feet. (2) The rail base opposite the gage pulley; elevation above gage datum, 29.74 feet.

Discharge measurements of Des Moines River at Des Moines, Iowa, in 1905

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
May 26	F. W. Hanna	278	2,275	2.48	8.50	5,653
June 29	do	262	1,905	2.22	7.40	4,227
July 20	Hanna and Clapp	283	2,238	2.32	8.30	5,201
August 8	F. W. Hanna	204	1,704	1.20	6.50	2,048
September 22	M. S. Brennan	279	1,393	.76	5.57	1,064

Daily gage height, in feet, of Des Moines River at Des Moines, Iowa, for 1905.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	9.6	7.2	6.7	6.0	6.7	6.0	7.7
2	.....	10.15	7.4	6.5	5.95	6.7	5.9	7.7
3	.....	9.85	7.45	7.25	5.95	6.25	5.9	7.2
4	.....	9.75	7.3	7.1	6.0	6.2	5.9	6.9
5	.....	9.45	7.4	6.75	5.9	6.0	6.0	7.0
6	.....	9.15	7.25	6.6	5.7	6.0	6.1	7.3
7	.....	9.05	7.3	6.5	5.6	5.95	6.0	7.5
8	.....	8.8	7.9	6.4	5.6	5.8	6.4	8.3
9	.....	8.35	7.95	6.4	5.5	5.7	6.7	8.7
10	.....	9.5	7.7	6.3	5.5	5.7	6.8	8.5
11	.....	8.25	7.9	6.15	5.4	5.7	6.8	8.3
12	.....	7.5	8.0	6.15	5.3	5.65	6.9	8.1
13	.....	7.3	8.1	6.0	5.3	5.65	7.0	8.1
14	.....	7.2	9.5	5.95	5.2	5.7	7.0	8.0
15	.....	6.85	8.9	5.95	5.2	5.9	6.9	7.7
16	.....	6.7	8.95	5.9	5.2	6.0	6.9	.....
17	.....	6.7	8.7	6.1	5.3	6.4	6.8	.....
18	.....	6.5	8.9	6.1	5.4	6.4	6.75	.....
19	.....	6.4	8.7	6.0	6.0	6.4	6.7	.....
20	.....	6.3	8.1	5.9	6.0	6.35	6.5	.....
21	.....	6.4	7.9	5.9	5.8	6.4	6.4	.....
22	.....	6.6	7.65	6.0	5.5	6.5	6.35	.....
23	.....	6.7	7.3	5.95	5.7	6.4	6.4	.....
24	.....	6.4	7.25	6.0	5.95	6.4	6.7	.....
25	.....	6.3	7.1	6.2	6.0	6.3	6.7	.....
26	.....	6.25	7.15	6.15	6.2	6.4	6.8	.....
27	8.15	6.15	7.1	6.1	6.25	6.2	6.9	.....
28	8.15	6.0	7.05	6.05	6.4	6.2	6.9	.....
29	8.1	9.6	6.9	6.1	7.1	6.4	7.0	.....
30	8.6	7.05	6.9	6.05	6.9	6.2	7.4	.....
31	9.6	.....	6.85	6.0	.....	5.9	.....	.....

NOTE.—Ice conditions during December.

Station rating table for Des Moines River at Des Moines, Iowa, from May 27 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.00	510	6.20	1,810	7.40	3,710	8.50	5,650
5.10	595	6.30	1,950	7.50	3,880	8.60	5,830
5.20	685	6.40	2,095	7.60	4,050	8.70	6,020
5.30	780	6.50	2,245	7.70	4,220	8.80	6,210
5.40	880	6.60	2,400	7.80	4,390	8.90	6,400
5.50	980	6.70	2,555	7.90	4,570	9.00	6,590
5.60	1,085	6.80	2,715	8.00	4,750	9.20	6,970
5.70	1,195	6.90	2,875	8.10	4,930	9.40	7,350
5.80	1,310	7.00	3,040	8.20	5,110	9.60	7,730
5.90	1,430	7.10	3,205	8.30	5,290	9.80	8,110
6.00	1,555	7.20	3,370	8.40	5,470	10.00	8,500
6.10	1,680	7.30	3,540				

The above table is applicable only for open-channel conditions. It is based on five discharge measurements made during 1905. It is not well defined. The channel here is shifting and later measurements may plot on a different curve. This table is not very satisfactory, as the three lower measurements are not consistent.

Estimated monthly discharge of Des Moines River at Des Moines, Iowa, for 1905.

[Drainage area, 6,462 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
May 27–31	7,730	4,930	5,706	0.883	0.164
June	8,800	1,555	4,340	.672	.750
July	7,540	2,795	4,313	.667	.769
August	3,455	1,430	1,885	.292	.337
September	3,205	685	1,350	.209	.233
October	2,555	1,140	1,761	.273	.315
November 1–29	3,040	1,430	2,486	.385	.415

NOTE.—No estimate for ice period.

DES MOINES RIVER AT KEOSAUQUA, IOWA.

This station was established May 30, 1903. It is located on the county bridge one-fourth mile above the old dam site and Government locks.

The channel is straight for 1,000 feet above and below the station and has a width between abutments of 614 feet, broken by three bridge piers. The right bank is high and rocky and is not subject to overflow; the low alluvial bank on the left side is subject to overflow at extremely high stages. The bed of the stream is regular in shape and is composed of sand and gravel on the left and of rock on the right side. A slight shifting of the sand occurs at flood stages. The current is swift. The stream is divided into four channels by the bridge piers.

Discharge measurements are made from the downstream side of the bridge, to which the gage is attached. The initial point for soundings is the edge of the west abutment and is marked zero on the hand rail at the left bank.

The standard chain gage, which was read during 1905 by Oscar McCrary, is so located that the zero of its scale is 1 foot to the left of the sixth strut from the right end of the second span from the right end of the bridge. The length of the chain from the end of the weight to the marker is 36.80 feet. The gage is referred to bench marks as follows: (1) A cross on the bridge-seat stone at the northeast corner of the right abutment of the bridge; elevation above gage datum, 30.11 feet; above sea level, as determined from the Iowa Geological Survey bench mark in front of the Keosauqua railroad station, 617.06 feet. (2) A spike driven into a blazed place near the base of an oak tree on the north side of the road about 100 feet from the bridge; elevation above sea level, 619.83 feet; above gage datum, 32.88 feet. (3) Notch chiseled into a rock cliff on the right bank of the river south of the road leading across the highway bridge at a distance of 120 feet from the east end of the bridge; elevation above gage datum, 36.25 feet. (4) On the top of the guard rail, 2 feet east of the zero of the gage; elevation above gage datum, 36.80 feet.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 99, p 29; 130, pp 65–66.
Discharge: 99, p 29; 130, p 36.
Discharge, monthly: 99, p 31; 130, p 37.
Gage heights: 99, p 30; 130, p 36.
Rating table: 99, p 30; 130, p 37.

Discharge measurements of Des Moines River at Keosauqua, Iowa, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
March 27	M. S. Brennan	590	3,494	2.79	4.91	9,760
June 28	F. W. Hanna	580	2,034	1.82	2.20	3,695
July 21	S. K. Clapp	588	4,500	3.49	6.42	15,710
September 21	M. S. Brennan	588	3,259	2.95	4.30	9,618
October 26	do	577	2,415	2.10	2.60	5,076

Daily gage height, in feet, of Des Moines River at Keosauqua, Iowa, for 1905.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	9.4	4.05	4.0	4.25	9.4	2.6	1.88	2.15	2.15	2.75
2	.....	.....	8.2	3.7	3.4	4.6	9.4	[a]2.9	1.72	2.2	2.1	2.5
3	.....	.....	8.3	3.7	3.05	5.1	7.4	[a]3.2	1.68	2.18	2.02	1.9
4	.....	0.8	7.2	3.7	2.9	5.5	7.3	3.5	1.62	2.05	1.98	1.85
5	.....	.....	6.8	3.5	2.7	5.25	5.1	3.2	1.55	1.95	1.98	1.75
6	.....	.....	6.6	3.35	2.45	4.9	4.35	2.85	1.48	1.8	3.05	1.38
7	0.8	.....	6.0	3.5	2.35	4.6	4.35	2.6	1.42	1.65	4.8	1.52
8	.....	.....	5.8	3.7	2.25	4.2	4.0	2.3	1.4	1.55	5.05	1.8
9	.....	.....	5.5	3.75	2.2	4.0	4.3	2.1	1.4	1.48	4.45	1.95
10	.....	.....	5.1	3.8	2.72	22.8	4.6	1.98	1.38	1.55	3.85	2.1
11	.....	.8	4.6	3.6	4.75	14.4	4.5	1.88	1.32	1.4	3.2	2.35
12	.....	.....	4.15	3.35	7.0	10.6	4.7	1.8	1.3	1.35	2.95	2.1
13	.....	.....	3.9	3.2	7.6	8.05	4.4	1.72	1.22	1.4	2.9	2.4
14	.8	.....	3.6	2.9	8.4	5.6	3.9	1.7	1.2	1.48	2.88	2.4
15	.....	.....	3.2	2.75	8.6	4.6	4.5	6.3	1.4	1.78	2.85	2.2
16	.....	.....	2.9	2.55	8.4	3.95	6.2	4.9	1.88	1.62	2.78	2.08
17	.....	.....	2.8	2.45	8.5	3.6	6.5	3.2	2.4	3.75	2.7	1.95
18	.....	.9	2.95	2.35	8.0	3.35	4.6	3.5	2.75	7.35	2.62	2.05
19	.....	.....	4.0	2.22	7.6	3.2	4.1	3.65	3.65	7.6	2.55	2.0
20	.....	.....	5.4	2.45	7.6	3.65	6.1	2.68	4.6	6.6	2.5	2.0
21	.7	.....	5.7	6.2	7.7	3.2	6.4	2.25	4.35	5.5	2.4	1.95
22	.....	.....	5.8	5.65	7.3	3.05	5.0	2.5	3.75	4.5	2.3	1.8
23	.....	.....	5.9	4.1	6.7	2.9	4.35	4.1	3.1	3.8	2.15	1.78
24	.....	.....	6.4	4.7	6.1	2.75	3.65	6.0	2.38	3.0	2.3	1.65
25	.....	4.2	6.6	4.1	5.6	2.65	3.3	8.2	1.9	2.7	3.45	1.55
26	.....	4.4	5.2	4.75	5.2	2.45	3.05	5.0	1.68	2.62	3.2	1.68
27	.....	4.4	4.9	6.3	4.75	2.28	2.9	3.35	1.62	2.52	3.3	1.6
28	.8	4.7	4.8	5.9	4.35	2.18	2.8	2.7	1.62	2.42	3.3	1.75
29	.....	.....	5.2	5.7	4.15	2.52	2.8	2.42	1.75	2.32	3.2	1.8
30	.....	.....	4.8	5.05	4.25	4.85	2.8	2.4	2.0	2.28	3.1	1.68
31	.....	.....	4.35	.....	4.4	.....	2.72	2.2	.....	2.18	.....	1.6

[a] Gage heights interpolated.

NOTE.—River frozen over January 1 to February 25. Water rose flush with surface of ice at each reading. Thickness of ice, 0.4 foot January 1; 1 foot January 21, and 1.3 feet February 4. There were slight ice conditions during December, but not sufficient to modify the flow appreciably.

Station rating table for Des Moines River at Keosauqua, Iowa, from January 1 to December 31 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	300	2.00	3,305	3.50	7,200	5.80	13,890
0.60	450	2.10	3,545	3.60	7,470	6.00	14,550
0.70	610	2.20	3,790	3.70	7,740	6.20	15,210
0.80	780	2.30	4,035	3.80	8,010	6.40	15,870
0.90	960	2.40	4,285	3.90	8,280	6.60	16,530
1.00	1,150	2.50	4,540	4.00	8,550	6.80	17,210
1.10	1,350	2.60	4,795	4.20	9,090	7.00	17,890
1.20	1,550	2.70	5,055	4.40	9,650	7.50	19,590
1.30	1,755	2.80	5,320	4.60	10,220	8.00	21,290
1.40	1,965	2.90	5,585	4.80	10,800	8.50	23,010
1.50	2,180	3.00	5,850	5.00	11,400	9.00	24,790
1.60	2,395	3.10	6,120	5.20	12,000	9.50	26,590
1.70	2,615	3.20	6,390	5.40	12,620	10.00	28,390
1.80	2,840	3.30	6,660	5.60	13,250	11.00	32,090
1.90	3,070	3.40	6,930				

The above table is applicable only for open-channel conditions. It is based on 19 discharge measurements made during 1903–1905. It is fairly well defined between gage heights 0.8 foot and 6.4 feet. The table has been extended beyond these limits. Above 11 feet the discharge is estimated, being based on 1 measurement at 15.7 feet.

Estimated monthly discharge of Des Moines River at Keosauqua, Iowa, for 1905.

[Drainage area, 14,290 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	26,230	5,320	12,750	0.892	1.03
April	15,540	3,839	8,398	.588	.656
May	23,360	3,790	12,840	.898	1.04
June	75,750	3,741	12,790	.895	.999
July	26,230	5,108	11,160	.781	.900
August	21,970	2,615	6,609	.462	.533
September	10,220	1,550	3,542	.248	.277
October	19,930	1,860	5,607	.392	.452
November	11,550	3,258	5,724	.401	.447
December	5,188	1,923	3,165	.221	.255

See gage-height table footnote.

MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in the Des Moines River basin in 1904.

Miscellaneous discharge measurements in Des Moines River basin in 1904.

Date.	Stream.	Locality.	Width.	Area of section.	Mean velocity.	Discharge.
			Feet.	*Square feet.*	*Feet per second.*	*Second-feet.*
May 28	Des Moines	Des Moines	384	2,014	2.41	4,852
June 6	do	Fort Dodge	307	1,142	2.39	2,729
Nov. 13	do	Des Moines	168	176	.42	74
Nov. 14	Raccoon	do	115	146	1.36	199

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 29,013 square miles is distributed among three States; 24,726 square miles are in Illinois, and extend 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. From the upper extremity of this band are two projections—one north into Wisconsin, comprising 1,080 square miles in that State; the other east into Indiana, including 3,207 square miles of its northern portion.

The eastern projection is the basin of Kankakee River, while the northern one forms the basins of Fox and Desplaines 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 Desplaines.

The region drained by the Illinois is level and undulating and includes some of the finest land in the United States. Many large and prosperous cities are situated within it, and it is covered with a network of railroads.

The drainage into the Illinois is 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. It is located on the Peoria and Pekin Union Railroad bridge over the Illinois River, 1½ miles southwest of Peoria. It can be reached by street cars.

The channel is straight for 3,000 feet above and 2,000 feet below the station, and has a width of about 1,000 feet, broken by six piers. A railroad embankment runs along the right bank, which is high. The left bank is low and liable to overflow. The bed of the stream is composed of gravel and silt. The section is deep and the flow sluggish.

Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the face of the abutment on the right bank.

The gage, which was read during 1905 by Peter A. Blumb, is a plain staff fastened to the central pier of the bridge. The bench mark is the southwest corner of the top stone of the west abutment of the bridge; elevation, 125.722 feet below the Chicago datum. The gage at this point has for its zero a point 153.814 feet below the Chicago city datum. The gage reads up from this point, and in order to obtain the height of the river, referred to the Chicago datum, it is necessary to subtract the gage reading from 153.814 feet.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann=Annual Report; WS=Water-Supply Paper):

Description: Ann 21, iv, p 176; WS 83, p 172; 98, pp 199-200; 128, p 39.
Discharge: Ann 21, iv, p 176; WS 98, p 200; 128, p 39.
Discharge, monthly: WS 98, p 202.
Gage heights: WS 98, pp 200-201; 128, p 40.
Rating table: WS 98, p 201.

Discharge measurements of Illinois River near Peoria, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 5	M. S. Brennan	950	12,190	1.60	13.70	19,450
May 11	S. K. Clapp	953	11,570	1.85	13.00	21,450
June 28	M. S. Brennan	941	10,690	1.44	12.25	15,410
July 31	do	893	7,143	1.15	8.50	8,242
September 31	do	909	7,896	1.16	9.28	9,137
October 30	do	890	7,059	1.11	8.26	7,835

Daily gage height, in feet, of Illinois River near Peoria, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.75	9.33	12.5	14.0	13.9	14.7	11.6	8.46	8.08	8.42	8.17	7.92
2	8.75	9.33	13.0	14.0	13.9	14.6	11.55	8.46	8.17	8.33	8.17	7.92
3	8.75	9.33	13.5	14.0	13.8	14.4	11.35	8.38	8.25	8.25	8.08	8.08
4	8.79	9.33	14.2	13.8	13.7	14.2	11.0	8.42	8.79	8.38	8.08	8.08
5	8.88	9.33	14.5	13.8	13.6	13.9	10.95	8.42	9.12	8.33	8.0	8.08
6	8.92	9.33	14.8	13.7	13.6	14.4	10.4	8.42	9.38	8.12	8.0	8.08
7	8.92	9.33	14.9	13.6	13.4	14.0	10.85	8.42	9.6	7.96	8.08	8.08
8	9.08	9.33	15.0	13.5	13.2	13.9	10.75	8.29	9.8	7.88	8.08	8.2
9	9.08	9.42	15.0	13.3	13.1	13.6	10.75	8.25	9.85	7.8	8.17	8.33
10	9.0	9.5	14.9	13.1	13.0	14.0	10.65	8.17	9.85	7.92	8.17	8.33
11	9.17	9.5	14.7	13.2	12.8	14.0	10.6	8.04	9.85	7.84	8.05	8.33
12	9.17	.....	14.5	13.1	13.0	14.0	10.45	8.0	9.8	7.75	8.0	8.33
13	9.17	.....	14.3	12.9	13.2	14.0	10.4	8.0	9.85	7.62	8.12	8.33
14	9.17	.....	14.0	13.8	14.0	14.1	10.35	8.17	9.6	7.58	8.05	8.33
15	9.17	.....	13.9	13.7	15.1	14.1	10.2	8.29	9.6	7.42	8.0	8.3
16	9.17	.....	13.6	13.5	16.2	14.0	10.1	8.33	9.55	7.55	8.0	8.25
17	9.17	.....	13.4	13.3	16.8	13.8	9.9	8.25	9.6	7.67	8.42	8.17
18	9.17	9.5	13.3	13.1	17.2	13.6	9.9	8.17	9.42	7.96	8.42	8.08
19	9.17	9.42	13.3	13.1	17.4	13.7	9.75	8.33	9.21	8.0	7.95	8.08
20	9.21	9.42	13.4	12.8	17.4	13.6	9.65	8.33	9.25	7.96	7.8	8.17
21	9.29	9.6	13.5	13.0	17.0	13.5	9.5	8.42	9.25	7.92	7.67	8.33
22	9.33	9.7	13.5	13.2	16.3	13.4	9.29	8.42	9.25	7.8	7.67	8.33
23	9.33	9.75	13.5	13.3	16.5	13.2	9.21	8.42	9.29	7.92	7.45	8.33
24	9.33	9.9	13.6	13.7	16.2	13.0	9.04	8.42	9.21	8.17	7.3	8.33
25	9.42	10.35	13.5	13.0	15.9	12.8	8.92	8.17	9.04	8.25	7.33	8.33
26	9.38	10.95	13.7	13.3	15.7	12.7	8.83	8.29	8.83	8.17	7.3	8.2
27	9.25	11.45	13.8	13.5	15.5	12.5	8.71	8.17	8.75	8.2	7.5	8.17
28	9.25	11.9	13.8	13.7	16.2	12.3	8.62	8.17	8.67	8.3	7.67	8.38
29	9.25	.....	14.0	13.7	15.1	12.1	8.58	8.08	8.58	8.25	7.55	8.55
30	9.25	.....	14.0	13.8	15.0	11.9	8.42	8.12	8.5	8.2	7.8	8.67
31	9.33	.....	14.0	.....	14.9	.....	8.5	8.17	.....	8.17	.....	8.75

NOTE.—Ice conditions January 1 to March 31. Thickness of ice, 0.5 to 1 foot.

Station rating table for Illinois River near Peoria, Ill., from January 1, 1904, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
7.40	6,990	9.90	10,210	12.30	15,470	14.70	22,930
7.50	7,080	10.00	10,390	12.40	15,730	14.80	23,310
7.60	7,175	10.10	10,570	12.50	16,000	14.90	23,700
7.70	7,270	10.20	10,760	12.60	16,270	15.00	24,090
7.80	7,370	10.30	10,950	12.70	16,540	15.10	24,510
7.90	7,470	10.40	11,140	12.80	16,820	15.20	24,940
8.00	7,575	10.50	11,340	12.90	17,110	15.30	25,370
8.10	7,680	10.60	11,540	13.00	17,400	15.40	25,810
8.20	7,790	10.70	11,750	13.10	17,690	15.50	26,260
8.30	7,900	10.80	11,960	13.20	17,990	15.60	26,710
8.40	8,020	10.90	12,170	13.30	18,290	15.70	27,170
8.50	8,140	11.00	12,390	13.40	18,590	15.80	27,640
8.60	8,265	11.10	12,610	13.50	18,900	15.90	28,120
8.70	8,390	11.20	12,830	13.60	19,210	16.00	28,600
8.80	8,520	11.30	13,050	13.70	19,520	16.20	29,560
8.90	8,650	11.40	13,280	13.80	19,840	16.40	30,530
9.00	8.790	11.50	13,510	13.90	20,160	16.60	31,510
9.10	8,930	11.60	13,740	14.00	20,480	16.80	32,500
9.20	9,080	11.70	13,980	14.10	20,810	17.00	33,500
9.30	9,230	11.80	14,220	14.20	21,150	17.20	34,500
9.40	9,390	11.90	14,460	14.30	21,490	17.40	35,500
9.50	9,550	12.00	14,700	14.40	21,840	17.60	36,500
9.60	9,710	12.10	14,950	14.50	22,200	17.80	37,500
9.70	9,870	12.20	15,210	14.60	22,560	18.00	38,500
9.80	10,040						

The above table is applicable only for open-channel conditions. It is based on 27 discharge measurements made during 1903–1905. It is fairly well defined between gage heights 8.3 feet and 16 feet.

Estimated monthly discharge of Illinois River near Peoria, Ill., for 1904.

[Drainage area, 13,250 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1904.					
March 21–31	57,650	37,650	51,330	3.87	1.58
April	54,950	26,440	39,000	2.94	3.28
May	28,410	13,910	19,310	1.46	1.68
June	13,910	7,713	11,000	.830	.926
July	8,572	7,118	7,789	.588	.678
August	8,092	7,008	7,577	.572	.660
September	9,614	6,860	7,531	.568	.634
October	9,822	7,491	8,508	.642	.740
November	7,450	7,156	7,333	.553	.617
December 1-12	7,400	7,080	7,186	.542	.242
1905.					
April	20,480	16,820	18,760	1.42	1.58
May	35,500	16,820	24,580	1.86	2.14
June	22,930	14,460	19,320	1.46	1.63
July	13,740	8,044	10,490	.792	.913
August	8,092	7,575	7,875	.594	.685
September	10,125	7,659	9,134	.689	.769
October	8,044	7,008	7,587	.573	.661
November	8,044	6,900	7,473	.564	.629
December	8,355	7,491	7,851	.593	.684

NOTE.—No estimate for ice period.

DESPLAINES RIVER NEAR CHANNAHON, ILL.

This station was established October 23, 1902. It is located just above the mouth of Jackson Creek, 2½ miles southwest of Millsdale and 2 miles east of Channahon, Ill.

The channel is straight for about 3,000 feet both above and below the station, and has a width of 360 feet and a maximum depth of 16 feet at ordinary stages. Both banks are low and liable to overflow, but a few feet from the top of the banks are high ridges which never overflow. The bed of the stream is composed of gravel. The current is moderately swift.

Discharge measurements at this station were discontinued April 14, 1904.

The gage, which was read during 1905 by Ruth Alexander, is a vertical staff. The bench mark is the top of the red-oak hub driven in the bluff between Jackson Creek and the south bank of Desplaines River, about 300 feet west of the west line of sec. 15, T. 37 N., R. 9 E., third principal meridian, and is on the farm owned by George Alexander; its elevation is 64.26 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 83, pp 174, 175; 98, pp 212, 213–214; 128, pp 40–41.
Discharge: 98, pp 212, 214; 128, p 41.
Discharge, monthly: 128, p 43.
Gage heights: 98, pp 213, 214–215; 128, p 42.
Rating table: 128, p 43.

Daily gage height,[a] in feet, of Desplaines River near Channahon, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	82.74	80.8	78.5	82.52	82.92	83.72	83.5	82.95	83.15	83.42	83.75	83.15
2	82.85	80.3	79.7	82.58	82.95	83.7	83.55	83.1	82.05	83.32	83.9	83.15
3	83.18	79.8	.....	82.25	83.08	83.65	83.45	83.15	82.9	83.42	83.85	83.35
4	83.05	80.0	82.2	82.82	83.15	82.4	83.4	83.22	82.4	83.3	83.88	83.2
5	82.89	80.1	82.6	82.8	83.3	82.52	83.3	83.4	82.5	83.35	83.8	83.35
6	82.88	80.2	82.5	82.85	83.32	82.98	83.45	83.5	82.52	83.3	83.1	83.28
7	83.1	.....	82.68	82.7	83.58	83.1	.....	83.3	.....	83.3	83.1	83.4
8	83.35	82.1	82.72	82.92	83.48	83.3	83.42	83.3	82.7	83.3	83.2	83.28
9	82.92	.....	82.7	82.98	83.6	83.45	83.82	83.0	82.95	83.3	83.68	83.22
10	82.92	79.3	82.85	82.98	83.4	82.65	83.85	83.3	83.08	83.2	83.78	83.4
11	82.78	.....	82.75	83.48	82.3	81.8	83.88	83.35	83.02	83.3	83.88	83.35
12	82.48	.....	82.76	84.85	78.6	82.58	83.85	83.3	83.1	83.4	83.9	83.32
13	82.48	.....	82.88	84.2	78.5	82.88	83.9	83.2	83.05	83.42	83.85	83.38
14	82.2	.....	82.7	83.65	79.2	83.05	83.3	83.2	83.2	83.35	83.85	83.35
15	81.2	.....	82.95	83.6	79.5	82.12	83.8	83.25	83.2	83.42	84.08	83.45
16	80.5	79.8	82.88	83.6	80.0	83.18	83.3	83.25	83.15	83.3	84.38	83.38
17	80.8	.....	82.6	83.62	80.4	83.25	83.38	83.35	83.15	83.5	84.35	83.38
18	81.15	.....	82.38	83.6	81.3	83.12	83.55	83.25	83.15	.....	84.35	83.28
19	81.6	79.75	82.05	83.55	82.18	83.1	83.4	83.12	83.2	83.25	83.8	83.4
20	81.95	.....	82.08	83.6	82.5	83.18	83.25	83.22	83.15	83.15	84.35	.....
21	82.5	.....	82.18	81.6	83.0	83.25	83.55	83.18	83.2	83.05	84.58	83.25
22	82.68	.....	82.12	82.4	82.92	83.25	83.50	83.12	83.3	82.98	84.6	83.6
23	82.75	79.9	82.02	82.65	83.32	83.22	83.48	82.95	83.2	83.22	84.6	83.6
24	82.85	.....	81.75	82.62	83.5	.....	83.65	82.98	83.22	82.88	84.4	83.6
25	81.45	.....	81.95	82.78	83.6	83.5	83.55	83.12	83.2	82.88	84.4	83.42
26	80.6	.....	82.0	82.8	83.6	83.28	83.3	83.2	83.32	83.05	84.1	83.5
27	80.4	80.2	82.05	82.55	83.72	83.35	83.35	83.18	83.1	83.3	83.5	83.5
28	80.4	.....	82.28	82.75	83.75	83.58	83.25	83.18	83.25	83.55	83.1	83.35
29	81.15	.....	82.28	82.82	83.68	83.78	83.0	83.1	83.38	83.08	83.4	83.5
30	81.05	.....	82.32	83.0	83.3	83.52	83.08	83.15	83.35	83.18	83.25	83.52
31	81.05	.....	82.5	.....	83.62	.....	82.88	83.15	.....	83.8	.....	83.48

[a] All gage heights of this station are negative, being below Chicago datum.

NOTE.—River frozen half over February 7–28. Gage heights are to water surface in a hole in the ice.

KANKAKEE RIVER AT DAVIS, IND.

This station was established July 13, 1905. It is located at the railroad bridge at Davis, 8 miles west of Hamlet, Ind.

The channel is straight for about 500 feet above and below the station. The right bank consists of grass and farm lands and the left is low and wooded; both banks are subject to overflow during high stages. The bed of the stream is sandy and slightly shifting. All the water passes to the left of the right abutment of the bridge. A portion of the flood water passes through another trestle about 500 feet to the left of the main channel. The velocity is medium at ordinary stages. The section is well adapted for measurements.

Discharge measurements are made from the railway bridge, which is supported by several trestle bents. The initial point for soundings is the inner face of the left pile bent of the structure.

A vertical staff gage, which was read during 1905 by M. H. Fancher, is fastened to the upstream side of one of the pile bents of the bridge. It is referred to bench marks as follows: (1) The rail base at sounding point No. 6; elevation, 16.67 feet above zero of gage. (2) Top of the 12-inch cap directly over the gage; elevation above gage datum, 13.71 feet. (3) Horizontal line of five nails in a telegraph pole about 7 feet north of point 150 feet from initial point for soundings; elevation above datum of gage, 11.95 feet.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
August 22	M. S. Brennan	72	241	0.88	4.55	213
October 3	do	74	238	1.33	4.70	317

Daily gage height, in feet, of Kankakee River at Davis, Ind., for 1905.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.9	4.7	4.6	4.8	5.8	17	6.6	4.7	5.7	4.6	5.0	.....
2	.....	4.9	6.4	4.6	4.9	5.7	18	5.8	4.6	5.6	4.8	5.0	.....
3	.....	4.9	7.3	4.6	4.9	5.5	19	5.4	4.6	5.4	4.9	5.0	.....
4	.....	4.8	7.8	4.6	4.8	.....	20	5.2	4.8	5.3	5.0	5.0	.....
5	.....	4.6	7.9	4.6	4.9	.....	21	5.0	4.7	5.2	5.0	5.0	.....
6	.....	5.5	7.8	4.6	4.9	.....	22	4.9	4.9	5.1	5.0	5.0	.....
7	.....	5.2	7.2	4.6	5.5	.....	23	4.8	4.6	5.0	5.0	4.9	.....
8	.....	4.9	6.5	4.6	5.5	.....	24	4.7	4.6	4.9	4.9	4.9	.....
9	.....	4.6	6.0	4.6	5.4	.....	25	4.7	4.9	4.9	4.9	5.0	.....
10	.....	4.6	5.9	4.7	5.3	.....	26	4.7	5.0	4.8	4.8	5.0	.....
11	.....	4.6	5.7	4.7	5.2	.....	27	4.7	5.0	4.7	4.8	5.0	.....
12	.....	4.6	5.6	4.7	5.1	.....	28	4.8	4.8	4.7	4.8	5.1	.....
13	.....	4.8	5.5	4.6	5.1	.....	29	5.7	4.8	4.7	4.8	5.2	.....
14	7.5	4.6	5.4	4.5	5.0	.....	30	5.5	4.7	4.6	4.7	5.9	.....
15	7.6	4.6	5.2	4.5	5.0	.....	31	5.2	4.6	.....	4.6	.....	.....
16	7.3	4.8	5.3	4.5	5.0	.....							

KANKAKEE RIVER AT MOMENCE, ILL.

This station was established February 22, 1905. It is located on the highway bridge in Momence, Ill., about one-half mile below the Chicago and Eastern Illinois Railway bridge.

The channel is straight for 700 feet above and below the station. Both banks are high, rocky, and do not overflow. The bed of the stream is composed of solid limestone rock, is free from vegetation, and is permanent. The river at this station is divided by an island, which begins about a mile above the bridge and terminates about 500 feet below. There are two channels at all stages, broken by the piers of the bridge. The left channel, in which most of the water flows, is admirably adapted to measurements at low water; the right channel is wide, with a rougher bed, which may affect the accuracy of measurements made at any stages of water above the ordinary. The current is swift. There are no dams or falls in the vicinity.

Discharge measurements are made from the five-span bridge to which the gage is attached. Two spans of the bridge are over the south and three spans over the north channel. The initial point for soundings in the south channel is 1 foot to the left of the inner face of the left abutment; that for the north channel is 1 foot to the left of the inner face of the left abutment.

A standard chain gage, which was read during 1905 by J. L. Clark, is attached to the downstream side of the second span from the left bank. The length of the chain from the end of the weight to the marker (end of copper chain) is 17.66 feet. The gage is referred to bench marks as follows: (1) Top of the city hydrant one block south of the highway bridge; elevation, 12.40 feet. (2) Northeast corner of north abutment of the south bridge; elevation, 13.93 feet. (3) Momence city bench mark, on the water tablet located

on the northwest corner of the Central House; elevation, 14.62 feet. All elevations are above datum of gage, which is 5.38 feet above Momence city datum. The city datum is 607.06 feet above mean sea level.

Discharge measurements of Kankakee River at Momence, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
February 22	F. W. Hanna	481	261	1.40	2.90	[a] 365
March 13	S. K. Clapp	482	941	2.91	2.78	2,737
May 11	M. S. Brennan	492	1,197	3.32	3.35	3,974
May 15	F. W. Hanna	406	1,513	3.55	3.95	5,370
June 25	M. S. Brennan	485	845	2.45	2.65	2,072
July 29	do	463	577	1.98	2.18	1,140
August 26	do	442	450	1.52	1.96	685
September 12	do	459	598	1.97	2.19	1,179
October 6	do	431	414	1.43	1.78	598

[a] Ice measurement.

Daily gage height, in feet, of Kankakee River at Momence, Ill., for 1905.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.8	3.15	2.9	3.5	2.55	2.05	1.8	1.92	1.8	2.05
2	.....	3.9	3.15	2.9	3.35	2.5	2.05	2.7	1.9	1.8	2.05
3	.....	3.8	3.1	2.9	3.2	2.5	2.0	3.05	1.9	1.8	2.15
4	.....	3.6	3.1	3.0	3.25	2.45	2.0	2.85	1.85	1.8	2.1
5	.....	3.8	3.05	3.0	3.25	2.4	2.0	2.6	1.82	1.82	2.25
6	.....	3.9	3.05	3.0	3.05	2.4	2.0	2.42	1.8	1.92	2.05
7	.....	4.5	3.0	2.95	2.9	2.32	1.98	2.32	1.75	1.95	2.0
8	.....	2.6	2.9	2.9	2.8	2.3	1.95	2.22	1.75	1.95	2.1
9	.....	2.7	2.9	2.9	2.7	2.38	1.95	2.2	1.7	1.95	2.3
10	.....	2.7	2.85	2.85	2.8	2.42	1.9	2.2	1.75	1.95	2.3
11	.....	2.8	2.85	3.4	3.3	2.5	1.9	2.2	1.75	1.95	2.0
12	.....	2.8	2.8	4.5	3.25	2.48	1.82	2.2	1.72	1.95	2.3
13	.....	2.8	2.75	4.4	3.1	2.4	1.9	2.2	1.7	[a] 1.95	2.35
14	.....	2.8	2.7	4.2	3.0	2.32	2.0	2.2	1.7	1.95	2.1
15	.....	2.8	2.7	[a] 4.0	2.8	2.25	2.08	2.2	1.7	1.95	1.95
16	.....	2.8	2.6	3.85	2.7	2.2	2.05	2.2	1.7	1.95	2.05
17	.....	2.9	2.55	3.95	2.6	2.13	2.0	2.25	1.7	1.98	.....
18	.....	3.0	2.5	3.95	3.0	2.12	1.95	2.25	1.72	2.0	.....
19	.....	3.05	2.5	3.85	3.0	2.15	1.95	2.22	1.78	2.0	.....
20	.....	3.05	2.65	3.8	2.8	2.18	2.0	2.2	1.8	2.0	.....
21	.....	3.0	3.15	3.7	2.75	2.2	1.95	2.2	1.75	2.0	.....
22	.....	2.9	3.2	3.6	2.75	2.2	1.95	2.15	1.78	1.95	.....
23	.....	2.9	3.1	3.55	2.7	2.2	1.9	2.1	1.8	1.95	.....
24	2.95	3.15	3.0	3.5	2.7	2.2	1.9	2.1	1.8	1.95	.....
25	3.1	3.2	2.9	3.45	2.65	2.2	1.9	2.02	1.8	1.95	.....
26	3.7	3.2	2.9	3.7	2.65	2.2	1.88	2.0	1.8	1.95	.....
27	3.8	3.1	3.0	3.75	2.7	2.2	1.8	2.0	1.8	1.95	.....
28	3.6	3.05	3.0	3.6	2.7	2.2	1.8	1.95	1.8	2.0	.....
29	.....	3.1	3.0	3.5	2.6	2.2	1.75	1.95	1.8	2.05	.....
30	.....	3.1	3.0	3.6	2.6	2.2	1.75	1.9	1.8	2.05	.....
31	.....	3.1	.....	3.55	.....	2.12	1.78	.....	1.8	.....	.....

[a] Gage height interpolated.

NOTE.—No ice record for this station.

Station rating table for Kankakee River at Momence, Ill., from February 24 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.60	310	2.40	1,590	3.20	3,460	3.90	5,300
1.70	410	2.50	1,810	3.30	3,710	4.00	5,570
1.80	520	2.60	2,030	3.40	3,970	4.10	5,840
1.90	650	2.70	2,260	3.50	4,230	4.20	6,120
2.00	810	2.80	2,490	3.60	4,490	4.30	6,400
2.10	980	2.90	2,730	3.70	4,760	4.40	6,680
2.20	1,170	3.00	2,970	3.80	5,030	4.50	6,960
2.30	1,380	3.10	3,210				

The above table is applicable only for open-channel conditions. It is based on eight discharge measurements made during 1905. It is fairly 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.

Estimated monthly discharge of Kankakee River at Momence, Ill., for 1905.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
February 24–28	5,030	2,850	4,068
March	6,960	2,060	3,392
April	3,460	1,810	2,744
May	6,960	2,610	4,281
June	4,230	2,030	2,753
July	1,920	1,018	1,368
August	946	465	710
September	3,090	650	1,262
October	682	410	500
November	895	520	721
December 1–16	1,485	730	1,053

YELLOW RIVER AT KNOX, IND.

This station was established August 21, 1905. It is located on the North Heaton Street Highway Bridge, 100 rods north of the New York, Chicago and St. Louis Railroad.

The channel is straight for about 200 feet above and 300 feet below the station. Both banks are high and wooded and are liable to overflow at extremely high stages. At time of floods part of the water will pass through a small masonry arch about 100 feet to the right of the right abutment. The bed of the stream is composed of sand and is slightly shifting. The current is fairly swift.

Discharge measurements are made from the single-span highway bridge, downstream side. The initial point for soundings is the downstream inner face of the left abutment.

A standard chain gage, which was read during 1905 by William B. Shaw, is located on the floor of the bridge, downstream side. The length of the chain from the end of the weight to the marker is 19.62 feet. The gage is referred to bench marks as follows: (1) West end of top surface of north abutment; elevation, 15.20 feet. (2) Nails in trunk of double birch tree 60 feet west of west hand rail; elevation, 8.10 feet. (3) Top of west wing wall of south abutment; elevation, 14.50 feet. Bench marks Nos. 1 and 3 are painted red on the surface of the stones. Elevations are above gage datum.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
August 21	M. S. Brennan	91	98	1.45	2.02	142
October 3	do	94	96	1.57	2.03	151

Daily gage height, in feet, of Yellow River at Knox, Ind., for 1905.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.9	2.0	2.1	3.3	17	.....	2.6	1.4	2.2	.....
2	.....	2.5	2.0	2.0	3.5	18	.....	2.7	1.8	2.2	.....
3	.....	2.9	1.9	2.0	3.5	19	.....	2.7	2.0	2.2	.....
4	.....	3.0	1.9	2.1	3.5	20	.....	2.9	2.4	2.2	.....
5	.....	3.0	1.7	2.2	3.5	21	1.2	2.1	2.5	2.1	.....
6	.....	3.0	1.6	2.3	3.4	22	1.2	2.1	2.6	2.1	.....
7	.....	2.9	1.6	2.5	3.4	23	1.1	2.9	2.6	2.1	.....
8	.....	2.7	1.6	2.6	3.4	24	1.1	2.9	2.5	2.2	.....
9	.....	2.4	1.7	2.7	3.3	25	1.0	2.7	2.4	2.2	.....
10	.....	2.4	1.7	2.9	3.1	26	1.0	2.4	2.3	2.3	.....
11	.....	2.4	1.6	2.9	3.0	27	.....	2.3	2.3	2.4	.....
12	.....	2.3	1.6	2.9	2.8	28	1.3	2.1	2.3	2.6	.....
13	.....	2.3	1.5	2.7	2.6	29	1.4	2.0	2.2	2.7	.....
14	.....	2.0	1.4	2.5	2.6	30	1.7	2.0	2.2	3.0	.....
15	.....	2.0	1.4	2.4	2.5	31	1.9	.....	2.2	.....	.....
16	.....	2.4	1.4	2.3	2.6						

FOX RIVER AT SHERIDAN, ILL.

This station was established in September, 1905, by F. W. Hanna. It is located at the Glen Park highway bridge at Sheridan, Ill.

The channel is straight for about 1,000 feet above and 1,500 feet below the station. The current is medium. The right bank is high and rocky, sparsely wooded, and does not overflow. The left bank is low, sparsely wooded, and overflows during high stages, the water passing over the road. The bed of the stream is clean and permanent. There is but one channel, broken by the piers of the bridge. Depth of water at ordinary stage, 5 feet.

Discharge measurements are made from the upstream side of the two-span steel highway bridge, which has a total length of 206 feet. There is also a timber trestle approach, 52 feet long, on the left bank. The initial point for soundings is the inner face of the right abutment, at the top, on the upstream side. Measurements should be good up to the stage at which the river overflows the left bank. Flood measurements may be taken from the railroad bridge 50 rods downstream.

A standard chain gage is fastened to the guard rail of the bridge on the downstream side; length of chain, 28.09 feet. During 1905 the gage was read once each day by Robert H. Campbell. Bench marks were established as follows: (1) A red-paint mark and the letters "U. S. B. M." on top of the clyindrical abutment pier supporting the end of the first span of the bridge at the left bank; elevation, 23.05 feet. (2) Point of the top of a flat rock on the right bank, 29.3 feet west of the initial point for soundings; elevation, 31.70 feet. Elevations refer to the gage datum.

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

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
September 19	Hanna and Brennan	199	1,020	1.08	4.05	1,097
October 31	M. S. Brennan	199	1,005	1.07	4.12	1,079

Daily gage height, in feet, of Fox River at Sheridan, Ill., for 1905.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1		3.65	4.0	3.95	17		3.5	3.85	
2		3.55	3.9	3.9	18		3.75	3.9	
3		3.6	3.85		19		4.1	3.9	
4		3.55	3.85		20	4.05	4.35	3.8	3.65
5		3.55	3.9		21	3.95	4.25	3.95	
6		3.45	3.85	4.1	22	3.9	4.25	3.9	
7		3.45	4.1		23	3.95	4.3	3.9	
8		3.4	4.05		24	3.85	4.25	[a]3.85	
9		3.3	4.0		25	3.75	4.45	3.8	
10		3.5	3.95		26	3.7	4.4	3.65	
11		3.6	3.9		27	3.8	4.35	3.45	3.7
12		3.5	3.9		28	3.75	4.3	4.05	
13		3.45	3.75	3.5	29	3.7	4.2	4.2	
14		3.45	4.0		30	3.7	4.05	4.15	
15		3.4	3.95		31		4.15		
16		3.4	3.95						

[a] Gage height interpolated.

NOTE.—River frozen December 3–31. Gage heights are to water surface in a hole in the ice.

SANGAMON RIVER AT DECATUR, ILL.

This station was established April 29, 1905. It is located at the "Cowford" Bridge on East Cantrell street, Decatur, Ill.

The channel is straight for 500 feet above and 1,000 feet below the station. Both banks are low, covered with some brush and willows, and subject to overflow, but all the water passes between the abutments of the bridge, as the roadway is high. The bed of the stream is composed of clay and rocks, is free from vegetation, and is permanent. The current is sluggish. About one-fourth mile below the bridge is a fordway, and several miles below the station is a small dam, used to impound water for the city water supply.

Discharge measurements are made from the downstream side of the single-span steel bridge to which the gage is attached. Low-water gagings are best made by wading at the ford, one-fourth mile below the bridge. The initial point for soundings is the face of the left abutment, downstream side, marked with a circle on the guard rail and post of the bridge.

A standard chain gage, read by Miss Hattie Devore, is fastened to the floor of the bridge, downstream side. The length of the chain from the end of the weight to the end of the chain proper is 28.01 feet. The gage is referred to bench marks as follows: (1) Top of bottom chord of truss of bridge opposite the weight of the gage, downstream side; elevation, 26.84 feet above datum of gage. (2) Top of the downstream corner of the right abutment at the bridge seat.

This station was discontinued September 10, 1905.

Discharge measurements of Sangamon River at Decatur, Ill., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 29	S. K. Clapp	128	973	0.81	10.12	788
May 18	do	120	812	.68	8.82	555

Daily gage height, in feet, of Sangamon River at Decatur, Ill., for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May	June.	July.	Aug.	Sept.
1	.....	9.8	7.7	6.2	6.0	5.8	17	.....	9.6	7.4	7.9	6.0	.....
2	.....	9.2	7.5	6.3	6.1	5.9	18	.....	8.8	7.2	7.5	5.9	.....
3	.....	8.9	7.4	6.3	6.2	6.6	19	.....	8.5	7.0	7.3	5.9	.....
4	.....	8.5	7.2	6.8	6.1	6.2	20	.....	8.2	6.7	7.0	5.8	.....
5	.....	8.5	6.9	6.9	6.2	6.0	21	.....	7.9	6.6	7.2	5.8	.....
6	.....	9.0	6.8	8.1	6.1	5.9	22	.....	7.7	6.7	6.8	5.9	.....
7	.....	9.4	6.7	8.2	6.0	5.8	23	.....	7.4	6.6	6.7	5.9	.....
8	.....	9.2	6.8	8.3	6.0	5.8	24	.....	7.4	6.5	6.5	6.0	.....
9	.....	8.9	6.7	8.0	6.0	5.8	25	.....	7.1	6.7	6.4	5.9	.....
10	.....	8.7	6.5	8.9	5.9	5.9	26	.....	7.2	6.6	6.3	5.8	.....
11	.....	8.3	6.8	9.4	5.8	.....	27	.....	7.0	6.4	6.2	6.0	.....
12	.....	8.2	7.3	9.8	6.0	.....	28	.....	7.0	6.5	6.4	5.9	.....
13	.....	8.8	8.4	9.4	6.0	.....	29	10.1	7.1	6.3	6.2	5.8	.....
14	.....	9.8	8.7	9.5	6.0	.....	30	10.0	7.6	6.3	6.3	5.9	.....
15	.....	10.6	8.0	9.0	6.0	.....	31	.....	7.9	.....	6.1	5.8	.....
16	.....	10.7	7.8	8.4	6.0	.....							

INDEX.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 171.]

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 may be had on application.

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

1. A limited number are delivered to the Director of the Survey, from whom they may 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 may 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 may 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.

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. 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, Nos. 165, 166, 167, 168, 169, 170, and 171.
West of Mississippi River, Nos. 171, 172, 173, 174, 175, 176, 177, and 178.

The Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which hydrographic and reclamation work in the respective localities is carried on and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., 876 Federal Building; Belle Fourche, S. Dak.; Cody, Wyo.; Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1108 Union Trust Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Huntley, Mont.; Hazen, Nev.; Boise, Idaho; North Yakima, Wash.; Portland, Oreg., 351 Washington street.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

MAY, 1906.

O