Report of the water resources investigation of Minnesota, 1909-1910 [1911-1912] By State drainage commission [in cooperation with U.S. Geological survey]

Minnesota.
St. Paul, McGill-Warner co., 1910-12.

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REPORT

OF THE

WATER RESOURCES INVESTIGATION

OF MINNESOTA

1911-1912

BY
STATE DRAINAGE COMMISSION

1912
McGill-Warner Co.
Saint Paul

REPORT

OF THE

WATER RESOURCES INVESTIGATION

OF MINNESOTA

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BY THE

STATE DRAINAGE COMMISSION

IN COOPERATION WITH THE

UNITED STATES GEOLOGICAL SURVEY

Letter of State Drainage Commission Submitting Report

REPORT OF
GEORGE A. RALPH
CHIEF ENGINEER

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ROBERT FOLLANSBEE

District Engineer, United States Geological Survey

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REPORT OF STATE DRAINAGE COMMISSION.

St. Paul, January 1, 1913.

To the Legislature of the State of Minnesota:

The State Drainage Commission pursuant to provision of joint resolution number 19 of the Legislature of the State of Minnesota for the year 1909, respectfully submit the following report. Accompanying this report and forming a part hereof will be found the report of George A. Ralph, Chief Engineer of the State Drainage Commission and the report of Robert Follansbee, District Engineer United States Geological Survey.

The conservation of natural resources is a question that should command the best thought, the most profound consideration of the people of all lands. The necessity for conserving and controlling the natural resources of our country which are the physical foundations of all prosperity, has been very forcibly called to public attention. No other question concerning the welfare of all the people has been given more serious consideration during the past decade; nor has any question affecting our national weal met with such popular approval by all classes, than this patriotic effort of statesmen, scientists, government officials and students of economic questions from all parts of our country, to further the general welfare of mankind by insisting on the protection and proper use of our waters, forests, soil and minerals.

The people of Minnesota fully appreciate the great importance of a proper solution of the problem of conserving these resources, and the urgent necessity for the enactment of laws that will safeguard the rights of the present as well as succeeding generations.

Our state contains valuable and extensive forests. Vast deposits of iron and other minerals, a wonderful wealth of productive soil, and abundance of pure water, with most favorable conditions for power development, navigation and fishing industries. Few, if any, of the states of the Union have been so favorably endowed by nature with these great natural resources.

The water resources of the state are very fully and clearly set forth in the exhaustive reports of the Engineers hereto attached.

The Commission is not unmindful of the very able services rendered by the Engineers representing the Federal Government; also the Engineers employed by the Drainage Commission, and take this opportunity of expressing their gratitude for their faithful and efficient services.

The State Drainage Commission presents this report with the recommendation that an annual appropriation of $2,500 be made for the purpose of carrying on stream gauging work, which added to $6,000.00 which is to be appropriated by the United States Geological Survey, will give a fund of $8,500.00 for this purpose, which is the amount the Engineers estimate will be required for this purpose. The Commission further recommends that this report be fully discussed in the forthcoming message of the Governor to the Legislature.

ADOLPH O. EBERHART,
Governor.
SAMUEL G. IVERSON,
State Auditor.
JULIUS A. SCHMAHL,
Secretary of State.
State Drainage Commission.

REPORT

OF

GEORGE A. RALPH

on the

Water Resources Investigation of Minnesota

Carried on Under the Direction

Of

State Drainage Commission

In Co-operation with

Water Resources Branch

United States Geological Survey

1911 and 1912

REPORT OF GEO. A. RALPH, CHIEF ENGINEER OF THE STATE DRAINAGE COMMISSION.

Gentlemen:—

I submit herewith my report of the work carried out under the direction of your Commission, under authority conferred by Joint Resolution No. 19, of the State Legislature, approved April 20, 1909, which is as follows:

Joint Resolution No. 19.

Whereas, The water supplies, water powers, navigation of our rivers, drainage of our lands and the sanitary condition of our streams and their water sheds generally form one great asset and present one great problem; therefore be it

Resolved, By the House of Representatives, the Senate concurring, that the State Drainage Commission be and is hereby directed to investigate progress in other states toward the solution of said problem in this state, to formulate a general plan for state supervision and control over its waters and all matters pertaining thereto and to report its findings and recommendations to the Governor on or before January 1, 1911, of which report 500 copies shall be printed.

Approved April 20, 1909.

Cooperation With Federal Government.

After the passage of the above resolution by the State Legislature, your commission appointed a committee to study the methods employed in the water resources branch of the United States Geological Survey with a view to their utilization by the State Drainage Commission, for studies of the water resources problem as outlined in the resolution of the Legislature. Your Engineer was somewhat acquainted with the work of this bureau and their plan of cooperation with the several states in carrying out work of this character. As a result of these studies and investigations the commission entered into an agreement with the U. S. Geological Survey —a copy of which follows:

Cooperative Agreement.

Whereas, an act making appropriations for sundry civil expenses of the government for the fiscal year ending June 30, 1910, and for other purposes, duly passed by the Senate and House of Representatives of the United States of America in Congress assembled, provides among other appropriations for the maintenance of the United States Geological Survey, the following:

"For gauging the streams and determining the water supply of the United States, and for the investigation of underground currents and artesian wells, and for the preparation of reports upon the best methods of utilizing the water resources, one hundred thousand dollars,"

And whereas, the director of said United States Geological Survey has given due consideration to the demands and needs of the various parts of the United States for such investigations, and to the amounts of money made available therefor by said act of Congress, and has made what he believes to be an equitable distribution of said moneys, according to said demands and needs,

And whereas, as a result of said distribution there has been allotted the sum of two thousand, seven hundred and fifty ($2,750) dollars for investigations of water supply in the State of Minnesota,

And whereas, the people of the State of Minnesota, appreciate the value of said water supply investigations to the various interests in said region, and being desirous of securing the completion of said work at a date earlier than said completion would be possible with the funds provided by Congress, to the end that the full benefits thereof may speedily be realized, have through their duly accredited representatives, in legislature assembled, passed the following act:

Be it enacted by the Legislature of the State of Minnesota:

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

Section 2. As soon as practicable after the completion of the survey of any watershed or part of a watershed, said drainage commission shall cause to be prepared such plans, maps, specifications, and estimates of the cost as it may deem necessary for the system or systems of drains or ditches for the several counties included in whole or in part in such watersheds; such maps, plans, and estimates to be prepared in duplicate and to be divided into sections so as to include in each section or sections, as far as practicable, the plans and estimates relating to any county included in the survey.

Section 3. On the completion of the report of such survey or part thereof relating to any county in this state, a copy of so much of such report, relating to such county, shall be filed with the county auditor of the county included therein.

Section 4. Upon the filing of such report with the county auditor, as provided for in section three of this act, all subsequent drainage work carried out under any of the drainage laws of this state shall be constructed in conformity with such plans, except as modified by the State Drainage Commission.

Section 5. The State Drainage Commission shall prescribe such rules and regulations governing the construction of ditches in any county in this state under the provisions of this act as may seem to them just and proper.

Section 6. The Drainage Commission of the State of Minnesota is hereby authorized to cooperate with the United States in the execution of drainage or topographical surveys in any county in this state whenever said Drainage Commission deem it expedient and in the best interests of the state to do so.

Section 7. This act shall take effect and be in force from and after its passage.

Approved April 23, 1909.

The following Joint Resolution was also passed by the State Legislature:

Whereas, The water supplies, water powers, navigation of our rivers, drainage of our lands and the sanitary condition of our streams and their watersheds generally form one great asset and present one great problem; therefore,

Be it Resolved, By the House of Representatives, the Senate concurring, that the State Drainage Commission be, and is hereby directed to investigate progress in other states toward the solution of said problem in such states, to investigate and determine the nature of said problem in this state, to formulate a general plan for state supervision and control over its waters and all matters pertaining thereto, and to report its findings and recommendations to the Governor on or before January 1st, 1911, of which report 500 copies shall be printed.

Approved April 20, 1909.

And whereas, it is believed that greater economy and efficiency will result if the work contemplated under both appropriations aforesaid be conducted under common agreement with respect to location, methods and administration.

Now, therefore, shall the following agreement issue:

This agreement, made and entered into this fifteenth day of

May, 1909, by and between George Otis Smith, Director, for and on behalf of the United States Geological Survey, party of the first part, and the State Drainage Commission, for and on behalf of the State of Minnesota, party of the second part, WITNESSETH:

That there shall be maintained in the State of Minnesota a co-operative investigation of the water resources and that for the purpose of carrying out the terms of the act authorizing the parties hereunto to enter upon the investigations aforesaid, this agreement is hereby entered into between said parties upon the following basis:

1. The investigations shall be under the supervision of the Director of the United States Geological Survey, who shall be represented in all work, negotiations, and disbursements involved in the performance of this agreement by a duly accredited representative, whose agency shall be formally certified to for the information and guidance of the party of the second part; the methods of investigation shall be those usually followed by the party of the first part, and they shall be subject to such modification or improvement as may be suggested by the party of the second part and approved and confirmed by said Director, for and on behalf of the party of the first part.

2. During the progress of the work all notes, maps, measurements, gagings and other material shall be open to the inspection of the party of the second part, and if the work is not carried on in a manner satisfactory to said party of the second part, he may, on formal notice, terminate this agreement.

3. The contribution of the party of the first part shall be the sum of two thousand, seven hundred and fifty dollars ($2,750), which shall be expended in office studies, computations, and the preparation of reports for publication; the contribution of the party of the second part shall be the sum of twelve thousand five hundred dollars ($12,500), which shall be expended in field work within the State of Minnesota; the term of this contract shall expire on June 30, 1910, at which time a new agreement shall be made, under which the party of the first part shall contribute to the work herein described such a sum as is possible under an equitable distribution of the appropriation of said party for water-supply investigations, said sum being not less than two thousand seven hundred and fifty dollars ($2,750), and as much more as it is possible to contribute, due regard being given to the appropriation made by the Congress of the United States and the completion of other work now in progress, it being understood that the party of the first part shall during subsequent years make allotments necessary to complete

the work herein provided and which eventually shall equal in the aggregate the contribution made by the party of the second part.

Provided that this agreement shall become void on July 1, 1910, or on any first day of July subsequent thereto during the continuation of this contract, in case the Congress of the United States shall fail to make suitable provision for the investigations herein described for the fiscal year beginning on any such date, in which case no portion of the contribution of the party of the second part for the corresponding year shall be expended.

4. Accounts of expenses incurred in the performance of the work herein provided shall be rendered monthly in the manner required by the laws and regulations of the parties hereunto, and shall be paid in accordance therewith; vouchers for the payment of such expenses shall be referred to either party hereunto for payment as may from time to time be determined by said parties by their respective representatives, the decision in each case to be based on the convenience of said parties or the balance remaining in the two allotments.

5. The work contemplated under this agreement shall be subject to special agreement as to location between the parties hereto or their respective representatives, and shall consist of the determination of the flow of rivers, the survey of rivers, and reservoir sites, and allied investigations relative to the determination of the water resources of the State of Minnesota, and the expense therefor shall include the necessary field work, travel, and subsistence, drafting, computations, estimates, and every other service or expense necessary to the final completion of the work.

6. The result of the investigations, surveys, observations, measurements, computations, and other matters acquired in the due performance of this agreement shall be furnished to the party of the second part on demand; the original notebooks, computation sheets, records, maps, etc., duly attested, shall ultimately be deposited in the office of the party of the first part and shall become a part of the records of said office, certified copies of the same being furnished to the party of the second part on demand.

7. The result of the work contemplated in this agreement, together with interpretations thereof, shall be published under the authority of the party of the first part during, or as soon as possible after the termination of the contract period herein specified, and said publication shall contain full and complete statements of the cooperative relations of the parties hereto, but the cost of publication shall not be included in the contributions herein pro-

vided by the parties to this agreement; and it is hereby understood and agreed that, although the records and results of the work contemplated in this agreement shall be considered the property of the party of the first part, so far as first rights of publication are concerned, this reservation shall not act to prevent the party of the second part from compiling and arranging for official use any of the results collected under this agreement should it choose so to do.

In witness whereof, we have hereunto set our hands and seals this fifteenth day of May, in the year one thousand nine hundred and nine.

GEO. OTIS SMITH, Director,

For and on behalf of the United States Geological Survey, party of the first part.

JOHN A. JOHNSON, Governor,
S. G. IVERSON, State Auditor,
JULIUS A. SCHMAHL, Secretary of State,
State Drainage Commission.

For and on behalf of the State of Minnesota, party of the second part.

SUMMARY OF ACCOMPLISHMENTS.

Consequent to the cooperative agreement with the United States Geological Survey, the following results have been accomplished:

Daily and monthly records at 67 points on the important streams in the State have been compiled. For the majority of the streams the records extend from 1909 to date, but in a few cases notable long-time records are available as follows:

Mississippi River above Sandy River—1895-1912.
Mississippi River at Anoka—1905-1912.
Mississippi River at St. Paul—1892-1912.
Sandy River below Sandy Lake Reservoir—1893-1912.
Pine River below Pine River Reservoir—1895-1912.
Minnesota River near Mankato—1903-1912.
St. Croix River near St. Croix Falls—1902-1912.
Ottertail near Fergus Falls—1899-1912.
Red River at Fargo, N. D.—1902-1912.
Red River at Grand Forks, N. D.—1883-1912.
Red Lake River at Crookston—1901-1912.

Many of those long-time records are the result of work done by the U. S. Geological Survey previous to its cooperation with the

State, while others are the result of work done by the U. S. Engineer Corps and individuals as noted in each record.

To determine the loss by evaporation from reservoirs, an evaporation station has been established on Sandy Lake in cooperation with the U. S. Engineer Corps, and all existing records in states bordering on Minnesota have been compiled.

Surveys have been made of 26 rivers making a total of 1454 miles of river. This mileage is divided as follows:

	Miles
Baptism River	9
Beaver Bay River	7
Big Fork River from Sec. 32, T. 150 N., R. 25 W. to Mouth	153
Brule River	7
Cannon River from Cannon Lake to Mouth	61
Cascade River	7
Cloquet River from Brimson to Mouth	70
Cross River	8
Crow Wing River from Crow Wing Lake to Mouth	89
Devil Track River	6
Gooseberry River	3
Little Fork River from Sec. 16, T. 62 N., R. 21 W. to Mouth	123
Manitou River	5
Ottertail River from Phelps Dam to Sec. 26, T. 132 N., R. 44 W.	51
Pigeon River from South Fowl Lake to Mouth	30
Poplar River	6
Prairie River from Crooked Lake to Mouth	33
Red Lake River from Red Lake to Crookston	143
Root River from Orion Mill to Mouth	107
Rum River from Onamia to Mouth	142
St. Louis River from Skibo to Scanlon	149
Snake River from a point 4 miles below Grasston to Mouth	24
Temperance River	6
Vermilion River from Vermilion Lake to Crane Lake	42
Wild Rice River from White Earth River to T. 143-144 N., R. 48 W.	105
Zumbro River from a point on the South Branch to Mouth	68

In addition to these surveys, profiles were compiled of the following rivers from surveys made by the U. S. Engineer Corps and individuals:

	Miles
Mississippi River from Lake Itasca to State Line	658
Minnesota River from Bigstone Lake to Mouth	339
Rainy River and Boundary Waters from North Lake to Lake of the Woods	254

Topographic surveys to determine the storage capacities and adaptability as reservoirs were made of Ottertail, Red Lake, and Mille Lacs, and of Birch and Garden lakes on Kawishiwi River. A number of smaller sites were surveyed in connection with the river surveys.

Estimates of available undeveloped power were made on all streams for which river profiles have been made. Instead of considering the total fall of the river in estimating power, only those portions of the rivers were selected which have possible dam sites of 15 feet head or greater. By this means a much nearer approach to the economically possible water power development was made. The total power possibilities as just outlined, for continuous flow during low water was 120,000 horsepower. A census of the existing power developments shows the total installed power to be approximately 188,000 horsepower.

To show the sources of pollution of the streams and the extent to which unfiltered river water is used as municipal water supplies, data have been compiled showing the method of sewage disposal and source of municipal water supply, from each town of 500 inhabitants or over, located on the rivers or tributaries. Additional data have been compiled showing the rural population per square mile in different parts of each principal drainage area. This information shows that a large number of towns and cities discharge their untreated sewage into the rivers, but that comparatively few towns are using unfiltered river water for municipal purposes.

Value of Work.

It has been the aim of those intrusted with making these investigations to secure, as far as practicable, complete data of the water resources of the State, and to prepare a report of the work in the most convenient form for the use of the people of the State, and others who may be interested in the use, regulation and control of public waters.

In this report will be found maps of all important streams, **showing the true course of the stream,** with contour lines showing the extent of the valley and the elevation of the river banks.

Profiles of each stream showing the fall in feet for each mile and the total fall from the source to the outlet.

Runoff tables which show the discharge in second-feet for each day in the year at given points along the stream.

Precipitation records.

Evaporation records.

Maps and data relative to the most feasible sites for storage reservoirs.

Developed and undeveloped water power data.

Municipal water supply and stream pollution data, and much other information pertaining to the waters of the state.

It is doubtful if there ever has been a report issued in this State under State authority, for which there has been such a wide spread demand as for the commission's report for 1909 and 1910.

Requests have been received from the Minister of Public Works, Brazil; from public officials and others in England, France, Switzerland, Italy, Germany, Russia, Canada, and Mexico; also from nearly every state in the Union. From the publishers of Engineering Journals, Engineers and others interested in this subject.

This report includes the 1909 and 1910 report together with much additional information. It is intended to be a final report of this nature, dealing with the water resources of the State.

Discharge measurements should be continued for several years in order to get records of the runoff of the streams of the State that will be of much value.

The records of stream flow in the future will be published in water supply papers, and reports issued by the United States Geological Survey. Arrangements can undoubtedly be made with this department for a supply of these papers.

Acknowledgments.

I fully appreciate the very generous assistance rendered myself as Engineer of the State Drainage Commission, also the Engineers of the U. S. Geological Survey working in cooperation with us, by the U. S. War Department, the U. S. Weather Bureau, the State Board of Health, by various water power companies, railway companies, and others, all of which is gratefully acknowledged.

Respectfully submitted,

GEO. A. RALPH,
Chief Engineer,
State Drainage Commission.

WATER RESOURCES OF MINNESOTA

RESULTS OF SURFACE WATER INVESTIGATIONS

BY THE

UNITED STATES GEOLOGICAL SURVEY

IN COOPERATION WITH THE

STATE DRAINAGE COMMISSION

PREPARED UNDER THE DIRECTION OF
M. O. LEIGHTON, CHIEF HYDROGRAPHER

BY

ROBERT FOLLANSBEE
DISTRICT ENGINEER

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR.

UNITED STATES GEOLOGICAL SURVEY.

WATER RESOURCES BRANCH.

Denver, Colorado, Dec. 1, 1912.

Mr. George A. Ralph,

Chief Engineer, State Drainage Commission,

St. Paul, Minnesota.

Dear Sir:—

I transmit herewith my report on the Water Resources of Minnesota, covering the results of work done under the cooperative agreement between the United States Geological Survey and the State Drainage Commission.

The field work was started in May, 1909, by Mr. J. C. Hoyt, Assistant Chief Hydrographer of the Geological Survey. I was placed in charge in June, 1909, and directed the work until November, 1911, since which date the field work has been supervised by Mr. W. G. Hoyt, the present district engineer for the Minnesota district.

During the period covered by the investigations the stream flow data have been collected by Prof. E. F. Chandler and C. R. Adams, assistant engineers; G. A. Gray and S. B. Soule, junior engineers, and C. J. Emerson, field assistant. The river surveys were made by C. R. Adams, C. J. Emerson, L. W. King, W. W. Hawley and G. L. Rosing, as chiefs of the party; and C. L. Smith, W. M. Murphy, G. L. Rosing and R. W. Hosfield, instrument men. The maps of the river surveys were prepared by L. W. King, M. J. Orbeck and B. J. Peterson, draftsmen. Acknowledgments are due all these assistants for their unflagging energy and their fidelity to the work at all times.

I wish to make special acknowledgment to Mr. W. G. Hoyt for assistance rendered in the preparation of this report. Your own continuous interest in the work has been greatly appreciated.

Very truly yours,

ROBERT FOLLANSBEE,

District Engineer.

WATER RESOURCES OF MINNESOTA

By ROBERT FOLLANSBEE

UTILIZATION OF THE WATER RESOURCES OF THE STATE.

Among the most important of Minnesota's natural resources are its rivers, and unlike many other natural resources the rivers are practically inexhaustible. Not only, however, are they in large part wasted but, if uncontrolled, they may inflict immense damage at times of flood.

As Minnesota contains no coal mines, the possibility of obtaining power from its rivers is of especial importance. By utilizing the energy of the streams it is possible to generate power more cheaply than it can be generated by steam. A most striking example of the beneficial effect of cheap power is found in Minneapolis, which owes its pre-eminence largely to the milling and other industries fostered by the cheap power afforded by St. Anthony Falls.

Although the opinion that the State has parted with its right to control power development where it is not the riparian owner is widely accepted, this opinion does not imply that the State cannot assure fair rates to power consumers, for the State's right to regulate the price of commercial power is as clear as its right to regulate the charges of railroads, warehouses, and other public utilities.

The rivers are of value not only for power development but also for transportation. Even in sections of the State where efficient railroad service is given, certain classes of low-grade freight can be transported much cheaper by water than by rail. By controlling and improving the larger streams water transportation can be greatly extended and transportation charges can be further reduced.

Neglect to regulate the rivers not only prevents utilization of a valuable resource but allows positive injury to go unchecked, as is shown by the severe floods to which some of the river valleys are subject—notably the Minnesota, Red, Root, Des Moines, Cedar, Rock, and Wild Rice. The improvement of these rivers by straightening their channels, building levees, constructing reservoirs, or by other means, would not only probably insure freedom from disastrous floods, but would also provide more efficient outlets for the large drainage systems needed to reclaim the many thousand acres of swamp land in the State.

As the country districts of Minnesota become more thickly settled and the cities more populous, the closely allied subjects of sewage disposal and municipal water supply will increase in importance. As the rivers will be largely used for sewage disposal, the allowable degree of their pollution, if any, will depend on the discharge, especially during the period of low water. On most of the rivers this period comes during the winter months, when the rivers flow under ice and when sunlight affords less aid in destroying the sewage bacteria. The question concerning municipal water supplies derived from rivers will relate rather to the degree of pollution than to the sufficiency of flow.

NEED FOR SURFACE WATER INVESTIGATION.

Before the surface waters of the State can be fully utilized and the damage from their unrestrained flow effectively prevented it is necessary to ascertain the quantity carried by the streams by measuring the flow of each river at various points. As the discharge of a stream varies from season to season and from year to year, records of flow must be collected for a series of years in order to determine closely the extremes of flow that play such an important part in the utilization of the water resources.

Work of this kind, which must be carried on for a number of years before adequate data are obtained, can be performed systematically and in detail only by governmental agencies—either Federal or State—for private enterprises can not wait long enough after the planning of a project to acquire the requisite data. Realizing this fact, the State Drainage Commission entered into a cooperative agreement with the United States Geological Survey, in accordance with which a systematic study of the water resources of Minnesota was begun in May, 1909, under the direction of the National Survey.

Although for most of the streams the records cover less than four years, the period includes two years—1910 and 1911 (and for some areas the winter months of 1911-1912)—during which the precipitation was so far below the normal that the streams fell lower than for many years, as is shown by rainfall records (Pl. I.) and by certain long-time records of stream flow. Therefore the low-water flow thus determined may be considered the minimum in a cycle of many years.

No extreme high water discharge has occurred during the time covered by the investigations, so that data concerning floods are not yet available; but as the records of stream flow are to be con-

tinued, it is probable that before many years such data will be obtained.

Records of stream flow, although the most important, are not the only data necessary to the economical use of the water resources. In planning power development, knowledge of the fall of the river is nearly as important as knowledge of the stream flow, as discharge and fall are the two factors that determine the available power. To obtain this second factor—which must also be considered in problems of navigation, drainage, flood prevention and, to a less extent, pollution due to sewage—the more important rivers were surveyed, and from the surveys river profiles were prepared which show the fall between any two points and also the topographic features along the rivers.

The suitability of the larger lakes for use as storage reservoirs must also be determined. It is popularly supposed, because Minnesota contains so many lakes, that it contains also many available reservoir sites. As a matter of fact but few of the lakes are suited for use as reservoirs. Most of the lakes are so far up on the headwaters of the streams that the tributary runoff is too small to make them valuable for use as reservoirs to increase greatly the low-water flow of the stream for several months. It must not be inferred that because a lake is used as a reservoir for log driving it could be successfully used to store water for power or for navigation. In log driving the reservoir is operated, not to increase the low-water flow of the stream, but to store water through the fall and winter for release during a short time in the spring and early summer, in order to reinforce the flow while the logs are being driven to the saw mills. Much less water is required for this purpose than for use in water power or navigation, where the flow must be increased for several months.

For the same reason that the lakes are not suited to store water for power development or for navigation, they are also unsuited for use as reservoirs for flood prevention. Most of the lakes lie so near the headwaters that they can be of little use in restraining the flood runoff that is derived in large part from the far greater drainage area below.

ARRANGEMENT OF REPORT.

The data presented in the report are, for convenience, grouped by drainage basins.

The rivers are divided into three groups, the first comprising the Mississippi and its tributaries; the second, streams flowing to Hudson Bay, including Red and Rainy rivers and their tributaries;

and the third comprising the streams flowing to Lake Superior—the St. Louis and its tributaries and minor streams.

In the first group data for the Mississippi are given first and then data for each important tributary from the source downward.

In the second group data for Red River are followed by data for its more important tributaries, which in turn are followed by the data for Rainy River and its tributaries.

In the third group data for the St. Louis are followed by data for its important tributaries, and these are followed by data for the minor streams flowing directly into Lake Superior, beginning at the upper end of the lake.

For each main river and principal tributary are given, so far as available, the following data:

General information concerning areas drained, presented under the headings:
Source, course and tributaries
Topography, geology, and forestation
Rainfall and runoff
Floods
Navigation
Regulation of flow.
  Natural control of lakes and swamps
  Artificial control by reservoirs
  Log driving
Drainage

Specific information; presented under the headings:
Drainage areas
Gaging station records (for each station maintained)
  Station description
  Table showing daily discharge
  Table of monthly estimates

Developed water power:
  Description of each plant with estimate of available power at the given head for (a) lowest monthly record, (b) average of lowest monthly record for each year, (c) average of lowest of 6 high-water months for each year.

Undeveloped water power:
  Profile of river showing topography of banks.
  Description of possible sites and projects and estimate of height of dam necessary to develop.
  Length of dam and pipe line (if any).
  Area that would be flooded by proposed dam.
  Available horsepower at given head for (a) lowest monthly record, (b) average of lowest monthly record for each year, and (c) average of lowest of 6 highwater months for each year.

Storage:
- Description of feasible reservoir sites with capacities as determined from surveys
- Effect of storage on flow of the river shown by means of mass curves.

Sanitary statistics of the river for—
- Towns of 500 inhabitants and more, located on streams, showing source of water supply, and method of sewage disposal.

The data pertaining to the drainage basins are followed in the report by certain data which apply to the entire State and which are discussed in the order indicated below:

- Laws and regulations pertaining to Minnesota streams
  - Federal laws
  - State laws
  - International Treaty for boundary waters
- Distribution of rainfall in Minnesota
- Evaporation records at points in North Dakota, Minnesota, Wisconsin, and Iowa
- Gazetteer of all streams in the State showing source and outlet
- Bibliography showing published sources of information used in preparing this report.

ACKNOWLEDGMENTS.

Acknowledgments of aid rendered are due to the organizations, companies, and persons named below:

Officials of the United States Engineer Office, St. Paul, for use of unpublished records of run-off, and maintenance of evaporation records.

Officials of the United States Weather Bureau, for daily gage heights of the Mississippi at St. Paul, and the Minnesota at Mankato.

State Board of Health for cooperation in the Mille Lacs Survey, and for valuable data relative to municipal water supply and sewage disposal.

Kettle River Company, Minneapolis, for records of flow and profile of Kettle River.

Great Northern Power Co., Duluth, for various records of flow in St. Louis River basin, as discussed in the report.

Minnesota & Ontario Power Co., International Falls, cooperation in maintaining gaging station on Rainy River at International Falls.

Mr. S. B. Johnson, Ottawa, Canada, Department of Public Works, for cooperation in maintaining gaging station on Rainy River at International Falls and for gage heights of Rainy Lake at Ranier and precipitation records at Fort Francis.

Mr. L. P. Wolff, consulting engineer, St. Paul, for records of flow

from St. Croix River 1902-1905.

Stone & Webster Engineering Corporation for records of flow of St. Croix River for 1905-1912.

Consumers Power Co., for cooperation in maintaining gaging station on Blue Earth River near Rapidan.

Minnesota Canal & Power Co., Duluth, for records of Kawishiwi River, 1905-1907.

Mr. E. B. Banks, city engineer, Superior, Wis., for the profiles of Kawishiwi and Rainy rivers.

Crookston Water Works, Light & Power Co., for cooperating in installation of automatic gage on Red Lake River at Crookston.

St. Anthony Falls Water Power Co., Minneapolis, for winter records of the Mississippi at Minneapolis.

Mr. R. D. Thomas for data on power development on the Mississippi at Minneapolis.

Various managers and owners for descriptions of power plants.

The Minnesota Forest Service for information regarding forestry and log driving.

The United States Forest Service for information regarding forestry on the Superior National Forest.

METHODS OF COLLECTING AND COMPILING DATA.

STREAM GAGING RECORDS.[1]

[1]The description of the methods used in compiling the records of stream flow presented in this report is taken chiefly from Water-Supply Paper U. S. Geol. Survey No. 261, pp. 18-27.

FIELD METHODS OF MEASURING STREAM FLOW.

Three distinct methods are used to determine the flow of water in open channels: (1) By measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir or dam; (3) by measurements of the velocity of the current and the area of the cross section. Only the third method is here described as the other methods are not used in the work in Minnesota.

Streams in general may present throughout their courses, to a greater or less extent, all gradations from permanent and semipermanent to varying conditions of flow. In accordance with the situation of the measuring section with respect to the physical conditions, current-meter gaging stations may in general be divided into four classes: (1) including stations located at points where the conditions that control the flow at the gage are comparatively permanent; (2) those located where conditions change only during

A. DISCHARGE MEASUREMENT OF VERMILION RIVER BY MEANS OF CAR AND CABLE.

B. WINTER MEASUREMENT OF BIG FORK RIVER.

periods of extreme high water; (3) those where changes occur frequently but do not cause a variation greater than about 5 per cent of the discharge curves from year to year; and (4) those located where changes constantly occur.

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

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

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

In making a measurement with a current meter a number of points, called measuring points, are measured off above and in the plane of the measuring section at which observations of depth and velocity are taken. These points are spaced equally for those parts of the section where the flow is uniform and smooth and are spaced unequally for other parts, according to the discretion and judgment of the engineer. In general the points should not be spaced farther apart than 5 per cent of the channel width nor farther apart than the approximate mean depth of the section at the time of measurement.

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

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

The Price current meter is now used almost to the exclusion of other types of meters by the United States Geological Survey in the determination of the velocity of flow of water in open channels, a use for which it is adapted under practically all conditions. Briefly, the meter consists of six cups attached to a vertical shaft which revolves on a conical hardened steel point when immersed in moving water. The revolutions are indicated electrically. The rating, or relation between the velocity of moving water and the revolutions of the wheel, is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval. The ratio of revolutions per second to velocity of flow in feet per second is very nearly a constant for all speeds and is approximately 0.45.

Two classes of methods of measuring velocity with current meters are in general use—the multiple-point and the single-point.

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

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

In the second multiple-point method the meter is held successively at 0.2 and 0.8 depth, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this multiple-point method gives the mean velocity very closely for open-water conditions and that in a completed measurement it seldom varies as much as 1 per cent from the value given by the vertical velocity curve method. Moreover, the indications are that it holds nearly as well for ice-covered rivers. Nearly all the Minnesota work has been done by this method.

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

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

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

The determination of the flow when the stream is ice covered is more difficult than during the open season, partly because of the diversity and instability of conditions during the winter months and partly because of lack of definite information in regard to the laws of flow of water under ice. In Minnesota the winter flow is determined by means of discharge measurements made monthly on streams selected as representative. These measurements are made through the ice by the 0.2 and 0.8 method, the hydrographer recording at the same time the gage height to the water surface as it rises in the holes in the ice, and the thickness and character of the ice. [See Plate II. (b).] As most of the streams are frozen over throughout the winter, and as winter thaws sufficient to materially affect the flow are uncommon, the discharge during the winter months is very uniform, slowly decreasing to midwinter when it is a minimum. Accordingly the discharge is estimated largely by interpolation between discharge measurements. Records of semi-weekly observations of gage height to the water surface are made to show the steadiness of the flow.

OFFICE METHODS OF COMPUTING DISCHARGE.

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

The table of daily gage heights, not published in this report, records the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day, usually in the morning and in the evening.

The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable.

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

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

In preparing the rating curves special consideration is given to the class of stations represented. (See below.) The discharge measurements for all classes of stations, when plotted with gage heights in feet as ordinates and discharges in second-feet as abscissas, define rating curves more or less parabolic in form. For many stations curves of area in square feet and mean velocity in feet per second are also constructed to the same scale of ordinates as the discharge curve. These curves are used mainly to extend the discharge curves beyond the limits of the plotted discharge measurements and give a check to the form of the discharge curve and to determine and eliminate erroneous measurements.

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

The gaging stations in Minnesota may be divided into two general classes:

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

The stations of class 2—those located where conditions of flow change only during periods of extreme high water—include many of those maintained in Minnesota. If sufficient measurements could be made at stations of this class, results would be obtained nearly equaling those of class 1, but owing to the limited funds at the disposal of the Survey this is manifestly impossible, nor is it necessary for the uses to which discharge data are applied. The critical points are as a rule at relatively high or low stages. The percentage error, however, is greater at low stages. No absolute rule can be laid down for stations of this class. Each rating curve must be constructed mainly from the measurements of the current year, the engineer being guided largely by the past history of the station and the following general law: If all measurements ever made at a station of this class are plotted on cross-section paper, they will define a mean curve which may be called a standard curve. It has been found in practice that if after a change caused by high stage a relatively constant condition of flow occurs at medium and low stages, all measurements made after the change will plot on a smooth curve which is practically parallel to the standard curve with respect to their ordinates or gage heights. This law of the parallelism of ratings is the fundamental basis of all rating tables and estimates at stations with semipermanent and shifting channels. It is not absolutely correct but, with few exceptions, it answers all the practical requirements of estimates made at low and medium stages after a change at a high stage. This law appears to hold equally true whether the change occurs at the measuring section or at some controlling point below. The change is, of course, fundamentally due to change in the channel caused by cut or fill, or both, at and near the measuring section. For all except small streams the changes in section usually occur at the bottom.

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

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

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

ACCURACY AND RELIABILITY OF RECORDS.

Practically all discharge measurements made under fair conditions are well within 5 per cent of the true discharge at the time of observation. Inasmuch as the errors of meter measurements are largely compensating, the mean rating curve, when well developed, is more accurate than the individual measurements.

The accuracy of stream-flow data depends primarily on the natural conditions at the gaging station and on the methods and care with which the data are collected. Errors of the first group depend on the degree of permanency of channel and of permanency of the relation between discharge and stage.

Errors of the second class are due, first, to errors in observation of stage; second, to errors in measurements of flow, and, third, to errors due to misinterpretation of stage and flow data.

With relatively few exceptions the observers perform their work honestly. Care is taken, however, to watch them closely and to inquire into any discrepancies. In general, observations are taken twice a day at 8 and 6, and the mean of these readings taken as the mean for the day. Where the flow is controlled to an appreciable extent, two or three additional readings are taken at such times as tend to give the true mean for the day. However, it is not feasible to do this in all instances. With a few exceptions, however, it is believed that the readings give a fair average for the day.

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

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

Even though the monthly means for any station may represent with a high degree of accuracy the quantity of water flowing past the gage, the figures showing discharge per square mile and depth of run-off in inches may be subject to gross errors which result from including in the measured drainage area large noncontributing districts and they should therefore be considered as only approximate.

The table of monthly discharge is so arranged as to give only a general idea of the flow at the station and should not be used for other than preliminary estimates. The determinations of daily discharge allow more detailed studies of the variation in flow by which the period of deficiency may be determined.

RIVER SURVEYS.

The river surveys were made to obtain the information necessary to determine the water surface of the rivers at medium stage and to map the shore lines, adjacent topography and the more important artificial features, leaving detailed surveys to be made by those interested in the various projects. This information has been plotted on the published sheets to a scale of 1,000 feet or 2,000 feet to the inch.

The surveys were made with transit and stadia and included determinations of levels, a magnetic traverse, and sketches of shore topography. A surveying party consisted of a topographer, transitman, two rodmen and teamster. In the later work canoes were used. The topographer, who was chief of party, kept the transit notes and made the topographic sketches, using a small field drawing board and plotting the traverse shots as made. These sketches were invaluable when the final map was made in the office and were very much more satisfactory than the fragmentary sketches made in the transit notes, as they were plotted to scale, usually 1 inch to 1,000 feet. The transitman ran the transit and directed the rodmen in giving proper side and main shots. The transit was used to run not only the traverse but also the levels, the transit being used as a level. Main traverse elevations were never obtained by vertical angles except in surveying the streams in the northeastern part of the state, where the fall is very great and many of the streams flow through gorges.

In order to illustrate the method of procedure let it be assumed that the transitman has just reached a station. (As azimuth is carried by the magnetic needle it is only necessary to occupy every other station.)

The transitman, having set up his instrument, backsights on the preceding station (which was the forward station at the last set up), and, by reading stadia distances and magnetic bearing, locates his present position in the traverse. He then levels the telescope and reads the intersection of the middle wire on the rear stadia rod which gives the present H. I. He also reads the upper cross hair, and then the entire stadia interval (telescope remaining level). (In this way he had a check not only on the distances, but also on the level reading, because if either were in error, the half interval consisting of the level reading and the upper cross hair reading would not be consistent with the entire stadia interval. In that case the observation was repeated until there was agreement.) This check was of especial importance because, owing to the fact that only every alternate station was occupied by the instrument, there was only one stadia determination of the distance between stations. On the later surveys the following check for azimuth was used: The compass box was set for the magnetic deflection and the bearings of the rear and forward stations read.

Then the compass box was set for zero deflection and the bearings again read. If the readings were all correct the latter set differed from the former by the amount of the deflection. Section lines and corners were also tied in wherever possible, giving an additional rough check.

The rear rodman, having given the above described rear shot, moves forward, giving such side shots as are necessary to give the topography adjacent to the river banks and as far back as the bluff line where this is within a few hundred feet of the river. (It must be borne in mind that it is not the function of these surveys to show the topographic features in elaborate detail, but only to show them in a general way and thus indicate the most feasible reservoir and dam sites, which it is expected will be surveyed in detail by those interested. In general, sufficient side shots are taken to sketch in the 5-foot contours.) The rear rodman having given the necessary side shots—which are augmented by hand level and pacing by the topographer in the vicinity of the station occupied—proceeds to a point on the river bank from 1,500 feet to 2,000 feet beyond the front rodman, so that when the transitman mives up he will occupy a position midway between the two, thus giving a back shot and front shot of from 750 feet to 1,000 feet each. Of course if the river was very winding it was not possible to take shots as long as this, as the rodman was not visible.

During the open season the traverse points were chosen on the banks of the stream, the two rodmen keping on one side and the topographer and transitman on the other. In this way every odd numbered station (transit station) was on one side of the river and every even numbered station (not occupied by transit) on the other side. Canoes were used getting across the river whenever necessary.

During the winter season, however, the party walked along the channel of the river, and as the ice was usually from 1 to 2 feet thick, the stations were taken directly on it. In both seasons the elevation of the water surface was taken at the head and foot of all rapids, falls or dams, and at least every half mile in smooth stretches. These water surface elevations were the most important part of the survey, as from them the profile was made.

In order to determine the magnetic variation, observations on Polaris or solar observations were made every few miles, and whenever local attraction was suspected the station was occupied by the transit and azimuth carried in the regular way, but very little evidence of local magnetic attraction was found.

To show the true conditions the river profile must be referred to a stage that is constant throughout the length of the stream. Gages were accordingly set at different points and read daily during the survey. As river surveys could be made only during the summer, fall, and winter, when flow is fairly steady, it was possible to determine a low-water stage at one gage where the gage reading was practically constant long enough for water to traverse the entire length of the river, and during this time readings were also made on all the other gages. These simultaneous readings determined for each gage the low-water stage, which was taken as the reference plane. Whenever the gages indicated a stage differing from the determined standard, the water elevations for those days were properly corrected by the amount indicated by the nearest gage. As there was no great variation in condition of flow of the rivers surveyed, the relation of discharge to gage height was fairly constant between two adjacent gages and little appreciable error was caused by correcting water elevations according to the nearest gage.

The initial elevations for each river survey were taken from a bench mark of the Mississippi River Commission, United States Geological Survey, or from a railroad bench mark, and thus all elevations were referred to mean sea level. By utilizing the surveys of various Federal and State organizations it was possible to get occasional independent checks in the level line. The results of these checks showed that though the accuracy was not equal to that of good wye-level work, it was well within the limits required for a preliminary survey of this type.

RESERVOIR SURVEYS

The lakes were surveyed to ascertain their availability for use as reservoirs. As the storage of the entire runoff for a year at any of the lakes would require only a few feet additional feet capacity, data were needed to determine whether it would be more feasible to create the necessary storage by raising the water surface, or by lowering the surface by dredging the outlet and allowing the difference between the lower surface and the natural surface to represent the storage. For this purpose it was only necessary to locate the 5-foot contour above the water surface and the contour of 5-foot depth.

A closed main traverse was run around each lake and to this traverse were tied the necessary side shots or side traverses to locate the 5-foot above-surface contour and the necessary soundings to locate the contour of 5-foot depth. These soundings were usually made by means of a stadia board held at the proper place by a rodman in a canoe or boat.

As no greater storage was needed than would be given by lowering the lake surface to a maximum of 5 feet, soundings at greater depths were not taken except in the Mille Lacs survey, where soundings across the lake were made from a steamer running at uniform speed on a definite course, from a station on the main traverse, to the opposite shore. The soundings were taken at regular intervals, and plotted at equal intervals along the projected course.

The principal shots were plotted as in the river surveys and the 5-foot contour was sketched in the field.

Ottertail Lake was surveyed by the topographic branch of the United States Geological Survey in connection with work in that section of the State. The standard methods of that branch were used except that the scale was somewhat larger, and at the request of the water resources branch special soundings were made for the contour of 5-foot depth, in order that the results of the survey might be used to determine the reservoir capacity.

DEVELOPED WATER POWER.

The work of compiling data relative to the developed water power in Minnesota was carried on in 1909 and 1910, altho where necessary the data were revised to show the situation existing in 1912. Most of the plants (including all of the larger ones) were visited by one of the engineers connected with this office. When all the plants on the main rivers and their chief tributaries had been visited, a letter was sent each County Auditor asking at which points in the county water power was being developed. In this way information was obtained concerning a number of additional plants (most of them developing less than 100 horsepower) and data for most of these were procured by mail. As a result of this work it is believed that from the completed list very few plants were omitted, and those of very small size.

For each plant, answers to the following questions were obtained so far as possible from the owner or operator:

1. Name of stream on which power is located.
2. To what large river is the stream tributary?
3. Location of power in township, county; above or below what tributaries?
4. Name of mill or power station.
5. Name and address of owner, or operator.
6. Have any records of height of water been kept?
7. What discharge measurements have been made in this locality? By whom?
8. Installed horsepower; average horsepower actually developed.
9. Use to which power is applied.
10. Market price of power in this locality.
11. Method of supplying water to wheels (canal or flume, pipe line, etc.).
12. Operating capacity of canal or pipe line.
13. Pondage (approximate area, range of head, capacity, flashboards).
14. Total operating head forebay to tail race.
15. Water wheels (kind, make, age, size, usual gate opening, rated power at usual gate and head).
16. Water wheel governors (automatic or otherwise, make).
17. Generators (make, kilowatts, voltage, phase, current, connection, remarks).
18. Transmission lines (location, length, voltage, size of wire, kind of poles, etc.).
19. Hours per day plant runs.
20. Auxiliary steam horsepower.
21. Portion of stream flow plant is entitled to.
22. What part of year is water supply sufficient?
23. Additional remarks.

No tests were actually made, altho the installed rating of the wheels was checked by the manufacturers' tables, using the average head available. The installed horsepower in hydro-electric plants was taken as the rating of the water wheels and not from the electrical generators attached. Exciter wheels were omitted.

UNDEVELOPED WATER POWER.

The estimates of undeveloped water power are based on the special surveys showing fall and contour (latter for possible dam sites) and on stream-flow records. As the minimum flow of the streams almost without exception occurs during the winter months, and as from the character of the records only monthly estimates of flow are made, the unit of flow is the monthly mean.

The flow for some days may fall somewhat below the mean for the month, but this shortage is partly or wholly offset by the fact that the horsepower is estimated for continuous flow although in practice the demand for power may not be continuous. It there is sufficient pondage at the power site the water supply during the hours of minimum demand can be stored for release during the hours of the peak load.

In estimating the water power available for commercial uses it is necessary to consider the amount that can always be developed, except at manufacturing plants (such as pulp mills) where the output can be increased and decreased with the water supply.

From the profile of the river and the sketch of the topography adjacent to the shore line possible dam sites have been selected. In general no head of less than 15 feet has been considered, as the low-water flow of the streams is so small that developments at lower head would hardly prove commercially feasible.

Although the records for most of the stations cover only the last three or four years, two distinct periods of extreme low flow occurred during that time. In most parts of Minnesota the rainfall for 1910 was lower than for many years. Plate I. shows the rainfall at three stations in different parts of the State. The great deficiency in precipitation caused the lakes and the ground water to fall so low that during the following January and February, when the flow was dependent on those two sources of supply, it reached the lowest stage in many years, as is shown by certain long-time records. This statement applies to Rainy, Red, St. Louis, Snake, Kettle, lower Minnesota, lower Rum, Sauk, and Root rivers. On the Crow Wing the lowest flow occurred in the summer of 1910. On the Red Lake and upper Rum rivers the drought of 1910 so dried out the swamps surrounding Mille Lacs and Red Lake that the lakes were probably at minimum level in the latter part of 1911, for the rain that fall at that time was absorbed by the ground and did not reach the lakes. Thus, the extreme cold weather in the first part of 1912, taken with the extreme low lake levels, caused the flow of the Red Lake and upper Rum rivers during that period to be less than during January and February, 1911. The long-time records on the Mississippi show that the flow during January, 1895, was about 40 per cent less than that of January, 1911—the lowest during the last three years—but that may be due largely to the fact that during the earlier period water was being stored in the Sandy Lake and Pine River reservoirs with practically no flow from them whereas during the later period water was flowing from both reservoirs. As the rainfall in 1894 was more than twice that in 1910, the natural flow during January, 1895, would probably have been greater than during January, 1911. On the upper Minnesota and Crow rivers the ground water was so much depleted by the drought of 1910 that the extreme cold weather during the early part of 1912 caused the flow to fall even below that of the preceding winter. On Zumbro River, the normal flow of which is derived largely from ground water, the full effect of the drought of 1910 was felt in July, 1911, when the flow was lower than during the preceding or the following winter. It therefore appears that, although the minimum flow did not occur during 1910, it was directly traceable to the drought of that year.

It is manifestly unreasonable to base estimates of available water power wholly on minimum flow which in all probability occurs only once in many years. It is more reasonable to consider chiefly the mean flow for the lowest month of the average low year. The years of low flow from 1895 to date, as shown by the records of the Mississippi and the long-time records of the Minnesota and Red rivers, are 1909, 1910, and 1911. Accordingly, to determine the low flow for the rivers lacking long-time records, the mean of the lowest monthly flow in each low year has been selected. If the flow for the lowest year was very much less than that for the other low years, the record of the lowest year has been disregarded in estimating the available water power.

At some sites it may be possible to install auxiliary stream power to be used only during a part of the year. By fixing rather arbitrarily a period of six months during a low year and a shorter period during a high year for the use of auxiliary power, the mean flow for the lowest of the six high-water months of the low years has been determined.

Thus, for each river that has been surveyed, the possible sites have been selected, and for each site estimates have been made covering—

(a) The continuous horsepower at 80 per cent efficiency possible of development during the lowest month on record.

(b) The continuous horsepower (80 per cent) possible during the lowest month of the average low year.

(c) The continuous horsepower possible for the six high-water months of an average low year.

These estimates are based on the short formula HP (80 per cent) $= \frac{\text{flow x head.}}{11}$

For a few streams where power can be developed at reservoir sites of considerable capacity the power available from regulated flow is estimated.

For other streams, which have not been surveyed but for which elevations at various points are approximately known, a skeleton profile has been drawn to show the fall at certain localities. As topographic maps are not available it is not possible to indicate dam sites, but of these streams the total horsepower in each section is estimated.

No attempt is made in this report to determine the cost of power—either steam or water. Those interested in the subject are referred to "The Cost of Power" by Seth A. Moulton in the Second Annual Report of the Maine State Water Storage Commission.

DRAINAGE AREAS.

Drainage area boundaries were determined from the few special opographic maps available, the approximate contour maps in the eports of Geological and Natural History survey of Minnesota, nd the topographic maps in the State drainage engineer's report 1 the Topographic Survey of Minnesota. These boundaries were en transferred to a hydrographic base map of the State prepared the State drainage engineer on the scale of 1 inch to 5 miles. The eas within these boundaries were determined by polar plani-ters. The Canadian areas for the boundary waters were obtained m the official maps published by the Canadian Government. e small areas in the bordering States were obtained from Post-ite maps of those States.

The total areas of the major basins in the State were adjusted htly to equal the total official area of the State, and the same entage of adjustment applied to the minor basins compri- the major. The drainage areas in each basin are arranged in following order:

'he main river in the group heads the list and the drainage s of different points on the river are arranged in descending r, beginning nearest the source. Next the different streams arging directly into the main river are arranged in descending beginning with the stream nearest the source. Where more one area is measured on a stream; these areas are arranged nilar manner. The same order is used in applying to areas eams flowing into the principal tributaries. (These smaller ns following immediately the streams into which they flow.)

SANITARY CONDITION OF RIVER WATERS.

In order to determine the sanitary condition of the river waters with reference to pollution by sewage and the extent to which they are used for municipal supplies, letters of inquiry were sent to the officials of all the towns which are situated on streams and which contain 500 or more inhabitants. This limit of population makes it practically certain that the inquiries reached all towns having municipal sewage systems and waterworks plants. Settlements having neither waterworks nor sewerage systems have been included with rural population. Information obtained in this manner was supplemented by data obtained from the State Board of Health.

The statistics collected show distances between points of pollution, the average fall of the river, and any ponding that may occur. No examination of the waters, either chemical or bacteriological, has been made to determine the actual spread of pollution, as that subject is too broad to be covered in a general report on the water resources of the State. This report indicates only in a general way the sources of pollution. A study of the quality of surface waters was made by the United States Geological Survey in cooperation with the State Board of Health some years ago.[1]

[1]Quality of Surface Waters in Minnesota: Water-Supply Paper U. S. Geol. Survey No. 193, by F. F. Westbrook and R. B. Dole. This report contains many analyses of the various river waters.

MISSISSIPPI RIVER BASIN.

MISSISSIPPI RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Mississippi River drains the greater part of Minnesota and consequently is the most important stream in the State. The portions of Minnesota lying outside this basin are the northwestern section, which is in the Red and Rainy river (Hudson Bay) basins and the northeastern part which lies in the Lake Superior basin.

Mississippi River rises in a small lake called Hernando de Soto, situated in the northeastern part of Becker County. From this lake it flows north into Lake Itasca. Above Lake Itasca it is known as Nicollet Creek. From Lake Itasca to the mouth of Crow Wing River it flows almost in a circle, as at this point it is only 75 miles from its source, while the distance following the river is 350 miles. Leaving the lakes, its course is northward, but below the junction with the Crow Wing it turns to the south and continues in this direction until it finally reaches the Gulf of Mexico.

The total length of the river from its source to the Iowa State line is about 660 miles.

The important tributaries of the Mississippi beginning at the source and following down the west bank, are Leech Lake, Willow, Pine, Crow Wing, Sauk, Crow, Minnesota, Cannon, Zumbro, and Root. On the east bank are Prairie, Elk, Rum, St. Croix, and Black.

TOPOGRAPHY AND GEOLOGY.

The entire drainage basin except the extreme southeastern part, which lies in the "Driftless Area," is covered with a drift sheet ranging in thickness from 100 to 300 feet. The bulk of the drift is composed of blue till, a compressed mixture of sand, clay, and gravel. In the eastern part of the basin, the blue till gives way to red till. In the southwestern part of the State the till is overlain by a layer of loam which is separated from the till by a distinct line of demarkation. Along the valleys of the Mississippi and most of the larger streams flowing southward are deposits of stratified gravel and sand which are found also as isolated plains in Cass, Wadena, Meeker and Kandiyohi counties. As a rule these deposits lie on the till and in many places they are covered by a finer sand. Extensive lenticular beds of stratified gravel and sand constitute a large portion of the till in the rolling or broken tracts, including the Leaf Hills in the northwestern part of the basin and the Coteau des Prairies in the southwestern part.[1] In the southeastern part of the State the basin is covered with a loess loam or stratified clay which in places is very sandy.

[1]Abstracted from N. H. Winchell, Final Report on the Geology of Minnesota, Vol. 1.

The surface of this drift sheet forms a somewhat undulating plain with comparatively slight irregularities which form long, low swells and hollows. Many of the depressions have no outlet and to them are due the multitude of swamps and lakes in the basin.

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

Below the mouth of the Crow Wing the river flows in a general southeasterly direction to the southern boundary of the State.

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

Minnesota River enters the Mississippi about eight miles below St. Anthony Falls, and below its mouth the width of the main stream averages 1,000 feet. From this point to the State line it is a broad, placid stream. In many places, especially where tributaries enter, fertile flats lie between the river and the bluffs. Fifty-five miles below the mouth of the Minnesota is Lake Pepin, an expansion of the river apparently caused by the immense quantities of sand brought down by the Chippewa.

FORESTATION.

The headwaters of the main stream and its tributaries which lie in Wisconsin and in Minnesota, north of the line drawn diagonally through Douglas, Stevens, Meeker, McLeod, Sibley, Le Sueur, Rice and Dakota counties, are in a region that was originally forested. Most of this area has been cut over extensively, although a comparatively little land has been cleared, except in the southern part of the area where agriculture is making rapid strides. The remainder of the drainage area is prairie land. The upper stretch of the basin is in the jack-pine region, the middle part is in the region of hardwood timber. Although the timbered areas have been cut over extensively, conditions are favorable for forest reproduction and in many places are growths of young conifers which are just beginning to have a commercial value.

RAINFALL AND RUNOFF.

Rainfall records have been kept for many years in various parts of the basin, and from them it is seen that the mean annual rainfall decreases from 33 inches in the extreme southeastern part of the State to 24 inches in the western part. The mean annual rainfall for the entire basin is about 27 inches and from 3 to 4 inches occurs as snow which remains during the winter months.

A number of records in the upper part of the basin show that since 1888 the wettest year was 1905 when the rainfall was about 37 inches. In the driest year, 1910, the precipitation was 17.5 inches. In the southern part of the area the longest records are those at St. Paul which are continuous since 1837. The wettest year was 1849 when the rainfall was 49.7 inches and the driest 1910 with a precipitation of 10.2 inches.

Owing to the regulation of the upper river by the reservoirs, comparisons of annual rainfall and runoff at points on the upper river do not show the natural conditions. Since 1898, however, the mean runoff for the upper 4,500 square miles of drainage area has been 7.55 inches, or 27.5 per cent of the rainfall. At St. Paul complete runoff records are available since 1900, and as the runoff from only 15 per cent of the drainage area at that point is controlled, the comparison between rainfall and runoff will be more nearly natural. The runoff has varied from 1.62 to 7.26 inches or from 5.1 to 23.9 per cent of the mean rainfall over the basin.

The following table shows the annual variation in rainfall and runoff at St. Paul:

Relation between rainfall and runoff of Mississippi River at St. Paul.

Year	Rainfall in Inches	Runoff in Inches	Percentage of Rainfall .
1900	27.12	2.44	9.0
1901	22.93	2.95	12.9
1902	27.35	2.34	8.6
1903	32.28	6.01	18.6
1904	24.88	3.92	15.8
1905	32.70	6.10	18.7
1906	33.25	7.26	21.8
1907	23.78	5.68	23.9
1908	30.38	6.00	19.7
1909	26.88	4.86	18.2
1910	15.37	2.62	17.3
1911	27.56		5.1

REGULATION OF FLOW.

According to some authorities, the basin of the upper Mississippi contains from 5,000 to 6,000 lakes, nearly all of which are near the sources of the main river and its northern tributaries. In addition there are vast swamp areas in this region, so that there is a great natural reservoir for steadying the flow of the river. Very little of this swamp land has been drained at the present time.

Far overshadowing the natural effect of the lakes and swamps on the flow of the Mississippi is the reservoir system operated by the United States Engineer Corps, chiefly in the interest of navigation below St. Paul. There are six reservoirs in the system described as follows:

Lake Winnibigoshish reservoir, which includes Cass Lake, is the unit nearest the source of the river. It is situated within the main channel of the river in Itasca, Beltrami and Cass counties, and is formed by a dam at the outlet of Lake Winnibigoshish which also controls the water of Cass Lake, further upstream. The first dam was a timber structure built in 1883-4 while the present dam is of the steel concrete type and was built in 1899-1900. The area of water surface at low water is 117 square miles and at highwater, 161 square miles. These areas with a range of 14 feet give a capacity of about 43,992,000,000 cubic feet. Cass Lake which forms a part of the Winnibigoshish reservoir has a range of about 4.75 feet between high and low water, representing a storage of some 7,500,000,000 cubic feet or 16 per cent of the total reservoir capacity. When the reservoir is full and there is a strong runoff from the drainage basin, the water elevation of Cass Lake is about one foot higher than that of Lake Winnibigoshish.

Leech Lake reservoir is the next lower unit to Winnibigoshish. It is not located on the main river but 27 miles distant, being connected by Leech Lake River which enters Mississippi River in the northeastern corner of Cass County. It is formed by a dam at the outlet of the lake, which was originally a timber structure, built in 1883-4, but rebuilt of reinforced concrete in 1900-2. The area of water surface at low water is 173 square miles, and at high water, 234 square miles. These areas with a range of head of 5.74 feet give a capacity of 33,094,300,000 cubic feet. The area of the water shed including lake area is 1,163 square miles.

Pokegama Falls reservoir which is the third unit, is formed by a dam located above Pokegama Rapids near the town of Grand Rapids. This dam which was originally a timber structure built in 1883-4 was rebuilt as a reinforced concrete dam in 1902-4, and holds the water on Pokegama Lake which is not in the main river channel but situated a short distance from it. The area of the water surface in the reservoir varies from 24 to 25 square miles, which with a range of 7.5 feet gives a capacity of 5,260,000,000 cubic feet. This reservoir is considered to be the distributor for the three upper reservoirs, the water from all of which pass Pokegama dam.

Sandy Lake reservoir is located on Sandy River which flows into Mississippi River near Libby P. O. in Aitkin County, and is formed by a dam 1 mile above the mouth of Sandy River. The dam is a timber structure built in 1895. The area of water surface at low water is 8 square miles and at high water is 16.5 square miles. These areas with a range of 9.4 feet give a capacity of about 3,157,900,000 cubic feet. In times of extreme flood stage, Mississippi River drowns out the main dam and fills Sandy Lake Reservoir as much as three feet higher than is intended for reservoir purposes.

Pine River reservoir, the next lower unit in the system, is formed by a dam across Pine River, 15 miles above its junction with Mississippi River, in the central part of Crow Wing County. The dam which was originally built in 1886, and afterwards rebuilt, is located at the outlet of Cross Lake, and raises the water level in Cross, Pine, Daggett, Rush, Whitefish, Trout, and Hay lakes by varying amounts. The area of water surface at low water is 18 square miles, and at high water, 24 square miles. These areas with a range of 16.15 feet, give a capacity of 7,732,900,000 cubic feet.

Gull Lake reservoir, the lowest unit in the system, is located in the southern part of Cass and Crow Wing counties, and comprises Gull, Round, and Long lakes which are to be connected by ditches not yet constructed. The dam which was completed in 1912 is located on Gull River a half mile below the outlet of Gull Lake, and provides for a range of stage of 6 feet in the reservoir. The area at low water is 28.2 square miles and at high stage 30.2 square miles. The reservoir capacity is 4,910,100,000 cubic feet.

Although the reservoirs are operated primarily in the interest of navigation, they also have a beneficial effect on water power and flood control. The operation during the winter, or non-navigation season, is based on the necessity for having 39,000,000,000 cubic feet empty storage capacity on April 1 to take care of the spring high water. Thus if the preceding year has been very dry and the storage has been nearly exhausted, the reservoirs allow only the normal minimum winter flow (as determined previous to building the reservoirs) to pass down the river. If the preceding navigation season has not drawn heavily on the reservoirs the winter flow is increased by a sufficient amount to make possible the required empty storage capacity April 1. During the navigation season the stored water is held until the Weather Bureau gage at St. Paul registers a stage lower than 3 feet. Then the reservoirs are opened in an attempt to hold the river at the 3-foot stage which will insure sufficient water for navigation as far down stream as Lake Pepin, below which point the effect of the stored water is largely lost.

NAVIGATION.

At the present time the head of navigation for the lower river is St. Paul, although the Federal government is building a high dam just above the mouth of the Minnesota, which will make possible slack water navigation nearly to St. Anthony Falls in Minneapolis. On the upper river there are navigable stretches from a point 10 miles below Brainerd to Grand Rapids; from Cohasset to Pokegama Lake and Ball Club; on Winnibigoshish and Cass lakes; Lake Bemidji; Lake Irving and Lake Plantagenet. The Mississippi River is used extensively for log driving as far down as Minneapolis and St. Paul.

DRAINAGE.

The upper part of the Mississippi basin is flat and contains a large amount of swamp land. The following table, compiled from the report of the State Drainage Commission, shows the present status of drainage in this section:

Artificial drainage in the Mississippi River basin in Minnesota.

County	Original Area of Swamp Land (Acres)	Area Benefited by Drainage (Acres)
Itasca	590,600	23,500
Hubbard	77,000	5,900
Cass	316,200	......
Wadena	80,000	44,000
Aitkin	529,900	219,500
Crow Wing	127,000	15,300
Total	1,720,700	308,200

This table shows that less than 20 per cent of the swamp land has been either wholly or partly drained.

DRAINAGE AREAS.

The following drainage areas have been measured in the Mississippi basin[a]:

Drainage areas in Mississippi River basin.

River.	Drainage area above.	Area Square miles.
Mississippi	Lake Bemidji outlet	596
Do	Lake Winnibigoshish outlet	1,520
Do	Prairie River	3,460
Do	Sandy River	4,510
Do	Fort Ripley	10,700
Do	Sauk Rapids	12,400
Do	Crow River	14,500
Do	Anoka	17,100
Do	Rice Creek	18,800
Do	Minnesota River	19,200
Do	St. Paul	35,700
Yellow Head	Lake Plantagenet inlet	136
Turtle	Turtle Lake outlet	106
Do	Mouth	270
Pigeon	do	116
Leech Lake River	Leech Lake outlet	1,240
Do	Mouth	1,400
Steamboat	do	144
Kabekona	West Bay inlet	106
Boy	Woman Lake	207
Do	Mouth	482
Deer	do	136
Vermilion	do	34
Prairie	Lake Wabana outlet	360
Do	Mouth	501
Wabana Lake Outlet	do	89
Split Hand Lake Outlet	do	44
Swan	Swan Lake outlet	113
Do	Mouth	340
Sandy	do	424
Savanna	do	40
Prairie	Tamarack River	81
Do	Mouth	201
Tamarack	do	108
Rice Lake Outlet	do	118
Willow	Big Rice Lake outlet	62
Do	Mouth	455
Hill	do	82
Moose	do	92
Rice	do	327
Mud	do	94
Little Willow	do	85
Pine	Government Dam	452
Do	Mouth	694
Nokasippi	do	268
Long Lake Outlet	do	132
Little Elk	do	152
Swan	do	144
Two Rivers	do	126
Spunk Brook	do	124
Platte	Skunk River	87
Do	Mouth	353
Skunk	do	146
Little Rock	do	93
Watab	do	84
Clearwater	do	183
Coon Creek	do	106
Rice Creek	do	214
Minnehaha Creek	Lake Minnetonka outlet	127
Do	Mouth	192
Vermilion	do	258
Whitewater	North Branch	42
Do	Mouth	343
North Branch Whitewater	do	126
South Branch Whitewater	do	111

[a] For areas in the basins of Crow Wing, Sauk, Elk, Crow, Rum, St. Croix, Minnesota, Cannon, Zumbro, Root, Cedar, and Des Moines rivers, see descriptions of those rivers.

GAGING STATION RECORDS.

MISSISSIPPI RIVER ABOVE SANDY RIVER.

Location.—A short distance above the mouth of Sandy River in Sec. 25, T. 50 N., R. 24 W., near Libby postoffice in Aitkin County.

Records available.—September 1, 1895, to December 31, 1912.

Drainage area.—4,510 square miles.

Gage.—Vertical Staff.

Discharge measurements.—Made by an employee stationed at Sandy Lake dam nearby.

Cooperation.—This station is maintained by the United States Engineer Corps for the purpose of determining the flow of the river above Sandy Lake Reservoir. The results are taken from unpublished records in the United States Engineer Office at St. Paul.

Daily discharge, in second-feet, of Mississippi River above Sandy River.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1895.					1895.				
1	2,192	2,322	2,128	1,216	16	2,206	2,059	2,087	668
2	2,193	2,375	1,866	1,161	17	2,207	1,870	2,047	653
3	2,194	2,256	1,908	1,106	18	2,208	1,988	2,007	638
4	2,195	2,281	1,951	1,070	19	2,209	2,008	1,967	636
5	2,196	2,240	1,993	1,034	20	2,210	2,009	1,880	634
6	2,197	2,295	1,974	999	21	2,211	2,011	1,794	633
7	2,198	2,350	1,954	963	22	2,212	2,183	1,707	620
8	2,199	2,429	1,995	923	23	2,213	1,982	1,620	606
9	2,200	2,193	2,036	883	24	2,213	2,012	1,533	592
10	2,201	2,177	2,077	843	25	2,213	2,042	1,447	579
11	2,201	2,240	2,118	804	26	2,214	1,911	1,360	565
12	2,202	2,293	2,159	768	27	2,214	1,977	1,333	552
13	2,203	2,218	2,200	733	28	2,215	2,043	1,306	538
14	2,204	2,142	2,229	698	29	2,251	2,109	1,278	518
15	2,205	2,248	2,258	683	30	2,286	2,176	1,251	498
					31	....	2,163	....	477

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
1	430	438	230	600	5,011	....	2,065	1,687	1,965	2,120	3,133	1,055
2	400	435	235	620	5,376	....	2,120	1,754	1,985	2,059	3,181	1,009
3	380	432	230	610	....	....	2,180	1,821	2,080	2,103	3,230	963
4	400	429	225	585	....	....	2,210	1,890	2,175	2,148	3,245	918
5	450	426	210	565	....	....	2,190	1,957	2,270	2,193	3,235	895
6	480	423	185	545	....	3,840	2,160	2,024	2,365	2,238	3,200	874
7	420	419	180	516	....	3,763	2,077	2,091	2,323	2,282	2,600	853
8	380	416	165	530	....	3,687	1,994	2,157	2,348	2,327	2,030	832
9	410	413	165	535	....	3,611	1,911	2,223	2,367	2,372	1,900	810
10	410	410	175	555	....	3,534	1,829	2,289	2,450	2,417	1,785	808
11	410	407	183	610	....	3,458	1,746	2,357	2,400	2,462	1,755	806
12	410	404	200	950	....	3,382	1,663	2,423	2,350	2,507	1,745	804
13	465	392	230	1,750	....	3,305	1,580	2,489	2,300	2,551	1,740	803
14	465	380	258	2,150	....	3,229	1,544	2,555	2,250	2,596	1,740	801
15	445	368	290	2,425	....	3,153	1,509	2,558	2,200	2,641	1,740	799
16	440	460	330	2,550	....	3,077	1,473	2,562	2,150	2,686	1,740	807
17	460	445	348	2,655	....	3,000	1,438	2,565	2,100	2,731	1,694	816
18	460	415	350	2,750	....	2,924	1,402	2,569	2,050	2,775	1,648	824
19	420	270	350	2,826	....	2,848	1,367	2,572	2,100	2,820	1,603	833
20	470	180	360	2,925	....	2,800	1,331	2,575	2,150	2,865	1,557	841
21	520	130	365	2,820	....	2,750	1,291	2,531	2,200	2,910	1,511	850
22	520	115	365	2,400	....	2,860	1,251	2,487	2,250	2,955	1,466	858
23	445	125	375	2,350	....	2,925	1,210	2,443	2,300	3,000	1,420	867
24	490	130	385	2,675	....	2,675	1,170	2,400	2,350	3,000	1,374	901
25	530	145	405	2,960	....	2,375	1,172	2,356	2,400	3,000	1,329	935

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
26	520	160	422	3,250		1,814	1,175	2,312	2,420	3,000	1,283	969
27	520	175	439	3,547		1,920	1,210	2,239	2,360	3,000	1,237	1,002
28	520	200	455	3,913		1,975	1,300	2,166	2,300	3,000	1,192	1,036
29	495	225	484	4,279		2,025	1,390	2,094	2,240	3,000	1,146	1,070
30	425		513	4,645		2,000	1,485	2,021	2,180	3,043	1,100	1,104
31	438		541				1,590	1,948		3,085		1,138
1897.												
1	1,010	900	690	1,417	3,062	2,754	2,999	4,685	2,174	2,756		2,958
2	906	860	694	1,590	3,023	2,680	2,758	4,464	2,199	2,794		2,971
3	802	851	681	1,764	2,983	2,605	3,714	4,242	2,224	2,832		2,889
4	699	843	668	2,104	2,944	2,531	4,671	4,020	2,333	2,869		2,846
5	595	834	654	2,444	2,904	2,457	5,627	3,798	2,443	2,907		2,742
6	590	833	641	2,784	3,174	2,382	5,793	3,576	2,552	2,607		2,733
7	585	831	633	3,124	3,444	2,308	5,960	3,468	2,661	2,307		2,621
8	580	830	625	3,464	3,582	2,535	6,126	3,359	2,736	2,007		2,625
9	585	828	616	3,804	3,719	2,762	6,292	3,251	2,811	2,105		2,612
10	590	769	638	4,143	3,857	2,989	6,459	3,142	2,886	2,203		2,526
11	594	710	658	4,483	3,771	3,210	6,625	3,116	2,961	2,301		2,405
12	599	651	662	4,823	3,686	3,432	6,791	3,090	2,935	2,256		2,345
13	603	662	667	5,163	3,600	3,653	6,957	3,064	2,908	2,210		2,272
14	606	674	671	5,503	3,486	3,591	7,124	3,069	2,882	2,165		2,280
15	609	685	675	5,843	3,371	3,529	7,290	3,073	2,878	2,119		2,190
16	702	696	679	5,443	3,256	3,467	7,456	3,078	2,874	2,155		2,117
17	796	693	686	5,040	3,141	3,405	7,623	3,082	2,870	2,192		2,018
18	890	690	692	4,863	2,914	3,561	7,789	3,051	2,866	2,228		1,872
19	905	687	699	4,683	2,686	3,717	7,567	3,021	2,862	2,264		1,576
20	920	688	706	4,503	2,459	3,873	7,346	2,990	2,859	2,420		1,339
21	922	689	736	4,323	2,232	3,828	7,124	2,903	2,870	2,576		1,473
22	924	690	765	4,143	2,176	3,739	6,902	2,817	2,881	2,732		1,659
23	926	691	800	3,962	2,119	3,763	6,681	2,730	2,893	2,811		1,746
24	928	692	836	3,782	2,063	3,695	6,459	2,643	2,902	2,890		1,785
25	930	689	871	3,602	2,007	3,650	6,237	2,557	2,915	2,969		1,828
26	893	685	906	3,422	1,951	3,517	6,015	2,470	2,789	3,048		1,832
27	900	681	947	3,342	1,894	3,384	5,794	2,383	2,662	3,030		1,815
28	908	685	987	3,262	1,838	3,252	5,572	2,296	2,536	3,011		1,802
29	915		1,028	3,182	2,168	3,119	5,350	2,010	2,609	2,993		1,794
30	923		1,069	3,102	2,498	2,878	5,129	2,123	2,683	3,060		1,768
31	930				2,828		4,907	2,148		3,127		1,746
1898.												
1	1,716	1,257	1,289	1,472	1,514	2,377	3,481	3,278	3,156	2,071	3,597	2,042
2	1,693	1,207	1,280	1,467	1,608	2,344	3,558	3,278	3,276	2,976	3,551	2,037
3	1,670	1,207	1,289	1,472	1,737	2,592	3,580	3,225	3,446	3,025	3,538	2,037
4	1,647	1,217	1,289	1,502	1,876	3,584	3,851	3,198	3,557	3,038	3,591	2,037
5	1,577	1,227	1,300	1,513	1,725	4,261	3,851	3,104	3,589	2,957	3,371	2,032
6	1,507	1,237	1,322	1,513	1,647	4,404	3,941	2,872	3,602	2,949	3,432	2,032
7	1,507	1,237	1,324	1,475	1,636	4,490	3,986	2,740	3,616	2,980	3,612	2,008
8	1,393	1,299	1,303	1,511	1,626	4,547	4,053	2,770	3,580	2,989	3,619	1,930
9	1,291	1,361	1,282	1,500	1,626	4,633	3,615	2,604	3,304	2,976	3,698	1,933
10	1,291	1,361	1,259	1,511	1,748	4,088	3,570	2,538	3,304	2,998	3,724	1,845
11	1,302	1,350	1,297	1,404	1,814	4,112	4,121	2,478	3,281	2,989	3,671	1,724
12	1,313	1,339	1,335	1,457	1,876	4,121	4,121	2,527	3,255	2,958	3,797	1,680
13	1,324	1,328	1,373	1,393	1,898	4,178	4,008	2,461	3,188	2,954	3,739	1,629
14	1,335	1,316	1,411	1,404	1,937	4,236	3,940	2,394	3,121	2,940	3,693	1,619
15	1,337	1,328	1,327	2,193	2,110	4,207	4,396	2,527	2,121	2,904	3,660	1,566
16	1,369	1,340	1,238	1,515	2,227	4,441	4,283	2,758	3,167	2,895	3,613	1,457
17	1,401	1,352	1,327	1,280	2,367	4,465	4,211	3,023	3,390	2,900	3,654	1,423
18	1,403	1,364	1,351	1,216	2,439	4,438	4,170	3,023	3,591	2,904	3,594	1,330
19	1,405	1,379	1,375	1,173	2,371	4,385	4,361	2,748	3,672	2,936	3,555	1,386
20	1,407	1,327	1,399	1,146	2,019	4,383	4,361	2,714	3,563	2,945	3,407	1,352
21	1,409	1,275	1,423	1,194	2,098	4,192	4,057	2,682	3,384	2,954	3,414	1,322
22	1,448	1,266	1,447	1,221	2,282	4,001	3,852	2,781	3,362	2,927	3,731	1,327
23	1,487	1,257	1,471	1,424	2,008	3,830	3,757	2,847	3,312	2,913	3,513	1,118
24	1,487	1,248	1,495	1,595	2,297	3,619	3,668	2,815	3,401	2,904	3,506	1,084
25	1,426	1,237	1,519	1,708	2,593	3,449	3,536	2,749	3,289	2,895	1,821	1,050
26	1,365	1,255	1,543	1,745	2,570	3,404	3,504	2,749	3,070	2,891	1,953	1,033
27	1,304	1,273	1,567	1,836	2,394	3,285	3,468	2,742	3,047	2,895	2,059	1,011
28	1,304	1,291	1,591	1,809	2,148	3,276	3,445	2,762	3,114	2,886	2,442	958
29	1,305		1,594	1,574	2,386	3,324	3,423	2,874	3,204	2,878	2,488	934
30	1,306		1,514	1,499	2,341	3,349	3,577	2,894	3,460	2,869	2,521	929
31	1,306		1,476		2,263		3,541	2,841		2,846		900

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1	1,378	1,228	1,122	1,322	4,299	7,705	6,446	2,697	4,824	3,381	4,546	2,153
2	1,353	1,228	1,122	1,365	4,567	7,730	6,317	2,783	4,912	3,437	4,437	2,101
3	1,341	1,256	1,132	1,396	4,706	7,788	6,168	2,761	4,906	3,480	4,394	2,084
4	1,335	1,251	1,122	1,368	4,674	7,843	5,760	3,031	4,580	3,462	4,286	1,984
5	1,329	1,194	1,122	1,381	4,744	7,896	5,178	3,385	4,416	3,391	4,205	1,481
6	1,329	1,222	1,122	1,368	4,728	7,897	4,291	3,540	4,384	3,479	4,080	1,226
7	1,304	1,216	1,101	1,385	4,728	7,942	4,548	3,498	4,416	3,422	4,722	1,187
8	1,292	1,211	1,074	1,350	4,811	7,987	4,496	3,427	4,427	3,026	4,624	1,468
9	1,304	1,183	1,013	1,387	4,806	8,026	4,496	3,498	4,267	2,985	4,510	1,705
10	1,297	1,172	1,022	1,297	4,891	8,045	4,535	3,554	4,354	3,125	4,661	1,890
11	1,292	1,044	1,050	1,345	5,025	8,064	4,405	3,786	4,403	3,054	4,590	2,136
12	1,297	1,016	1,103	1,396	5,293	8,080	4 217	3,786	4,234	3,295	4,487	2,351
13	1,292	992	1,145	1,448	5,346	8,097	4,185	3,455	4,234	3,379	4,521	2,515
14	1,292	1,019	1,134	1,506	5,336	8,113	4,191	3,428	4,278	3,379	4,494	2,644
15	1,286	1,019	1,155	1,539	5,325	8,123	4,081	3,335	4,229	4,725	4,195	2,653
16	1,280	1,101	1,207	1,539	5,114	8,134	3,971	3,271	4,523	4,202	4,033	2,631
17	1,300	1,101	1,137	1,452	5,141	8,154	3,862	3,568	4,464	5,916	4,112	2,686
18	1,281	1,101	1,127	1,409	5,151	8,161	3,756	3,342	4,172	6,581	3,947	2,734
19	1,281	1,090	1,127	1,478	5,307	8,160	3,691	3,696	4,112	7,629	3,887	2,764
20	1,323	1,079	1,112	1,591	5,285	8,158	3,659	4,193	4,074	4,853	3,752	2,734
21	1,323	1,079	1,112	1,808	5,864	8,157	3,551	4,590	4,052	6,057	3,714	2,592
22	1,317	1,011	1,112	1,855	5,907	8,156	3,499	4,788	4,211	6,085	3,654	2,424
23	1,262	994	1,133	1,778	5,182	8,153	3,454	5,432	4,205	6,531	3,627	2,338
24	1,268	971	1,143	1,795	5,000	8,146	3,369	4,232	4,297	6 474	3,578	2,338
25	1,268	960	1,143	1,907	5,214	8,139	3,279	4,430	4,134	6,375	3,627	2,351
26	1,268	971	1,164	2,098	5,144	8,125	3,326	4,430	4,030	6,304	3,638	2,179
27	1,262	1,099	1,136	2,135	5,214	8,109	3,191	4,381	3,970	5,724	3,835	1,869
28	1,267	1,122	1,177	2,223	4,984	8,099	3,012	4,317	3,954	5,511	3,803	1,857
29	1,261	......	1,363	2,283	4,808	8,084	2,851	4,203	4,103	5,369	3,765	1,964
30	1,328	......	1,519	2,314	4,650	8,064	2,657	3,664	4,081	5,040	3,760	2,029
31	1,316	......	1,612	......	4,821	......	2,440	3,487	......	4,757	......	2,007
1900.												
1	2,062	1,672	1,323	1,385	2,099	2,054	1,288	891	4,230	5,774	2,586	852
2	2,036	1,637	1,323	1,416	1,833	2,084	1,087	763	3,573	5,792	2,490	852
3	1,949	1,602	1,323	1,426	1,511	2,017	1,035	750	3,408	5,574	2,539	831
4	1,924	1,595	1,323	1,472	1,384	1,447	1,020	555	3,077	5,384	2,645	831
5	1,915	1,547	1,340	1,477	1,909	1,384	1,370	549	3,392	5,121	2,653	831
6	1,876	1,528	1,340	2,097	2,119	1,495	1,258	1,072	3,901	5,216	2,463	831
7	1,841	1,528	1,340	2,188	773	1,510	1,191	1,535	3,599	5,216	2,456	661
8	1,808	1,500	1,350	2,199	843	1,517	1,153	1,877	3,599	4,673	2,421	639
9	1,788	1,550	1,350	2,364	983	1,613	1,459	1,837	3,484	4,655	2,396	618
10	1,759	1,563	1,390	2,558	913	1,532	1,691	1,780	3,069	4,854	2,526	618
11	1,720	1,550	1,400	2,722	1,406	1,405	1,616	2,088	3,562	5,081	2,474	728
12	1,635	1,578	1,408	2,917	1,763	1,290	1,213	2,129	3,890	4,914	2,552	719
13	1,635	1,557	1,397	2,851	1,588	1,186	1,377	1,909	4,745	4,823	2,443	694
14	1,625	1,524	1,365	2,569	1,641	1,179	1,675	2,083	4,903	4,642	2,376	578
15	1,615	1,524	1,276	2,220	1,697	1,428	1,474	2,124	7,023	4,724	2,300	574
16	1,823	1,459	1,276	2,210	1,851	1,461	1,571	2,117	7,516	4,497	2,224	574
17	1,842	1,452	1,349	2,664	1,920	1,350	1,871	2,365	9,078	4,279	2,259	653
18	1,818	1,438	1,412	2,631	2,176	1,266	1,802	2,419	9,145	3,999	2,295	641
19	1,777	1,438	1,449	2,210	2,071	1,282	1,340	2,365	9,391	3,808	2,219	641
20	1,767	1,452	1,439	1,954	2,127	1,245	974	2,461	9,572	3,618	2,043	641
21	1,762	1,433	1,439	1,918	2,043	1,208	959	2,588	9,196	3,446	1,990	673
22	1,757	1,424	1,449	1,800	2,022	1,106	1,257	2,823	9,032	3,876	1,937	673
23	1,757	1,390	1,459	1,775	2,064	1,001	1,422	3,125	8,994	3,577	1,919	673
24	1,757	1,355	1,314	2,224	2,022	1,067	1,496	3,660	9,032	3,215	1,902	696
25	1,752	1,335	1,345	2,173	1,952	1,284	1,489	3,528	8,966	2,762	1,866	704
26	1,752	1,387	1,371	2,265	2,003	1,309	1,272	3,628	8,999	2,566	1,849	713
27	1,792	1,387	1,401	2,332	1,994	1,346	994	3,716	8,900	2,502	1,813	704
28	1,816	1,387	1,401	2,614	1,939	1,309	1,054	3,628	8,834	2,539	1,803	694
29	1,635	......	1,417	2,152	1,904	1,264	994	3,501	8,538	2,883	1,778	694
30	1,625	......	1,466	2,148	1,911	1,153	758	3,333	7,552	3,155	932	694
31	1,596	......	1,476	......	1,848	......	549	3,360	......	2,901	......	633
1901.												
1	601	753	1,533	2,053	5,851	4,640	6,878	3,176	3,346	2,683	3,700	2,325
2	600	763	1,453	2,053	6,025	4,640	6,905	3,255	3,306	2,648	3,694	2,334
3	610	770	1,388	2,104	6,129	4,681	6,950	2,860	3,219	2,708	3,717	2,325
4	633	780	1,348	2,171	6,185	4,647	6,950	2,662	3,158	2,825	3,717	2,136
5	633	813	1,348	2,293	6,206	4,640	6,950	2,544	3,102	3,030	3,717	2,127

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
6	628	913	1,284	2,324	6,185	4,536	6,591	2,480	2,790	3,124	3,759	2,001
7	584	997	1,228	2,293	6,192	4,509	6,546	2,423	2,734	3,453	3,653	1,992
8	584	851	1,448	2,113	6,241	4,446	6,495	2,692	2,632	3,553	3,688	1,974
9	584	753	1,414	2,688	6,234	4,315	6,428	3,292	2,880	3,574	3,747	2,001
10	584	858	1,430	2,837	6,486	3,887	6,332	3,324	2,900	3,609	3,747	2,001
11	627	901	1,612	3,154	6,430	3,566	6,265	2,250	2,900	3,344	3,717	2,046
12	627	964	1,620	3,458	6,402	3,465	5,318	2,242	2,900	3,385	3,653	2,046
13	627	1,047	1,724	3,995	6,354	3,472	5,177	2,336	2,773	3,385	3,571	2,046
14	619	1,080	1,741	4,267	6,399	3,437	5,161	2,423	2,763	3,397	3,453	2,023
15	628	1,118	1,821	4,416	6,301	3,499	5,054	2,352	2,712	3,408	3,453	1,978
16	646	1,052	1,813	4,687	6,176	3,983	5,542	2,344	2,773	3,322	3,453	1,955
17	650	1,079	1,829	4,772	4,657	4,363	4,918	2,348	2,834	3,310	3,629	1,739
18	519	1,146	1,749	4,901	4,490	4,577	4,188	2,316	2,854	3,310	3,559	1,622
19	528	1,196	1,765	5,030	4,072	4,674	3,860	2,308	2,854	3,280	3,489	1,626
20	519	1,319	2,006	5,192	4,404	4,736	3,287	2,143	2,720	3,287	3,489	1,622
21	510	1,419	1,894	5,289	3,972	4,770	3,062	2,158	2,720	3,639	3,489	1,604
22	510	1,523	1,861	5,354	4,002	4,575	2,787	2,474	2,730	3,639	3,489	1,595
23	528	1,543	1,820	5,464	4,049	4,630	3,087	2,774	2,565	3,645	3,489	1,595
24	546	1,620	2,286	5,587	4,243	6,598	3,059	2,940	2,550	3,651	3,489	1,595
25	598	1,519	2,334	5,677	3,922	7,344	2,468	3,035	2,550	3,641	3,489	1,654
26	620	1,485	2,286	5,768	3,797	7,682	2,412	4,028	2,580	3,629	3,489	1,659
27	643	1,519	2,181	5,826	4,335	7,979	2,446	3,972	2,889	3,617	3,489	1,659
28	629	1,519	2,119	5,890	4,238	8,256	2,480	3,845	2,848	3,374	3,789	1,659
29	633	......	2,031	5,993	4,203	8,588	2,835	3,727	2,848	3,386	3,676	1,659
30	633	......	1,951	6,220	4,342	8,823	2,779	3,178	2,865	3,421	3,541	1,668
31	633	......	1,859	......	3,819	......	2,756	2,996	......	3,433	......	1,673
1902												
1	1,656	1,492	1,448	3,192	1,962	4,541	2,588	1,708	2,272	2,374	3,110	2,943
2	1,656	1,397	1,448	3,046	2,104	4,413	2,525	2,059	2,450	2,425	3,625	2,950
3	1,656	1,216	1,490	2,783	2,245	4,447	2,404	2,163	2,552	2,297	4,165	2,936
4	1,629	1,238	1,396	2,385	2,822	4,233	2,404	1,629	2,640	2,168	4,449	2,936
5	1,614	1,365	1,438	2,269	2,570	4,062	2,549	1,492	2,692	2,156	4,839	2,975
6	1,595	1,444	1,475	2,648	2,750	4,021	2,404	1,540	2,705	2,068	5,372	3,038
7	1,536	1,311	1,469	2,789	2,678	4,124	2,353	1,586	2,679	2,042	5,709	3,153
8	1,517	1,311	1,470	2,473	2,678	4,166	2,258	1,673	2,660	2,119	5,744	3,194
9	1,507	1,295	1,474	2,064	3,038	4,121	2,529	1,653	2,609	2,223	6,001	3,289
10	1,324	1,271	1,506	2,251	2,750	4,164	2,626	1,595	2,596	2,334	6,053	3,309
11	1,324	1,192	1,516	2,286	2,822	4,206	2,684	1,589	2,558	2,231	6,330	2,543
12	1,314	1,128	1,463	2,222	2,827	4,181	2,684	1,524	2,341	2,231	6,508	2,556
13	1,522	1,176	1,500	2,269	2,834	4,085	2,684	1,511	2,379	2,532	6,597	2,556
14	1,522	1,161	1,645	2,123	3,036	3,999	2,684	1,452	2,328	2,467	6,543	2,550
15	1,512	1,136	1,708	2,006	3,097	3,914	1,990	1,417	2,407	2,377	6,561	2,425
16	1,517	1,107	1,856	2,035	3,025	3,768	1,844	1,423	2,280	2,300	6,685	2,495
17	1,470	1,117	1,909	2,153	3,025	3,717	1,699	1,469	2,191	2,303	6,898	2,448
18	1,460	1,139	1,909	2,018	3,025	3,657	1,546	1,438	2,203	2,329	6,845	2,373
19	1,355	1,148	1,877	1,988	2,998	3,512	1,626	1,399	2,179	2,393	6,863	2,349
20	1,435	1,148	1,937	1,842	3,358	4,027	1,577	1,399	2,166	2,604	6,863	2,274
21	1,416	1,155	2,008	1,813	5,305	3,864	1,516	1,386	2,102	2,617	6,898	2,233
22	1,416	1,161	2,036	1,334	6,257	3,676	1,929	1,568	2,259	2,668	6,898	2,220
23	1,449	1,202	2,036	1,936	6,257	3,574	2,171	1,490	2,297	2,642	7,076	2,064
24	1,521	1 270	2,056	1,936	6,185	3,351	2,050	1,470	2,386	2,152	6,987	2,131
25	1,422	1,301	1,961	1,936	5,990	3,420	1,923	1,433	2,386	2,203	7,005	2,030
26	1,427	1,301	1,945	1,982	6,084	2,949	1,583	1,550	2,223	2,345	6,863	1,960
27	1,436	1,321	2,130	1,982	6,293	3,137	1,316	1,582	2,236	2,384	6,754	1,838
28	1,415	1,439	2,262	1,935	5,048	2,795	1,024	1,861	2,299	2,504	6,666	1,743
29	1,348	......	2,246	1,509	4,954	2,539	1,243	2,185	2,484	2,607	6,524	1,671
30	1,401	......	2,458	1,771	4,735	2,009	1,365	2,822	2,420	2,716	6,524	1,641
31	1,434	......	2,342	......	4,198	......	1,729	2,831	......	2,819	......	1,573
1903.												
1	1,880	1,133	1,119	1,199	2,736	2,818	1,739	1,961	1,592	2,621	2,464	796
2	1,760	1,162	1,047	1,045	2,690	2,714	1,836	1,879	1,581	2,612	2,371	775
3	1,754	1,147	1,137	1,342	2,649	2,061	1,756	1,825	1,638	2,644	2,442	771
4	1,716	1,123	1,122	1,557	3,169	2,622	1,473	1,809	1,581	3,092	2,362	778
5	1,753	1,104	1,107	1,342	3,160	2,529	1,461	1,833	1,694	3,360	2,373	778
6	1,696	1,088	929	1,557	3,119	2,889	1,955	1,864	1,700	3,437	1,821	778
7	1,658	1,078	899	1,749	3,032	2,341	1,909	1,910	1,564	3,987	1,797	777
8	1,620	1,073	869	1,966	3,032	1,948	2,273	1,852	1,587	4,473	1,761	775
9	1,431	1,154	951	2,184	2,968	1,948	2,544	1,813	1,899	4,802	1,591	775
10	1,399	1,149	966	2,280	3,278	1,928	2,656	1,754	2,075	4,949	1,602	777

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
11	1,361	1,125	921	2,606	3,597	1,936	2,542	1,697	2,166	4,974	1,625	775
12	1,595	1,115	906	2,990	3,907	2,107	2,258	1,631	2,602	5,041	1,474	773
13	1,563	1,130	803	3,451	4,103	2,047	1,773	1,558	2,868	4,919	1,431	771
14	1,544	1,120	863	4,078	4,103	1,967	1,557	1,374	3,056	4,198	1,409	771
15	1,531	1,115	878	4,750	4,166	2,007	1,518	1,324	3,181	4,785	1,389	775
16	1,466	1,091	893	4,366	4,212	2,007	1,602	1,370	3,368	4,308	1,236	773
17	1,434	1,085	977	4,142	4,234	1,887	1,568	1,455	3,425	4,398	1,226	771
18	1,396	1,051	1,007	4,346	4,234	1,867	1,630	1,366	3,571	4,487	1,215	780
19	1,371	1,037	1,127	4,462	4,266	1,795	1,710	1,339	3,747	4,430	1,389	780
20	1,402	1,075	1,217	4,590	4,234	1,611	1,718	1,331	3,809	4,308	1,409	783
21	1,472	1,065	1,232	4,750	4,156	1,454	1,792	1,265	3,550	4,116	1,376	781
22	1,292	1,041	1,232	4,462	4,002	1,204	1,780	1,323	3,818	3,912	912	783
23	1,273	1,020	985	4,209	3,806	1,124	1,650	1,257	3,829	3,845	1,018	785
24	1,241	986	1,015	3,958	3,496	1,132	1,734	1,121	3,454	3,685	998	786
25	1,235	976	1,015	3,803	3,883	1,132	2,035	1,160	3,519	3,436	947	774
26	1,281	964	1,015	3,803	3,564	1,313	1,972	1,183	3,269	3,116	837	772
27	1,268	964	1,113	3,585	3,482	1,477	1,548	1,140	3,070	2,445	837	760
28	1,287	964	1,128	3,234	3,214	1,473	1,485	1,319	2,969	1,984	837	772
29	1,249	......	1,143	3,213	3,451	1,521	1,457	1,346	2,923	1,741	837	642
30	1,190	......	1,095	2,986	3,396	1,525	1,468	1,346	2,906	2,357	686	642
31	1,058	......	1,185	......	3,269	......	1,911	1,321	......	2,805	......	641
1904.												
1	654	698	636	818	3,491	2,212	1,993	1,756	1,835	2,162	2,242	647
2	707	644	638	842	3,468	2,306	1,971	1,851	2,145	2,123	1,911	875
3	721	638	653	870	3,451	2,118	2,100	1,818	2,155	2,069	1,806	875
4	730	583	657	917	3,422	2,102	2,081	1,588	2,195	1,960	1 826	858
5	725	583	654	853	3,371	2,443	1,916	1,679	1,955	1,890	1,747	834
6	663	550	651	1,284	3,360	2,244	1,970	1,919	1,486	1,867	2,014	823
7	654	568	629	1,463	3,377	2,424	1,862	2,039	1,788	1,890	2,219	823
8	673	604	624	1,750	3,434	2,707	1,674	1,833	1,888	1,780	1,984	806
9	668	600	653	1,901	3,434	2,809	1,592	1,891	1,888	1,795	1,931	744
10	654	604	653	2,090	3,392	2,707	1,754	1,824	1,948	1,780	1,973	702
11	664	610	676	2,261	3,392	2,644	1,819	1,790	2,087	1,920	1,658	768
12	664	646	683	2,412	3,375	2,400	1,685	1,869	2,087	2,075	1,642	778
13	664	628	618	2,554	3,255	2,174	1,831	1,786	1,888	2,194	1,616	803
14	664	628	659	2,701	3,232	2,072	1,734	1,800	1,788	2,227	1,768	796
15	739	634	649	2,809	3,187	2,245	1,535	2,162	1,718	2,281	1,673	790
16	734	616	647	2,890	3,311	2,127	1,535	2,315	1,626	2,406	1,636	793
17	720	536	611	2,961	3,260	1,925	1,913	2,287	1,647	2,571	1,521	779
18	776	584	606	3,003	3,197	1,806	1,676	1,970	1,827	2,594	1,411	786
19	773	612	583	3,098	2,998	1,927	1,471	1,717	1,638	2,726	1,603	768
20	773	624	614	3,216	2,644	1,718	1,493	1,780	1,568	2,804	1,687	768
21	749	642	614	3,278	2,559	1,888	1,638	1,795	1,638	2,827	1,645	771
22	593	621	660	3,278	2,479	1,932	1,527	1,780	1,698	2,858	1,520	847
23	640	633	609	3,311	2,700	1,751	1,678	1,607	1,781	3,030	1,483	820
24	659	633	592	3,344	2,683	1,701	1,732	1,799	1,936	2,859	1,310	813
25	754	633	740	3,754	2,711	1,875	1,732	1,909	1,966	2,587	1,257	837
26	722	615	779	3,590	2,711	1,987	1,376	1,794	1,956	2,564	1,204	827
27	736	615	751	3,609	2,691	2,079	1,317	1,880	1,896	2,331	1,189	848
28	727	633	677	3,558	2,651	2,074	1,614	1,843	1,906	1,973	948	772
29	706	639	671	3,530	2,623	1,900	1,961	1,848	1,876	1,929	985	758
30	701	......	665	3,535	2,583	1,746	1,918	1,857	1,836	2,240	1,001	745
31	687	......	694	......	2,287	......	1,691	1,891	......	2,652	......	773
1905.												
1	799	668	665	1,570	2,150	3,916	6,579	5,460	5,621	5,331	3,411	3,424
2	826	683	653	1,593	1,605	3,961	6,695	5,661	5,707	5,312	3,424	3,420
3	831	679	653	1,787	1,398	3,943	6,765	6,057	6,057	5,288	3,342	3,440
4	873	682	754	1,880	2,109	3,718	7,067	6,425	6,094	5,263	3,273	3,450
5	873	679	720	2,010	2,490	3,817	7,394	7,495	6,051	5,227	3,264	3,455
6	528	675	712	2,263	2,514	3,799	7,644	7,816	5,991	5,309	3,361	3,458
7	528	679	733	2,428	2,526	4,121	7,851	8,139	5,974	4,923	3,329	3,460
8	523	679	745	2,506	2,701	3,911	7,955	8,278	5,974	4,156	3,264	3,465
9	738	637	745	2,512	2,781	4,271	8,123	8,299	5,975	3,361	3,220	3,470
10	737	658	698	2,529	2,997	4,121	8,254	8,203	5,986	3,146	3,100	3,472
11	735	565	671	2,576	3,294	4,308	8,278	7,920	5,991	3,128	2,911	3,480
12	735	565	671	2,593	3,636	3,836	8,254	7,796	6,003	3,116	3,012	3,475
13	733	565	556	2,608	4,034	3,535	8,087	7,559	6,108	3,041	3,037	3,465
14	737	588	512	2,602	4,262	3,929	7,897	7,331	6,163	3,004	2,980	3,460
15	741	721	769	2,593	4,311	3,975	7,571	7,264	6,178	3,151	3,018	3,455

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
16	748	634	736	2,587	4,343	4,122	7,198	7,136	6,163	3,360	3,031	3,450
17	721	617	725	2,581	4,419	5,076	6,889	7,020	6,064	3,347	2,974	3,425
18	739	689	715	2,253	4,457	5,847	6,577	6,846	5,991	3,437	2,911	3,420
19	748	689	762	2,175	4,622	6,245	6,460	6,714	5,861	3,511	2,980	3,419
20	686	581	762	2,065	4,654	6,346	6,325	6,617	5,886	3,651	3,012	3,360
21	688	574	762	1,802	4,654	6,386	6,292	6,503	5,892	3,694	3,056	3,360
22	682	591	769	1,620	4,660	6,401	6,037	6,317	5,871	3,731	3,128	3,350
23	693	591	796	1,620	4,419	6,361	5,822	6,243	5,735	3,780	3,163	3,355
24	735	595	791	1,718	4,170	5,873	5,493	6,150	5,612	3,823	3,213	3,340
25	724	595	791	1,840	3,993	6,397	5,754	6,038	5,600	3,909	3,472	3,345
26	728	670	791	1,808	3,673	6,798	5,597	5,963	5,442	4,075	3,711	3,342
27	762	607	818	1,927	3,389	6,857	5,342	5,951	5,436	4,118	3,824	3,420
28	754	586	931	2,001	3,127	6,870	5,330	5,686	5,442	4,051	3,799	3,425
29	758	......	888	1,972	2,871	6,885	5,330	5,624	5,467	4,032	3,742	3,420
30	684	......	931	2,001	2,712	6,918	5,330	5,589	5,436	3,971	3,459	3,390
31	641	......	1,104	......	2,712	......	5,330	5,514	......	3,971	......	3,420
1906.												
1	3,440	2,578	2,945	2,703	7,306	5,770	4,780	2,440	1,966	2,636	2,793	3,250
2	3,440	2,516	2,929	2,881	7,158	5,526	4,798	2,406	1,971	2,822	2,741	3,232
3	3,450	2,516	2,914	3,060	7,010	5,206	4,786	2,373	1,976	3,008	2,687	3,213
4	3,445	2,496	2,783	3,117	6,862	5,206	4,675	2,339	1,983	3,194	2,683	3,195
5	3,420	2,476	2,651	3,173	6,714	5,215	4,583	2,306	1,985	3,380	2,679	3,176
6	3,415	2,456	2,520	3,230	5,960	5,105	4,127	2,272	1,990	3,570	2,675	3,158
7	3,410	2,436	2,522	3,287	5,206	5,325	3,831	2,239	1,991	3,467	2,672	3,137
8	3,408	2,416	2,524	3,370	5,004	5,580	3,572	2,205	1,798	3,364	2,710	3,119
9	3,329	2,396	2,526	3,525	4,986	5,813	3,492	2,172	1,795	3,261	2,748	3,023
10	3,250	2,397	2,528	3,690	5,056	5,830	3,948	2,138	1,790	3,158	2,787	2,926
11	3,171	2,511	2,571	3,890	4,668	5,860	3,849	2,105	1,832	3,055	2,779	2,830
12	3,092	2,626	2,614	4,170	4,504	5,804	3,868	2,071	1,830	2,952	2,770	2,733
13	2,935	2,741	2,612	4,780	4,488	5,897	3,480	2,037	1,789	2,849	2,762	2,637
14	2,895	2,856	2,610	5,624	4,398	5,890	3,412	2,000	1,748	2,746	2,753	2,540
15	2,855	2,971	2,608	6,150	4,318	5,579	3,412	1,983	1,747	2,741	2,745	2,443
16	2,815	3,086	2,606	6,245	4,475	5,504	3,412	1,966	1,821	2,566	2,736	2,444
17	2,775	3,301	2,604	6,380	4,632	5,409	3,137	1,949	1,895	2,391	2,727	2,446
18	2,735	3,270	2,620	6,646	4,789	5,308	2,957	1,949	1,969	2,216	2,774	2,447
19	2,695	3,240	2,637	6,880	4,948	5,209	2,945	1,861	2,043	2,041	2,822	2,449
20	2,664	3,209	2,654	7,156	4,861	5,062	3,313	1,773	2,117	1,866	2,869	2,450
21	2,663	3,179	2,646	7,310	4,906	4,915	3,288	1,684	2,191	2,044	2,917	2,451
22	2,662	3,045	2,638	7,525	5,157	4,708	3,381	1,685	2,271	2,222	2,964	2,453
23	2,661	2,911	2,630	7,537	5,290	4,618	3,708	1,718	2,275	2,401	3,012	2,418
24	2,655	2,778	2,622	7,549	5,441	4,673	3,936	1,753	2,300	2,579	3,060	2,382
25	2,650	2,844	2,583	7,561	5,583	4,728	3,689	1,787	2,325	2,757	3,087	2,347
26	2,649	2,910	2,544	7,573	5,726	4,783	3,665	1,822	2,350	2,936	3,114	2,311
27	2,649	2,976	2,505	7,585	5,870	4,838	3,517	1,856	2,375	3,118	3,141	2,276
28	2,648	2,926	2,510	7,571	5,854	4,893	3,204	1,891	2,400	3,050	3,168	2,240
29	2,647	......	2,515	7,497	5,396	4,949	2,310	1,925	2,425	2,982	3,195	2,204
30	2,645	......	2,520	7,454	5,304	5,006	2,479	1,960	2,450	2,914	3,222	2,199
31	2,640	......	2,525	......	5,450	......	2,571	1,961	......	2,845	......	2,194
1907.												
1	2,207	2,197	2,007	2,587	4,303	3,490	2,594	4,062	2,364	1,952	2,348	1,295
2	2,221	2,166	2,009	2,627	3,601	3,404	2,456	4,071	2,246	1,951	2,486	1,273
3	2,234	2,126	2,002	2,667	2,900	3,317	2,317	4,081	2,129	1,950	2,578	1,252
4	2,248	2,086	1,994	2,707	2,197	3,231	2,179	4,045	2,011	1,948	2,671	1,230
5	2,263	2,046	1,987	2,747	2,230	3,144	2,041	4,008	1,894	1,946	2,763	1,208
6	2,308	2,006	1,979	2,787	2,263	3,058	1,902	3,972	1,776	1,949	2,856	1,187
7	2,354	1,966	1,972	2,837	2,296	2,971	2,038	3,925	1,658	1,953	2,948	1,166
8	2,399	1,926	1,964	2,887	2,329	2,882	2,174	3,899	1,673	1,956	3,042	1,132
9	2,445	1,885	1,955	2,937	2,362	2,964	2,311	3,862	1,688	1,960	3,136	1,098
10	2,490	1,865	1,954	2,987	2,395	3,045	2,447	3,825	1,703	1,963	3,126	1,064
11	2,536	1,845	1,954	3,037	2,428	3,127	2,584	3,784	1,719	1,967	3,116	1,030
12	2,581	1,824	1,953	3,087	2,590	3,208	2,722	3,743	1,734	1,971	3,106	996
13	2,577	1,804	1,953	3,137	2,751	3,290	2,860	3,702	1,749	1,998	3,096	962
14	2,573	1,784	1,953	3,187	2,912	3,371	2,842	3,661	1,765	2,025	3,086	927
15	2,569	1,763	1,952	3,237	3,073	3,452	2,824	3,620	1,876	2,052	3,076	927
16	2,565	1,742	1,952	3,287	3,235	3,443	2,805	3,579	1,987	2,080	3,066	926
17	2,561	1,799	1,953	3,337	3,396	3,434	2,787	3,538	2,098	2,107	2,966	926
18	2,556	1,816	1,953	3,387	3,558	3,425	2,768	3,481	2,210	2,134	2,866	926
19	2,551	1,853	1,954	3,437	3,665	3,416	2,749	3,423	2,321	2,162	2,766	925
20	2,527	1,890	1,954	3,487	3,772	3,407	2,729	3,366	2,432	2,176	2,666	925

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
21	2,502	1,927	1,955	3,754	3,879	3,398	2,889	3,308	2,544	2,190	2,566	924
22	2,477	1,964	1,955	4,021	3,986	3,388	3,050	3,251	2,467	2,204	2,466	897
23	2,452	2,001	1,955	4,287	4,093	3,306	3,210	3,193	2,390	2,218	2,366	869
24	2,427	2,002	2,033	4,554	4,200	3,224	3,371	3,136	2,313	2,232	2,216	842
25	2,402	2,003	2,112	4,820	4,306	3,142	3,531	3,043	2,235	2,246	2,066	814
26	2,377	2,004	2,190	5,087	4,190	3,060	3,692	2,949	2,158	2,260	1,916	784
27	2,347	2,005	2,269	5,354	4,073	2,977	3,853	2,856	2,081	2,250	1,766	754
28	2,317	2,006	2,347	5,204	3,957	2,895	3,903	2,762	2,003	2,240	1,616	722
29	2,287	......	2,426	5,154	3,840	2,812	3,953	2,669	1,978	2,230	1,466	720
30	2,257	......	2,507	5,004	3,724	2,732	4,003	2,575	1,953	2,220	1,316	718
31	2,227	......	2,547	......	3,607	......	4,053	2,481	......	2,210	......	716
1908.												
1	691	597	835	869	2,208	3,501	3,644	2,847	1,822	2,475	1,934	1,053
2	667	597	838	888	2,400	3,501	3,634	2,827	1,842	2,480	1,861	1,054
3	642	596	841	906	2,315	3,501	3,624	2,807	1,862	2,485	1,787	1,055
4	618	596	844	925	2,230	3,501	3,614	2,787	1,884	2,492	1,714	1,056
5	617	596	848	935	2,145	3,501	3,501	2,767	1,904	2,499	1,641	1,057
6	616	595	851	945	2,060	3,501	3,387	2,747	1,909	2,506	1,567	1,035
7	615	595	855	955	1,975	3,601	3,274	2,727	1,914	2,513	1,492	1,013
8	614	595	857	965	1,890	3,701	3,160	2,707	1,919	2,520	1,452	991
9	613	596	859	975	1,805	3,801	3,047	2,557	1,924	2,527	1,412	969
10	612	597	861	985	1,885	3,901	2,934	2,407	1,929	2,534	1,372	947
11	611	598	863	995	1,965	4,001	2,819	2,257	1,934	2,466	1,332	925
12	610	599	865	1,000	2,045	4,101	2,786	2,107	1,939	2,397	1,292	903
13	609	600	867	1,005	2,125	4,201	2,753	1,957	1,949	2,329	1,252	923
14	608	600	870	1,010	2,205	4,181	2,720	1,807	1,959	2,260	1,212	943
15	607	600	864	1,015	2,285	4,161	2,686	1,657	1,969	2,192	1,202	963
16	606	642	858	1,020	2,365	4,141	2,653	1,652	1,979	2,123	1,192	983
17	605	684	852	1,025	2,358	4,121	2,620	1,647	1,989	2,055	1,182	1,003
18	604	726	846	1,030	2,351	4,101	2,586	1,642	1,999	2,058	1,172	1,023
19	603	768	840	1,035	2,344	4,081	2,633	1,637	2,009	2,061	1,162	1,043
20	602	810	834	1,040	2,337	4,060	2,680	1,632	2,072	2,064	1,152	1,028
21	601	853	828	1,045	2,330	4,007	2,727	1,627	2,135	2,067	1,142	1,013
22	600	860	831	1,050	2,323	3,953	2,775	1,622	2,198	2,070	1,132	997
23	600	856	834	1,055	2,316	3,900	2,822	1,642	2,261	2,073	1,122	982
24	600	852	837	1,060	2,485	3,846	2,869	1,662	2,324	2,077	1,112	967
25	600	847	841	1,065	2,654	3,793	2,917	1,682	2,387	2,067	1,102	951
26	600	843	844	1,255	2,823	3,739	2,907	1,702	2,450	2,057	1,092	935
27	600	839	847	1,446	2,992	3,684	2,897	1,722	2,455	2,047	1,082	928
28	598	834	851	1,636	3,161	3,674	2,887	1,742	2,460	2,037	1,072	921
29	598	832	855	1,827	3,330	3,664	2,877	1,762	2,465	2,027	1,062	914
30	598	......	859	2,017	3,500	3,654	2,867	1,782	2,470	2,017	1,052	907
31	597	......	863	......	3,670	......	2,857	1,802	......	2,007	......	900
1909.												
1	893	887	770	989	1,210	2,241	1,950	1,400	3,500	2,920	2,700	2,200
2	886	864	765	994	1,371	2,227	1,949	1,400	3,200	3,000	2,800	2,100
3	885	841	761	999	1,531	2,213	1,949	1,500	3,000	2,900	2,800	2,100
4	884	818	757	1,016	1,692	2,119	1,900	1,400	2,800	2,840	2,700	2,000
5	883	795	753	1,034	1,853	2,163	1,855	1,200	2,700	2,760	2,700	2,000
6	882	772	748	1,052	2,014	2,113	1,740	1,300	2,580	2,780	2,656	1,991
7	881	779	755	1,069	2,175	2,063	1,580	1,400	2,500	2,720	2,550	1,982
8	880	782	763	1,087	2,337	2,013	1,600	1,500	2,500	2,660	2,450	1,973
9	879	794	770	1,105	2,346	1,960	1,600	1,900	2,520	2,623	2,480	1,964
10	878	801	778	1,124	2,355	1,960	1,622	1,700	2,450	2,500	2,480	1,955
11	876	808	785	1,106	2,364	1,860	1,800	2,100	2,100	2,380	2,490	1,943
12	874	816	793	1,087	2,373	1,823	1,900	2,700	2,100	2,280	2,500	1,943
13	872	824	800	1,069	2,382	1,821	1,700	2,800	2,100	2,350	2,480	1,943
14	869	822	812	1,050	2,391	1,819	1,700	3,000	2,100	2,220	2,500	1,943
15	867	819	824	1,031	2,399	1,817	1,850	3,400	2,100	2,075	2,500	1,943
16	862	817	836	1,013	2,376	1,815	1,700	3,670	2,000	2,075	2,800	1,943
17	882	814	848	992	2,353	1,813	1,610	3,870	2,000	2,100	2,800	1,942
18	902	812	860	1,013	2,330	1,811	1,700	3,980	1,900	2,200	2,700	1,942
19	922	808	872	1,034	2,304	1,810	1,700	4,150	1,850	2,300	2,800	1,891
20	942	804	884	1,055	2,281	1,852	1,900	4,380	1,800	2,400	2,600	1,840
21	962	801	894	1,076	2,258	1,894	2,000	4,550	1,700	2,450	2,500	1,789
22	982	797	904	1,097	2,237	1,936	2,100	4,590	1,900	2,480	2,500	1,738
23	1,003	794	914	1,118	2,241	1,978	2,200	4,650	2,100	2,400	2,500	1,687
24	990	790	924	1,139	2,245	2,020	2,300	4,800	2,250	2,500	2,500	1,646
25	976	786	934	1,140	2,249	2,062	2,400	5,000	2,300	2,600	2,500	1,459

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909												
26	963	782	944	1,135	2,253	2,063	2,100	4,800	2,450	2,590	2,500	1,450
27	949	778	954	1,130	2,257	2,063	1,710	4,700	2,500	2,650	2,500	1,441
28	936	774	964	1,145	2,261	2,040	1,700	4,500	2,500	2,731	2,500	1,431
29	922	....	970	1,130	2,261	2,000	1,580	4,200	2,600	2,750	2,500	1,422
30	907	....	980	1,200	2,260	1,950	1,400	4,000	2,750	2,780	2,500	1,413
31	910	....	985	....	2,255	....	1,310	3,800	....	2,800	....	1,403
1910.												
1	1,393	1,125	1,363	2,485	2,876	2,107	2,131	2,328	2,792	2,354	2,381	663
2	1,348	1,126	1,351	2,485	2,843	2,085	2,137	2,367	2,834	2,304	2,194	663
3	1,303	1,127	1,339	2,499	2,810	2,063	2,144	2,405	2,876	2,255	2,007	664
4	1,258	1,128	1,327	2,513	2,777	2,040	2,151	2,444	2,918	2,205	1,810	665
5	1,213	1,129	1,314	2,527	2,744	2,063	2,159	2,482	2,960	2,156	1,623	667
6	1,168	1,166	1,363	2,541	2,711	2,086	2,166	2,521	3,002	2,106	1,440	667
7	1,123	1,203	1,412	2,555	2,710	2,110	2,173	2,559	2,965	2,056	1,349	668
8	1,112	1,240	1,461	2,569	2,615	2,133	2,181	2,598	2,928	2,006	1,257	669
9	1,107	1,277	1,510	2,574	2,520	2,156	2,189	2,636	2,891	1,955	1,229	669
10	1,102	1,314	1,559	2,479	2,425	2,180	2,186	2,676	2,854	1,905	1,220	672
11	1,097	1,351	1,608	2,384	2,330	2,204	2,183	2,716	2,817	1,871	1,171	672
12	1,092	1,353	1,613	2,289	2,235	2,194	2,180	2,756	2,779	1,832	1,143	680
13	1,087	1,352	1,697	2,194	2,140	2,180	2,177	2,796	2,728	1,793	1,115	670
14	1,082	1,352	1,781	2,099	2,137	2,165	2,174	2,835	2,676	1,754	1,087	670
15	1,081	1,352	1,865	2,004	2,211	2,151	2,170	2,834	2,625	1,715	1,058	678
16	1,079	1,352	1,949	2,000	2,285	2,137	2,167	2,832	2,573	1,676	1,030	680
17	1,077	1,352	2,033	2,188	2,359	2,122	2,164	2,831	2,521	1,636	1,002	682
18	1,075	1,352	2,117	2,376	2,433	2,107	2,160	2,829	2,468	1,567	974	684
19	1,073	1,352	2,118	2,564	2,507	2,106	2,157	2,828	2,416	1,498	946	684
20	1,071	1,355	2,396	2,752	2,581	2,105	2,153	2,826	2,415	1,429	918	686
21	1,069	1,355	2,674	2,940	2,584	2,104	2,150	2,824	2,414	1,359	890	688
22	1,068	1,360	2,952	3,128	2,529	2,103	2,147	2,816	2,413	1,290	861	690
23	1,076	1,360	3,230	3,132	2,473	2,102	2,144	2,808	2,412	1,220	832	692
24	1,084	1,365	3,508	3,095	2,418	2,101	2,163	2,800	2,411	1,370	804	693
25	1,092	1,365	3,786	3,058	2,362	2,101	2,183	2,792	2,410	1,420	776	687
26	1,100	1,368	3,787	3,021	2,307	2,106	2,203	2,784	2,409	2,076	747	681
27	1,108	1,370	3,570	2,984	2,251	2,111	2,223	2,776	2,408	2,426	718	675
28	1,116	1,375	3,353	2,947	2,195	2,116	2,243	2,768	2,407	2,506	700	669
29	1,117	....	3,136	2,910	2,170	2,121	2,263	2,760	2,405	2,576	681	663
30	1,120	....	2,919	2,909	2,145	2,126	2,283	2,752	2,403	2,500	662	657
31	1,125	....	2,702	....	2,120	....	2,290	2,750	....	2,568	....	651
1911.												
1	652	709	720	1,088	1,116	1,917	2,327	2,310	2,084	1,951	1,270	699
2	653	709	725	1,091	1,211	1,963	2,318	2,258	2,136	1,890	1,283	690
3	653	708	731	1,094	1,305	2,009	2,309	2,206	2,187	1,829	1,296	681
4	657	708	737	1,097	1,400	2,056	2,300	2,154	2,239	1,768	1,308	672
5	658	708	742	1,100	1,494	2,102	2,291	2,103	2,290	1,707	1,321	663
6	660	707	748	1,102	1,589	2,148	2,282	2,051	2,342	1,646	1,333	654
7	663	707	754	1,105	1,684	2,195	2,274	2,000	2,393	1,585	1,346	645
8	658	707	760	1,108	1,633	2,242	2,264	1,948	2,445	1,523	1,359	636
9	653	706	766	1,111	1,582	2,205	2,321	1,896	2,496	1,526	1,372	627
10	648	706	772	1,132	1,531	2,167	2,378	1,843	2,548	1,529	1,341	621
11	645	706	778	1,153	1,480	2,130	2,436	1,802	2,599	1,532	1,310	614
12	640	705	784	1,175	1,429	2,092	2,493	1,761	2,651	1,535	1,278	608
13	637	700	792	1,196	1,378	2,054	2,551	1,720	2,703	1,538	1,246	601
14	635	694	800	1,217	1,325	2,017	2,608	1,678	2,628	1,541	1,215	595
15	639	688	807	1,239	1,455	1,979	2,666	1,637	2,552	1,544	1,183	588
16	643	683	815	1,260	1,585	1,940	2,723	1,595	2,477	1,547	1,152	582
17	648	676	823	1,282	1,715	1,869	2,781	1,554	2,401	1,549	1,120	576
18	652	670	830	1,303	1,845	1,798	2,838	1,513	2,326	1,534	1,089	592
19	657	665	838	1,325	1,975	1,727	2,895	1,472	2,250	1,519	1,057	609
20	661	670	858	1,346	2,105	1,655	2,858	1,439	2,175	1,504	1,026	625
21	665	676	879	1,368	2,235	1,584	2,821	1,519	2,099	1,489	994	642
22	669	682	899	1,390	2,199	1,513	2,784	1,609	2,023	1,474	963	658
23	673	687	920	1,413	2,163	1,615	2,747	1,698	2,022	1,459	931	674
24	677	693	941	1,358	2,126	1,718	2,711	1,787	2,020	1,443	900	690
25	681	698	980	1,302	2,090	1,820	2,675	1,876	2,019	1,417	868	692
26	686	704	1,000	1,246	2,054	1,923	2,623	1,912	2,017	1,391	837	695
27	690	709	1,022	1,191	2,017	2,025	2,570	1,928	2,016	1,365	805	698
28	695	714	1,040	1,135	1,981	2,128	2,518	1,954	2,014	1,339	774	700
29	700	....	1,058	1,079	1,944	2,232	2,465	1,981	2,013	1,312	742	703
30	705	....	1,072	1,022	1,908	2,335	2,413	2,007	2,012	1,286	707	706
31	710	....	1,085	....	1,871	....	2,361	2,033	....	1,258	....	709

Daily discharge, in second-feet, of Mississippi River above Sandy River—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
1	684	396	542	671	1,060	1,520	1,540	1,350	1,310	2,440	1,460	......
2	659	411	538	687	1,120	1,540	1,570	1,360	1,380	2,340	1,420	......
3	634	426	534	703	1,190	1,570	1,600	1,370	1,460	2,240	1,380	......
4	609	441	530	718	1,250	1,590	1,630	1,380	1,530	2,140	1,340	......
5	583	456	527	734	1,320	1,610	1,660	1,400	1,600	2,040	1,300	......
6	557	471	524	750	1,380	1,640	1,700	1,410	1,670	1,940	1,260	......
7	532	486	521	765	1,450	1,660	1,730	1,420	1,740	1,930	1,220	......
8	528	501	518	781	1,510	1,680	1,760	1,430	1,810	1,930	1,180	......
9	523	517	515	796	1,580	1,690	1,740	1,440	1,880	1,930	1,150	......
10	519	533	512	812	1,640	1,700	1,720	1,450	1,960	1,930	1,110	......
11	514	548	516	827	1,700	1,710	1,710	1,460	2,030	1,920	1,070	......
12	510	544	519	843	1,770	1,720	1,690	1,470	2,100	1,920	1,030	......
13	505	540	523	859	1,760	1,730	1,680	1,480	2,170	1,920	990	......
14	500	537	527	867	1,740	1,740	1,660	1,490	2,240	1,920	988	......
15	496	534	530	875	1,730	1,750	1,650	1,500	2,310	1,920	986	......
16	491	531	534	883	1,710	1,760	1,630	1,510	2,300	1,910	983	......
17	487	528	543	891	1,700	1,760	1,620	1,520	2,280	1,850	981	......
18	482	525	552	899	1,680	1,770	1,610	1,510	2,270	1,780	979	......
19	478	521	561	907	1,670	1,760	1,600	1,490	2,250	1,720	976	......
20	473	518	570	915	1,640	1,750	1,590	1,470	2,240	1,650	974	......
21	468	515	580	923	1,620	1,730	1,580	1,460	2,220	1,590	972	......
22	460	518	589	931	1,590	1,720	1,570	1,440	2,210	1,520	970	......
23	451	522	598	940	1,570	1,710	1,540	1,430	2,250	1,520	967	......
24	443	526	605	948	1,540	1,680	1,520	1,410	2,290	1,520	965	......
25	434	530	612	956	1,510	1,650	1,490	1,400	2,330	1,510	963	......
26	426	534	620	964	1,500	1,620	1,470	1,370	2,380	1,510	960	......
27	417	537	627	972	1,500	1,600	1,440	1,340	2,420	1,510	958	......
28	409	541	635	980	1,500	1,570	1,420	1,320	2,460	1,500	955	......
29	400	545	642	988	1,500	1,540	1,390	1,290	2,500	1,500	953	......
30	390	......	649	995	1,500	1,510	1,360	1,270	2,540	1,500	950	......
31	381	......	656	......	1,500	......	1,340	1,240	......	1,500	......	......

Monthly discharge of Mississippi River above Sandy River.

[Drainage area, 4,510 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in millions of cubic feet.
1895.						
September	2,286	2,192	2,209	0.490	0.55	5,730
October	2,429	1,870	2,148	.476	.55	5,750
November	2,258	1,251	1,849	.410	.46	4,790
December	1,216	477	751	.167	.19	2,000
1896.						
January	530	380	452	.100	.12	1,210
February	460	115	323	.072	.08	809
March	541	165	311	.069	.08	833
April	4,645	516	2,003	.444	.50	5,190
May	......	......	......	......	......	......
June (6-30)	3,840	1,814	2,431	.539	.50	5,040
July	2,210	1,170	1,613	.358	.41	4,320
August	2,575	1,687	2,288	.507	.58	6,130
September	2,450	1,965	2,246	.498	.56	5,820
October	3,085	2,059	2,641	.586	.68	7,070
November	3,215	1,100	1,919	.425	.47	4,970
December	1,138	799	900	.200	.23	2,410

Monthly discharge of Mississippi River above Sandy River—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Minimum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in millions of cubic feet.
1897.						
January	1,010	580	783	0.174	0.20	2,100
February	900	651	740	.164	.18	1,790
March	1,069	616	743	.165	.19	1,990
April	5,843	1,417	3,770	.836	.93	9,770
May	3,857	1,838	2,866	.635	.73	7,680
June	3,873	2,308	3,209	.712	.79	8,320
July	7,789	2,999	6,101	1.35	1.56	16,300
August	4,685	2,010	3,088	.685	.79	8,270
September	2,961	2,174	2,722	.604	.67	7,060
October	3,127	2,007	2,579	.572	.66	6,910
November	....	....	....	....	....	....
December	2,971	1,339	2,167	.480	.55	5,800
1898.						
January	1,716	1,291	1,420	.315	.36	3,800
February	1,379	1,207	1,290	.286	.30	3,120
March	1,594	1,238	1,387	.308	.36	3,710
April	2,193	1,146	1,490	.330	.37	3,860
May	2,593	1,514	2,041	.453	.52	5,470
June	4,633	2,344	3,867	.857	.96	10,000
July	4,396	3,423	3,847	.853	.98	10,300
August	3,278	2,394	2,806	.622	.72	7,510
September	3,672	3,047	3,347	.742	.83	8,680
October	3,038	2,846	2,936	.651	.75	7,860
November	3,797	1,821	3,318	.736	.82	8,600
December	2,042	900	1,514	.342	.39	4,130
The year	4,633	900	2,441	.541	7.36	77,000
1899.						
January	1,378	1,261	1,301	.288	.33	3,480
February	1,256	960	1,104	.245	.26	2,670
March	1,612	1,022	1,158	.257	.30	3,100
April	2,314	1,297	1,615	.358	.40	4,190
May	5,907	4,299	5,034	1.12	1.29	13,500
June	8,161	7,705	8,044	1.78	1.99	20,800
July	6,446	2,440	4,093	.908	1.05	11,000
August	5,432	2,697	3,744	.830	.96	10,000
September	4,912	3,954	4,308	.955	1.07	11,200
October	7,629	2,983	4,659	1.03	1.19	12,500
November	4,722	3,578	4,116	.913	1.02	10,700
December	2,764	1,187	2,163	.480	.55	5,790
The year	8,161	960	3,445	.764	10.41	109,000
1900.						
January	2,062	1,596	1,781	.395	.46	4,770
February	1,672	1,335	1,492	.331	.34	3,610
March	1,476	1,276	1,377	.305	.35	3,690
April	2,917	1,385	2,153	.477	.53	5,580
May	2,176	773	1,752	.389	.45	4,690
June	2,084	1,087	1,396	.310	.35	3,620
July	1,871	549	1,279	.284	.33	3,430
August	3,716	549	2,276	.505	.58	6,100
September	9,572	3,069	6,400	1.42	1.58	16,600
October	5,792	2,502	4,192	.929	1.07	11,200
November	2,653	932	2,205	.489	.55	5,720
December	852	574	698	.155	.18	1,870
The year	9,572	549	2,250	.499	6.77	70,900
1901.						
January	650	510	597	.132	.15	1,600
February	1,620	753	1,117	.248	.26	2,700
March	2,334	1,228	1,747	.387	.45	4,680
April	6,220	2,053	4,129	.916	1.02	10,700
May	6,486	3,797	5,236	1.16	1.34	14,000
June	8,823	3,437	5,131	1.14	1.27	13,300
July	6,950	2,412	4,705	1.04	1.20	12,600
August	4,028	2,143	2,803	.622	.72	7,510
September	3,346	2,550	2,843	.630	.70	7,370
October	3,651	2,648	3,345	.742	.86	8,960
November	3,789	3,453	3,601	.798	.89	9,330
December	2,334	1,595	1,869	.414	.48	5,010
The year	8,823	510	3,004	.686	9.34	97,800

Monthly discharge of Mississippi River above Sandy River—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in millions of cubic feet.
1902.						
January	1,656	1,314	1,477	0.327	0.38	3,960
February	1,492	1,107	1,248	.278	.29	3,020
March	2,458	1,306	1,787	.396	.46	4,790
April	3,192	1,334	2,165	.480	.54	5,610
May	6,293	1,962	3,772	.836	.96	10,100
June	4,541	2,009	3,755	.833	.93	9,730
July	2,684	1,024	2,048	.454	.52	5,480
August	2,831	1,386	1,674	.371	.43	4,480
September	2,705	2,102	2,399	.532	.59	6,220
October	2,819	2,042	2,375	.527	.61	6,360
November	7,076	3,110	6,135	1.36	1.52	15,900
December	3,309	1,573	2,464	.546	.63	6,600
The year	7,076	1,024	2,608	.578	7.86	82,200
1903.						
January	1,880	1,158	1,460	.324	.37	3,910
February	1,162	964	1,076	.238	.25	2,690
March	1,232	803	1,028	.228	.26	2,750
April	4,750	1,145	3,136	.695	.78	8,130
May	4,266	2,649	3,568	.792	.91	9,560
June	2,889	1,124	1,879	.416	.46	4,870
July	2,650	1,457	1,816	.403	.46	4,860
August	1,961	1,121	1,507	.334	.39	4,040
September	3,829	1,564	2,733	.606	.68	7,080
October	5,041	1,741	3,737	.829	.96	10,000
November	2,464	686	1,455	.323	.36	3,770
December	796	641	763	.169	.19	2,040
The year	5,041	641	2,013	.446	6.07	63,600
1904.						
January	776	593	700	.155	.18	1,870
February	698	536	616	.137	.15	1,540
March	779	583	653	.145	.17	1,750
April	3,754	818	2,516	.558	.62	6,520
May	3,491	2,287	3,056	.678	.78	8,180
June	2,809	1,701	2,135	.473	.53	5,530
July	2,181	1,317	1,738	.385	.44	4,650
August	2,315	1,588	1,861	.413	.48	4,980
September	2,195	1,486	1,855	.411	.46	4,810
October	3,030	1,780	2,289	.508	.59	6,130
November	2,242	948	1,614	.358	.40	4,180
December	875	647	794	.176	.29	2,130
The year	3,754	536	1,652	.366	5.00	52,300
1905.						
January	873	523	723	.160	.19	1,940
February	721	565	637	.141	.15	1,540
March	1,104	512	752	.167	.19	2,010
April	2,608	1,570	2,137	.474	.53	5,540
May	4,660	1,398	3,409	.756	.87	9,130
June	6,918	3,535	5,085	1.13	1.26	13,200
July	8,278	5,330	6,759	1.50	1.73	18,100
August	8,299	5,460	6,761	1.50	1.73	18,100
September	6,176	5,436	5,859	1.30	1.45	15,200*
October	5,331	3,004	3,975	.881	1.02	10,600
November	3,824	2,911	3,248	.720	.80	8,420
December	3,480	3,340	3,422	.759	.88	9,160
The year	8,299	512	3,564	.790	10.80	113,000
1906.						
January	3,450	2,640	2,961	.657	.76	7,930
February	3,301	2,396	2,788	.618	.64	6,740
March	2,945	2,505	2,620	.581	.67	7,020
April	7,585	2,703	5,504	1.22	1.36	14,300
May	7,306	4,318	5,397	1.20	1.38	14,500
June	5,897	4,618	5,274	1.17	1.30	13,700
July	4,798	2,310	3,617	.802	.92	9,690
August	2,440	1,684	2,020	.448	.52	5,410
September	2,450	1,747	2,046	.454	.51	5,300
October	3,570	1,866	2,810	.623	.72	7,530
November	3,222	2,672	2,860	.634	.71	7,410
December	3,250	2,194	2,655	.589	.68	7,110
The year	7,585	1,684	3,379	.749	10.17	107,000

Monthly discharge of Mississippi River above Sandy River—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in millions of cubic feet.
1907.						
January	2,581	2,207	2,381	0.528	0.61	6,380
February	2,197	1,742	1,939	.430	.45	4,690
March	2,547	1,952	2,053	.455	.52	5,500
April	5,354	2,587	3,584	.795	.89	9,290
May	4,306	2,197	3,294	.730	.84	8,820
June	3,490	2,732	3,200	.710	.79	8,290
July	4,053	1,902	2,891	.641	.74	7,740
August	4,081	2,481	3,479	.771	.89	9,320
September	2,544	1,658	2,038	.452	.50	5,280
October	2,260	1,946	2,087	.463	.53	5,590
November	3,136	1,316	2,584	.573	.64	6,700
December	1,295	716	972	.287	.33	2,600
The year	5,354	716	2,542	.564	7.73	80,200
1908.						
January	691	597	611	.135	.16	1,640
February	860	595	696	.154	.17	1,740
March	870	828	849	.188	.22	2,270
April	2,017	869	1,099	.244	.27	2,850
May	3,670	1,805	2,415	.535	.60	6,470
June	4,201	3,501	3,835	.850	.95	9,940
July	3,644	2,586	2,972	.659	.76	7,960
August	2,847	1,622	2,062	.457	.53	5,520
September	2,479	1,822	2,077	.461	.51	5,380
October	2,534	2,007	2,245	.498	.57	6,010
November	1,934	1,052	1,311	.291	.32	3,400
December	1,057	900	980	.217	.25	2,620
The year	4,201	595	1,763	.391	5.33	55,800
1909.						
January	1,003	862	909	.202	.23	2,430
February	887	772	806	.179	.19	1,950
March	985	748	841	.186	.21	2,250
April	1,200	989	1,074	.238	.27	2,780
May	2,399	1,210	2,168	.481	.55	5,810
June	2,241	1,810	1,977	.438	.49	5,120
July	2,400	1,310	1,810	.401	.46	4,850
August	5,000	1,200	3,172	.703	.81	8,490
September	3,500	1,700	2,362	.524	.58	6,120
October	3,000	2,075	2,543	.564	.65	6,810
November	2,800	2,450	2,583	.573	.64	6,700
December	2,200	1,403	1,820	.404	.47	4,870
The year	5,000	748	1,839	.408	5.55	58,200
1910.						
January	1,393	1,068	1,129	.250	.29	3,020
February	1,375	1,125	1,295	.287	.30	3,130
March	3,787	1,314	2,219	.492	.57	5,940
April	3,132	2,000	2,607	.578	.64	6,760
May	2,876	2,220	2,445	.542	.62	6,550
June	2,204	2,040	2,119	.470	.52	5,490
July	2,290	2,131	2,180	.483	.56	5,840
August	2,835	2,328	2,701	.599	.69	7,230
September	3,002	2,403	2,638	.585	.65	6,840
October	2,576	1,220	1,915	.425	.49	5,130
November	2,381	662	1,154	.256	.29	2,990
December	693	651	671	.149	.17	1,800
The year	3,787	651	1,923	.426	5.79	60,700
1911.						
January	710	635	663	.147	.17	1,780
February	714	665	696	.151	.16	1,680
March	1,085	720	854	.189	.22	2,290
April	1,413	1,022	1,200	.266	.30	3,110
May	2,235	1,116	1,720	.381	.44	4,610
June	2,335	1,513	1,970	.437	.49	5,110
July	2,895	2,264	2,540	.563	.65	6,800
August	2,310	1,439	1,850	.410	.47	4,950
September	2,703	2,012	2,270	.503	.56	5,880
October	1,951	1,258	1,530	.339	.39	4,100
November	1,372	707	1,110	.246	.27	2,880
December	709	576	650	.144	.17	1,740
The year	2,895	576	1,430	.317	4.29	44,900

Monthly discharge of Mississippi River above Sandy River—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in millions of cubic feet.
1912.						
January	684	381	498	0.110	0.13	1,330
February	548	396	508	.113	.12	1,270
March	656	512	563	.125	.14	1,510
April	995	671	859	.190	.21	2,230
May	1,770	1,060	1,530	.339	.39	4,100
June	1,770	1,510	1,670	.370	.41	4,330
July	1,760	1,340	1,590	.353	.41	4,260
August	1,520	1,240	1,420	.315	.36	3,800
September	2,540	1,310	2,070	.459	.51	5,370
October	2,440	1,500	1,810	.401	.46	4,850
November	1,460	950	1,080	.239	.27	2,800

NOTE.—Above table computed by engineers of the United States Geological Survey from records of daily discharge furnished by the United States Engineer Corps.

MISSISSIPPI RIVER NEAR FORT RIPLEY.

Location.—At highway bridge 1 mile north of Fort Ripley. The nearest tributary is Nokasippi River which enters a short distance below.

Records available.—June 25, 1909, to September 30, 1910.

Drainage area.—10,700 square miles.

Gage.—Vertical staff whose datum was 1.40 feet lower than that of the U. S. Weather Bureau gage attached to the same pier.

Channel.—During the open-water season the river is used extensively for log driving, and the logs frequently jam on the rapids a short distance below the bridge, causing backwater. For this reason the station was discontinued.

Discharge measurements.—Made from bridge.

Winter flow.—The river is frozen over from December to March and during that time the readings were discontinued.

Regulation.—The flow of the river is controlled by government dams on the upper river in the interest of navigation.

Accuracy.—Owing to the effect of log jams no estimates of discharge have been made and only the base data are given.

Discharge measurements of Mississippi River near Fort Ripley.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet	Sq. ft.	Feet	Sec-ft.
1909.					
June 25	G. A. Gray	358	1,740	6.02	5,360
August 6	Robert Follansbee	351	1,610	5.63	4,260
August 31	C. J. Emerson	368	2,280	7.38	7,630
September 9	G. A. Gray	358	1,800	6.22	5,220
November 4	do	352	1,830	6.10	4,790
1910.					
March 23	G. A. Gray	363	2,410	7.66	8,700
May 20	do	352	1,870	6.21	4,930
July 23	Robert Follansbee		1,550	[1]5.45	2,530

[1] Backwater from log jam.

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

(Observer, L. A. White.)

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	......	......	......	......	......	......	5.62	6.40	7.25	6.35	6.02	6.29
2	......	......	......	......	......	......	5.66	6.29	7.16	6.34	6.12	6.38
3	......	......	......	......	......	......	5.65	6.48	6.98	6.25	6.15	6.45
4	......	......	......	......	......	......	5.35	6.05	6.80	6.24	6.15	6.67
5	......	......	......	......	......	......	5.11	5.72	6.58	6.38	6.10	6.32
6	......	......	......	......	......	......	5.31	5.58	6.48	6.35	6.09	7.64
7	......	......	......	......	......	......	5.48	5.55	6.50	6.31	6.02	7.65
8	......	......	......	......	......	......	5.49	5.50	6.34	6.31	5.98	7.98
9	......	......	......	......	......	......	5.35	5.68	6.24	6.38	6.10	8.10
10	......	......	......	......	......	......	5.25	5.88	6.22	6.22	6.05	......
11	......	......	......	......	......	......	5.12	6.26	6.24	6.06	6.05	......
12	......	......	......	......	......	......	4.95	7.47	6.12	6.12	5.99	......
13	......	......	......	......	......	......	5.18	7.22	6.10	6.01	5.98	......
14	......	......	......	......	......	......	5.42	8.45	6.16	5.95	6.04	......
15	......	......	......	......	......	......	5.38	8.62	6.06	5.95	5.98	......
16	......	......	......	......	......	......	5.30	8.62	6.02	5.90	6.00	......
17	......	......	......	......	......	......	5.40	8.60	5.98	5.85	6.10	......
18	......	......	......	......	......	......	5.31	8.59	5.88	5.82	6.10	......
19	......	......	......	......	......	......	5.16	8.38	5.81	5.82	6.10	......
20	......	......	......	......	......	......	5.68	8.22	5.89	5.94	6.05	......
21	......	......	......	......	......	......	6.15	8.00	6.18	6.00	6.05	......
22	......	......	......	......	......	......	6.98	7.88	6.21	6.07	5.82	......
23	......	......	......	......	......	......	7.72	7.92	6.29	6.08	6.02	......
24	......	......	......	......	......	......	7.90	8.10	6.35	6.05	5.99	......
25	......	......	......	......	......	6.01	7.68	8.02	6.38	6.05	5.87	......
26	......	......	......	......	......	5.96	7.60	7.92	6.31	6.08	5.85	......
27	......	......	......	......	......	5.85	7.56	7.79	6.34	6.10	5.95	......
28	......	......	......	......	......	5.75	7.25	7.61	6.35	6.05	5.94	......
29	......	......	......	......	......	6.80	7.02	7.55	6.44	6.08	6.01	......
30	......	......	......	......	......	5.68	6.76	7.42	6.35	6.18	6.18	......
31	......	......	......	......	......	......	6.61	7.32	......	6.10	......	......
1910.												
1	......	......	......	6.78	6.66	6.18	5.34	5.06	5.75	......	......	......
2	......	......	......	6.64	6.66	6.08	5.22	5.35	5.75	......	......	......
3	......	......	......	6.52	6.59	6.04	5.12	5.35	5.81	......	......	......
4	......	......	......	6.61	6.51	6.05	4.98	5.34	5.76	......	......	......
5	......	......	......	7.41	6.50	6.04	5.04	5.32	5.78	......	......	......
6	......	......	......	6.82	6.48	6.04	5.26	5.30	5.90	......	......	......
7	......	......	......	6.95	6.48	6.01	5.15	5.25	5.86	......	......	......
8	......	......	......	6.98	6.38	5.90	5.22	5.22	5.85	......	......	......
9	......	......	......	6.92	6.38	5.78	5.28	5.45	5.84	......	......	......
10	......	......	......	6.79	6.38	5.72	5.24	5.44	5.84	......	......	......
11	......	......	......	6.78	6.30	5.72	5.18	5.44	5.78	......	......	......
12	......	......	......	6.76	6.18	5.66	5.48	5.49	5.72	......	......	......
13	......	......	......	6.65	6.14	5.62	5.42	5.56	5.91	......	......	......
14	......	......	......	6.50	6.08	5.70	5.46	5.55	5.92	......	......	......
15	......	......	8.12	6.56	6.05	5.62	5.38	5.52	5.85	......	......	......
16	......	......	8.92	6.61	6.05	5.70	5.41	5.78	5.98	......	......	......
17	......	......	8.26	6.70	6.15	5.79	5.35	5.72	5.94	......	......	......
18	......	......	7.76	6.85	6.11	5.86	5.22	5.69	5.89	......	......	......
19	......	......	7.96	7.11	6.10	5.85	5.51	5.72	5.70	......	......	......
20	......	......	7.45	7.21	6.11	5.75	5.45	5.69	5.68	......	......	......
21	......	......	7.52	7.25	6.15	5.88	5.42	5.62	5.59	......	......	......
22	......	......	7.64	7.31	6.08	5.54	5.42	5.58	5.55	......	......	......
23	......	......	7.66	7.31	6.12	5.28	5.38	5.79	5.51	......	......	......
24	......	......	7.65	7.40	6.24	5.18	5.46	5.72	5.50	......	......	......
25	......	......	7.65	7.30	6.25	5.18	5.41	5.69	5.45	......	......	......
26	......	......	7.65	7.15	6.25	5.15	5.50	5.65	5.52	......	......	......
27	......	......	7.61	7.09	6.28	5.18	5.04	5.68	5.94	......	......	......
28	......	......	7.60	6.99	6.29	5.41	5.01	5.62	6.02	......	......	......
29	......	......	7.48	6.88	6.22	5.36	5.00	5.54	5.98	......	......	......
30	......	......	7.24	6.76	6.22	5.34	5.08	5.81	6.02	......	......	......
31	......	......	6.96	......	6.28	......	5.04	5.81	......	......	......	......

NOTE.—These gage heights were seriously affected by log jams below the station.

MISSISSIPPI RIVER NEAR SAUK RAPIDS.

Location.—Five miles above Sauk Rapids and above the site of the present Watab Dam. The nearest important tributary is Little Rock River, which enters 2 miles above.

Records available.—May 3, 1903, to December 31, 1905.

Drainage area.—12,400 square miles.

Gage.—Vertical staff; datum unchanged.

Channel.—Fairly permanent except for temporary backwater from log jams.

Discharge measurements.—Made by boat and cable.

Winter flow.—Ice causes backwater during the winter months, and during this period readings were made through the ice.

Regulation.—The flow of the river is controlled by government dams on the upper river, in the interest of navigation.

Accuracy.—Conditions at this station were favorable for accurate results, except during the winter period, and the records should be reliable.

Daily discharge, in second-feet, of Mississippi River near Sauk Rapids.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1						9,650	5,360	6,840	4,920	8,040	6,950	5,640
2						9,180	5,540	7,200	4,760	7,910	6,630	5,200
3					10,200	8,880	6,020	7,550	5,090	8,450	6,630	5,200
4					10,300	8,040	7,660	7,830	5,000	13,400	6,630	5,200
5					10,700	7,180	6,840	7,700	5,000	16,100	6,630	4,920
6					11,100	6,520	6,220	7,480	4,840	20,300	6,420	4,200
7					11,500	6,420	6,520	7,270	4,520	26,700	6,220	4,150
8					11,100	5,540	6,740	7,060	5,270	26,400	6,020	4,150
9					10,900	5,740	7,780	6,840	5,000	27,100	6,020	4,150
10					11,300	5,640	8,310	6,630	5,450	26,700	5,920	4,400
11					13,400	5,540	7,780	6,220	6,320	24,700	5,830	4,600
12					15,800	5,450	7,530	7,060	7,290	23,400	5,640	3,100
13					18,300	5,360	7,290	6,840	9,490	22,400	5,640	3,100
14					20,300	5,180	7,780	6,220	11,100	20,600	5,360	3,100
15					21,200	4,920	8,450	6,020	15,600	19,700		4,600
16					17,400	5,090	7,530	5,360	17,200	18,800		4,580
17					16,900	5,270	5,090	5,450	17,700	17,700		4,580
18					15,600	4,920	5,090	4,840	18,300	17,200		4,280
19					14,800	5,000	4,920	5,000	18,000	16,600		4,170
20					14,100	5,360	4,680	4,760	17,400	15,300		3,000
21					13,900	5,270	4,230	4,840	16,600	14,600		2,800
22					13,600	5,450	4,520	4,840	15,800	13,600		2,600
23					13,600	4,680	4,450	4,840	14,400	13,000		2,520
24					13,900	5,270	4,520	4,760	13,000	12,100		2,430
25					13,900	4,600	4,760	4,450	12,500	11,300		2,430
26					13,200	4,840	4,600	5,270	12,100	10,500		2,340
27					12,700	4,450	5,090	5,090	10,700	9,650	9,710	2,950
28					12,300	4,380	5,540	5,090	9,490	9,030	9,840	2,950
29					12,100	4,380	5,830	5,270	9,180	8,590	8,090	2,950
30					11,100	4,300	6,020	5,610	8,450	7,910	6,800	2,850
31					10,300		6,120	5,640		7,290		2,850
1904.												
1					12,300	8,180	8,040	3,740	4,540	5,640	7,290	3,740
2					11,300	8,310	[illegible]	3,810	4,600	5,640	7,060	
3					11,700	8,880	7,060	4,230	4,600	5,270	6,840	
4					11,300	10,200	6,740	4,020	4,160	5,640	6,630	
5	2,500				11,100	12,100	6,420	3,810	4,230	5,640	6,420	
6					11,100	12,700	6,420	3,740	4,300	5,640	6,020	
7					11,100	13,200	6,950	3,680	4,920	5,450	5,640	
8					11,300	12,500	6,950	3,740	4,800	5,540	5,640	
9					11,700	11,900	6,840	3,810	4,760	6,220	5,920	
10					12,100	11,500	6,520	4,600	4,520	8,880	5,830	

Daily discharge, in second-feet, of Mississippi River near Sauk Rapids.—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
11	......	......	......	19,100	12,500	11,100	6,120	4,760	4,380	9,340	5,830	......
12	......	......	......	14,400	12,500	10,500	5,830	4,840	4,300	9,650	5,740	......
13	......	......	......	13,000	12,100	9,980	6,220	4,840	4,160	9,810	5,640	......
14	......	......	......	12,100	11,900	9,490	6,120	4,680	4,300	9,810	5,540	......
15	......	......	......	11,700	11,900	9,030	6,220	4,450	4,450	9,340	5,090	......
16	......	......	......	11,700	11,300	8,450	6,420	4,300	4,300	9,340	5,540	......
17	......	......	......	11,700	11,300	7,780	5,920	4,920	4,160	9,340	5,360	......
18	......	......	......	11,700	10,900	7,530	6,220	5,000	4,160	9,340	5,270	......
19	......	......	......	11,700	10,200	7,060	6,520	4,840	4,090	9,980	5,090	......
20	......	......	......	11,100	9,490	6,420	6,740	4,640	4,020	10,200	4,920	......
21	......	......	......	10,700	9,340	6,320	6,630	4,540	4,300	9,980	4,760	......
22	......	......	......	10,300	9,180	6,020	6,220	4,340	4,450	9,810	4,760	......
23	......	......	......	11,300	8,590	5,830	4,920	3,800	4,600	9,980	4,760	......
24	......	......	......	12,300	8,880	5,540	4,300	3,800	4,680	10,300	4,760	......
25	......	......	......	12,500	9,030	6,120	4,160	4,050	4,920	9,810	4,680	......
26	......	......	......	13,000	8,590	6,740	4,160	4,440	4,840	9,490	4,680	2,360
27	......	......	......	13,900	8,310	6,840	4,450	4,340	4,840	8,880	4,450	......
28	......	......	......	13,400	8,180	5,920	4,160	3,900	5,450	8,590	4,230	......
29	......	......	......	13,400	7,910	6,950	4,070	3,700	5,640	8,310	3,880	......
30	......	......	......	13,000	7,660	7,780	4,020	3,800	5,640	8,040	3,740	......
31	......	......	......	......	7,910	......	3,950	4,340	......	7,780	......	......
1905.												
1	......	......	2,820	4,230	4,380	8,450	34,000	11,100	9,650	6,950	6,220	......
2	......	......	2,820	4,160	4,380	8,180	32,400	11,100	9,650	7,060	6,020	......
3	2,620	......	2,820	4,920	5,640	7,780	30,200	11,100	9,650	7,290	6,220	......
4	......	......	2,820	6,020	7,780	7,530	34,700	11,100	9,650	7,180	6,420	......
5	......	......	2,820	8,880	10,200	9,810	39,400	11,500	9,650	7,060	6,020	......
6	......	......	2,820	10,200	11,700	12,100	47,600	12,100	9,650	6,840	6,220	......
7	......	......	2,820	11,300	11,900	13,000	50,200	12,500	9,490	6,740	6,320	......
8	......	......	2,760	10,500	12,100	13,000	51,000	13,400	9,340	6,740	6,320	......
9	......	......	2,760	9,490	12,500	13,400	50,200	13,400	9,180	6,420	6,220	......
10	......	......	2,760	8,590	13,900	13,900	45,900	15,300	9,030	6,320	6,120	......
11	......	......	2,760	8,310	18,600	13,900	42,600	15,300	8,590	6,220	5,920	......
12	......	......	2,580	8,310	21,500	14,400	37,800	15,300	9,030	5,920	5,920	......
13	......	......	2,580	7,780	20,900	15,300	34,700	14,800	8,880	5,640	5,740	......
14	......	......	2,580	7,290	22,800	16,400	31,700	14,600	8,880	5,270	5,830	......
15	......	......	2,580	6,950	22,800	17,400	29,500	15,300	9,030	5,270	5,740	......
16	......	......	2,580	6,950	22,800	20,300	27,400	15,800	9,030	5,270	5,740	......
17	......	......	2,580	6,630	19,700	24,700	24,700	14,800	8,880	6,120	5,640	......
18	......	......	2,420	6,520	16,900	26,000	23,400	14,400	9,490	6,220	5,640	......
19	......	......	2,420	6,520	16,400	27,400	22,100	13,900	10,900	6,420	5,450	......
20	......	......	2,420	6,020	14,400	30,200	22,100	13,400	10,900	6,740	5,450	......
21	......	......	2,420	5,920	14,400	30,200	20,900	13,000	10,900	7,180	5,360	......
22	......	......	2,420	5,640	14,400	28,800	20,300	14,400	10,900	7,180	5,360	......
23	......	......	4,680	5,360	15,600	27,400	19,700	13,000	10,900	7,290	5,540	......
24	......	......	4,680	4,920	15,800	28,100	18,600	12,300	10,200	7,530	6,220	......
25	......	......	4,300	4,600	15,300	28,100	17,400	11,900	9,180	7,660	7,290	......
26	......	......	4,300	4,380	14,400	34,700	16,400	12,100	8,590	7,530	7,060	......
27	......	......	4,520	4,160	12,500	34,700	14,800	11,700	8,180	7,410	7,290	......
28	......	......	4,600	4,020	11,300	35,500	13,900	10,900	7,780	7,290	6,120	......
29	......	......	4,600	4,090	10,900	35,500	13,000	10,900	7,290	7,180	5,360	......
30	......	......	4,450	4,300	9,180	34,700	11,900	10,200	7,060	6,840	5,270	......
31	......	......	4,300	......	8,880	......	10,900	9,980	......	6,950	......	......

Note.—Open season discharge computed from a well-defined rating curve, except March 1 to 22, 1905, which is estimated. Winter discharge computed from measurements.

Monthly discharge of Mississippi River near Sauk Rapids.

(Drainage area, 12,400 square miles.)

Month.	Discharge in second-feet.				Run-off.	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	
1903.						
May (3-31)	21,200	10,200	13,600	1.10	1.19	B
June	9,650	4,300	5,750	.464	.52	B
July	8,450	4,230	6,090	.491	.57	B
August	7,830	4,450	6,000	.484	.56	A
September	18,300	4,520	10,300	.831	.93	A
October	27,100	7,290	16,000	1.29	1.49	A
November (18 days)	9,840	5,360	6,720	.542	.36	A
December	....	....	[1]3,740	.302	.35	D
1904.						
January	....	....	[1]2,340	.189	.22	D
February	....	....	[1]2,070	.167	.18	D
March	....	....	[1]2,620	.211	.24	D
April (11-30)	19,100	10,300	12,600	1.02	.76	A
May	12,500	7,660	10,400	.839	.97	A
June	13,200	5,540	8,700	.702	.78	A
July	8,040	3,950	5,910	.477	.55	A
August	5,000	3,680	4,240	.342	.39	A
September	5,640	4,020	4,570	.369	.41	A
October	10,300	5,270	8,280	.668	.77	A
November	7,290	3,740	5,400	.435	.49	A
December	....	....	[1]3,050	.246	.28	D
The period	19,100	....	5,850	.472	6.04	
1905.						
January	....	....	[1]2,620	.211	.24	D
February	....	....	[1]2,500	.202	.21	D
March	4,680	....	3,180	.256	.30	D
April	11,300	4,020	6,570	.530	.59	C
May	22,800	4,380	14,000	1.13	1.30	A
June	35,500	7,530	21,000	1.69	1.89	A
July	51,000	10,900	28,700	2.31	2.66	A
August	15,800	9,980	12,900	1.04	1.20	A
September	10,900	7,000	9,320	.752	.84	A
October	7,600	5,270	6,700	.540	.62	A
November	7,290	5,270	6,000	.484	.54	A
December	....	....	[1]7,190	.580	.67	D
The year	51,000	....	10,100	.810	11.06	

[1] Estimated from ice notes.

MISSISSIPPI RIVER AT ANOKA.

Location.—At highway bridge connecting Anoka with Champlain, a short distance above the mouth of Rum River.

Records available.—November 3, 1896, to September 10, 1897 (U. S. Engineer records); May 8, 1905, to December 31, 1912.

Drainage area.—17,100 square miles.

Gage.—Staff gage prior to 1909, now a chain gage; datum, unchanged since station was established, is the same as that used by the United States Engineer Corps in 1896 and 1897.

Channel.—Permanent; control temporarily changed for a few days at a time by log jams.

Discharge measurements.—Made from the bridge.

Winter flow.—The river is frozen from December to March, inclusive, and regular observations are discontinued. The monthly discharge for this period is based on the records of flow of the St. Anthony Falls Water

Power Co., Minneapolis and of the records of the U. S. Engineer Corps records at Lock and Dam No. 2, an allowance being made for the increase in flow between the different points.

Regulation.—The nearest dam is located at Minneapolis, but on account of the fall between the two points its influence does not extend to the Anoka station. The first dam above Anoka is at St. Cloud. The flow of the river is controlled by government dams on the upper river for the purpose of increasing the low-water, open-season flow in the interest of navigation. Although the river is used extensively for log driving, there is very little back water from log jams forming below the station, except for a few days at a time.

Accuracy.—Although no measurements were made during 1907 and 1908, those made subsequently indicate that there has been no change in the discharge rating curve as developed in 1897, 1905, and 1906, and therefore it can be applied to all gage heights since the establishment of the station. This permanence of conditions indicates that the records of flow are reliable.

Daily discharge, in second-feet, of Mississippi River at Anoka.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897.												
1	3,700	2,780	2,880	35,500	17,400	7,310	13,200	20,700	6,340	......	......	......
2	3,740	2,800	2,790	41,300	16,800	8,090	13,600	20,300	6,280	......	......	......
3	3,700	2,820	2,710	42,000	16,100	8,490	14,300	19,900	6,340	......	......	......
4	3,600	2,840	2,780	45,900	15,200	9,430	20,200	19,300	6,410	......	......	......
5	3,500	2,850	2,740	49,100	14,500	9,680	23,600	18,400	7,270	......	......	......
6	3,450	2,700	2,700	47,100	13,700	10,500	25,300	17,300	7,460	......	......	......
7	3,420	2,600	2,720	44,400	12,800	9,430	36,700	17,300	7,340	......	......	......
8	3,390	2,450	2,740	41,800	12,200	9,920	41,500	16,700	7,230	......	......	......
9	2,930	2,300	2,750	39,800	11,400	9,430	42,200	15,700	7,120	......	......	......
10	2,830	2,600	2,740	37,800	10,900	9,430	42,800	14,200	7,040	......	......	......
11	2,720	2,800	2,720	36,500	10,800	9,430	41,300	12,500	......	......	......	......
12	2,620	3,010	2,540	34,800	10,500	9,270	38,900	11,800	......	......	......	......
13	2,790	2,950	2,560	33,200	10,600	9,920	37,100	10,600	......	......	......	......
14	2,810	2,900	2,580	31,800	10,500	9,840	34,500	9,510	......	......	......	......
15	2,830	2,840	2,610	30,300	10,100	9,880	32,800	9,350	......	......	......	......
16	2,650	2,790	2,650	29,500	9,920	10,000	30,900	8,690	......	......	......	......
17	2,610	2,750	2,650	28,400	10,600	10,300	29,500	8,730	......	......	......	......
18	2,570	2,710	2,650	26,900	10,500	11,100	27,300	8,530	......	......	......	......
19	2,530	2,800	3,040	25,900	10,300	11,800	25,600	8,370	......	......	......	......
20	2,490	2,890	3,440	25,400	10,700	12,700	24,600	8,210	......	......	......	......
21	2,550	2,670	3,850	24,700	9,920	13,200	24,200	8,050	......	......	......	......
22	2,610	2,450	4,260	23,800	9,430	13,600	23,600	8,210	......	......	......	......
23	2,670	2,230	4,670	23,200	9,100	12,800	23,200	8,130	......	......	......	......
24	2,700	2,470	4,090	22,600	8,530	12,400	23,200	8,050	......	......	......	......
25	2,720	2,720	5,520	21,700	8,290	11,900	25,300	8,010	......	......	......	......
26	2,730	2,740	6,210	20,700	7,810	11,200	25,000	7,850	......	......	......	......
27	2,810	2,760	6,900	19,700	8,170	10,700	23,800	7,420	......	......	......	......
28	2,900	2,820	12,600	19,100	7,810	11,800	22,700	7,000	......	......	......	......
29	2,980	......	18,300	18,500	7,810	12,200	21,700	7,010	......	......	......	......
30	2,900	......	24,000	17,400	7,890	12,700	21,600	7,120	......	......	......	......
31	2,840	......	29,700	......	7,850	......	21,400	6,440	......	......	......	......
1905.												
1	......	......	......	......	......	13,500	32,700	15,000	13,200	11,700	10,700	......
2	......	......	......	......	......	12,400	32,700	15,000	13,000	11,300	9,840	......
3	......	......	......	......	......	11,500	32,700	15,000	12,800	11,300	9,640	......
4	......	......	......	......	......	11,500	33,200	15,000	12,400	10,900	9,640	......
5	......	......	......	......	......	15,000	34,300	14,800	12,400	10,900	9,640	......
6	......	......	......	......	......	15,900	37,400	14,800	12,400	10,700	9,640	......
7	......	......	......	......	......	17,300	41,100	15,000	12,400	10,300	9,640	......
8	......	......	......	......	......	18,300	43,800	15,200	12,400	10,300	10,300	......
9	......	......	......	......	15,400	19,200	44,300	15,200	12,200	10,300	10,300	......
10	......	......	......	......	17,100	19,700	43,200	15,200	12,200	10,300	10,300	......

Daily discharge, in second-feet, of Mississippi River at Anoka—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
11					18,700	19,700	42,200	15,200	11,900	10,300	10,300	
12					21,900	19,700	40,000	15,900	11,500	8,820	10,300	
13					26,600	19,700	39,000	16,100	11,500	8,820	9,640	
14					28,100	19,700	37,400	16,100	11,500	8,820	9,640	
15					30,100	19,700	33,200	16,100	11,700	8,820	9,020	
16					30,600	21,100	31,200	16,800	12,200	8,820	8,820	
17					32,700	22,600	29,600	19,200	11,700	8,820	8,820	
18					31,700	26,100	27,600	19,000	12,800	8,820	8,820	
19					29,900	28,600	26,800	18,500	14,100	8,820	8,210	
20					27,400	29,100	24,600	17,800	15,000	8,820	8,210	
21					25,600	29,400	24,600	18,700	15,700	11,500	8,210	
22					24,800	29,100	24,100	18,000	15,000	11,500	8,210	
23					24,100	28,600	23,600	16,800	14,800	11,500	7,810	
24					23,600	28,100	23,100	16,800	15,400	12,400	7,810	
25					22,100	28,600	21,900	16,800	15,400	12,400	7,810	
26					21,400	29,900	19,700	15,700	15,400	12,400	7,810	
27					19,500	31,700	19,000	16,400	13,200	13,200	7,810	
28					18,000	32,700	18,000	16,100	13,200	13,200	7,810	
29					17,300	32,700	17,500	15,000	12,400	12,400	7,810	7,910
30					15,900	32,700	17,300	14,600	12,200	12,400	7,810	
31					14,800		16,400	13,700		11,900		
1906.												
1				11,900	20,900	29,600	23,600	6,900	14,100	17,300	14,700	
2				12,400	20,900	28,600	23,800	6,900	14,100	16,600	14,600	
3				16,800	20,900	27,600	24,800	7,000	14,100	16,600	14,500	
4				26,600	20,900	29,600	24,600	7,100	14,100	15,900	14,400	
5				27,100	18,700	29,600	24,800	7,200	13,700	15,000	14,300	
6				22,100	18,700	31,900	24,100	7,400	13,500	15,000	14,200	
7				27,600	18,700	33,800	23,800	7,600	13,500	14,100	14,100	
8				29,600	18,700	34,800	24,600	8,000	13,200	14,100	14,100	
9				27,100	18,700	35,800	24,600	8,400	11,900	13,200	13,900	
10				26 600	19,700	36,600	23,600	8,610	10,700	11,900	13,700	
11				27,100	20,700	36,100	23,600	8,610	8,610	11,900	13,700	
12				26,100	20,900	35,800	20,900	8,610	8,610	11,500	13,700	
13				26,100	20,700	33,800	20,700	8,820	8,610	11,500	13,200	
14				26,600	20,700	32,200	19,700	9,220	8,610	11,500	12,800	
15				28,600	18,700	30,100	18,700	9,840	9,840	9,840	12,400	
16				29,400	16,800	27,600	17,500	9,840	9,840	9,840	12,400	
17				29,400	16,800	25,400	17,300	9,840	9,840	9,840	12,200	
18				28,800	16,100	24,100	15,000	9,840	9,840	10,500	11,100	
19				28,600	15,900	23,800	14,100	9,840	10,000	10,700	10,300	
20				27,600	16,800	23,800	13,000	10,000	10,000	10,700	10,000	
21				26,600	17,300	22,100	11,500	10,000	10,300	10,900	9,800	
22				26,600	17,500	22,100	10,000	10,000	10 700	10,300	9,600	
23				25,100	19,000	23,600	8,700	10,000	10,700	9,840	9,400	
24				23,600	20,600	23,800	8,500	10,000	12,200	9,840	9,300	
25				20,900	22,100	23,100	8,200	10,000	12,800	9,840	9,200	
26				20,900	22,100	22,400	8,000	10,700	14,100	11,900	9,100	
27				20,900	22,100	22,400	7,800	11,100	14,300	12,800	9,000	
28				21,100	26,600	23,600	7,600	12,800	15,000	14,100	8,900	
29				23,600	29,600	23,800	7,400	13,200	15,000	15,000	8,800	
30				20,900	29,600	23,800	7,200	14,100	15,000	14,900	8,700	
31					29,600		6,900	14,100		14,800		
1907.												
1				36,900	13,700	19,200	11,900	6,340	7,040	8,210	6,340	
2				34,800	13,700	18,700	11,100	6,020	6,680	8,210	6,340	
3				37,400	13,200	17,800	10,300	5,450	6,340	8,210	6,340	
4				33,800	13,200	17,300	9,430	5,450	6,020	8,210	6,340	
5				30,600	12,800	16,800	9,020	5,450	5,720	8,210	6,680	
6				29,600	12,400	16,400	9,020	5,450	5,450	7,810	7,040	
7				28,600	12,400	15,000	9,430	6,020	5,200	7,420	6,680	
8				27,600	11,500	14,100	8,210	6,340	4,960	7,420	6,680	
9				27,100	11,500	13,700	7,810	6,680	4,960	7,420	6,680	
10				25,600	11,100	14,100	7,420	6,340	4,730	7,420	6,340	
11				24,600	11,100	15,000	6,680	6,020	4,730	7,040	6,680	
12				24,100	9,430	18,300	6,340	5,450	4,960	6,680	7,040	
13				23,100	8,610	20,200	6,020	6,020	4,730	6,340	7,420	
14				22,100	9,020	21,100	6,340	6,020	4,730	6,020	6,680	
15				21,100	9,430	22,100	6,680	6,020	4,960	7,420	6,340	

Daily discharge, in second-feet, of Mississippi River at Anoka—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
16				20,200	9,840	22,600	6,680	6,680	5,200	6,680	6,020	
17				19,700	9,430	21,600	7,420	6,340	5,450	6,340	5,720	
18				18,700	9,840	20,700	7,420	6,020	5,450	6,340	6,020	
19				18,300	9,840	19,700	7,040	5,450	5,720	6,340	6,340	
20				17,800	9,020	18,700	6,680	7,420	6,340	6,340	6,020	
21				17,300	9,430	17,800	6,340	10,300	7,810	6,340	6,020	
22				16,800	9,840	16,800	5,450	9,840	8,610	6,340	6,020	
23				16,400	9,020	16,800	7,040	9,020	10,300	6,340	6,020	
24				16,400	8,610	15,900	6,680	8,610	9,840	6,020	6,020	
25				15,000	9,020	15,000	6,020	8,610	9,840	5,720	6,020	
26			24,100	15,000	10,300	15,000	5,720	8,210	9,430	6,020	6,020	
27			23,100	14,600	11,500	14,100	5,720	8,210	9,020	5,450	5,720	
28			25,100	14,100	13,700	13,200	5,720	8,210	9,430	5,200	5,720	
29			28,600	13,700	16,400	13,200	5,720	8,210	9,430	5,720	5,720	
30			32,200	13,700	18,300	12,400	5,720	7,810	9,020	6,340	5,720	
31			37,400		19,700		6,680	7,810		5,720		
1908.												
1				9,430	13,200	26,600	24,100	8,210	5,720	6,680	6,020	
2				9,430	13,200	28,100	23,100	8,210	5,450	6,340	5,720	
3				9,430	12,400	29,100	22,100	7,810	5,450	6,680	5,720	
4				9,020	11,500	28,600	20,700	7,810	5,450	6,020	5,450	
5				9,020	11,100	27,600	19,700	7,810	5,450	5,450	5,720	
6				9,020	11,100	27,100	18,700	7,810	5,720	6,680	5,450	
7				9,020	10,300	27,100	17,800	7,420	5,720	6,020	5,450	
8				9,430	9,840	27,100	16,800	7,420	5,450	5,450	5,450	
9				9,430	9,430	29,600	15,900	7,420	5,450	5,450	4,960	
10				9,020	9,020	32,200	14,600	6,680	5,450	5,450	4,960	
11				9,020	8,610	34,800	13,700	7,040	5,200	5,200	4,960	
12				9,020	8,610	39,000	12,800	6,680	5,200	5,200	5,450	
13				9,020	8,610	37,900	11,900	6,680	5,450	5,720	4,960	
......				8,610	9,020	35,800	11,100	6,340	5,450	5,450	4,960	
......				8,210	9,430	33,800	10,700	6,020	4,960	5,450	4,960	
16				8,210	9,840	31,700	10,700	6,020	5,720	5,450	4,960	
17				7,420	9,840	29,600	10,300	5,720	6,020	4,960	4,960	
18				7,420	10,300	28,100	9,840	5,720	6,340	4,960	4,960	
19				7,040	10,300	26,600	9,840	6,680	6,680	4,960	4,730	
20				6,340	10,700	24,600	9,840	6,340	6,020	4,960	4,730	
21				7,040	10,700	24,100	9,430	6,020	6,020	4,960	4,960	
22				6,680	10,700	24,100	9,430	6,020	6,680	5,200	4,730	
23				6,340	11,100	24,600	9,430	5,720	5,200	5,200	4,730	
24				6,680	12,400	24,600	9,020	5,720	5,450	5,450	4,730	
25				7,420	14,100	24,600	9,020	6,340	5,450	5,720	4,510	
26				8,210	15,900	25,100	9,020	7,040	5,450	6,020	4,510	
27				9,020	17,800	25,100	9,020	7,040	5,200	6,020	4,730	
28				10,300	19,700	25,100	9,020	7,040	5,450	6,020	4,510	
29				11,500	21,600	25,100	9,020	6,680	6,340	6,680	4,510	
30			9,840	12,400	23,600	25,100	8,610	6,020	6,680	6,340	4,510	
31			9,840		25,600		8,610	5,720		6,020		
1909.												
1				9,840	9,430	11,500	7,420	6,680	8,210	6,020	5,670	
2				12,800	9,430	12,400	7,230	6,020	8,010	6,340	5,960	
3				12,800	9,430	13,200	6,680	6,020	7,420	6,340	5,500	
4				13,200	9,840	13,200	6,680	5,450	7,420	5,450	5,780	
5				15,000	9,840	12,800	6,340	6,020	7,420	6,020	5,840	
6				15,000	9,840	15,000	6,180	5,450	6,680	6,020	6,020	
7				15,000	11,100	14,600	6,020	5,400	6,020	6,020	5,840	
8				15,000	11,500	12,400	5,720	5,720	5,870	6,020	5,720	
9				15,000	11,500	12,400	4,960	6,020	5,580	6,020	6,020	
10				15,000	12,400	11,500	4,960	6,340	6,020	6,180	5,720	
11				14,100	12,400	10,700	4,730	6,020	5,720	6,340	5,580	
12				13,200	12,400	10,300	5,080	6,510	6,020	6,340	5,670	
13				12,800	11,500	10,700	5,200	10,000	6,510	6,340	5,450	
14				11,500	10,700	10,700	4,960	10,700	5,580	6,340	6,340	
15				10,700	10,700	10,700	4,730	10,700	5,320	6,180	5,580	
16				9,840	11,500	10,700	4,840	11,900	5,200	5,870	5,610	
17				10,700	11,500	11,500	4,960	12,400	5,320	6,340	6,480	
18				9,840	11,500	11,500	4,730	12,400	5,200	5,580	5,400	
19				9,020	11,500	11,500	4,510	12,400	5,450	5,780	5,080	
20				8,610	11,500	10,300	4,510	11,700	5,740	5,670	5,450	

Daily discharge, in second-feet, of Mississippi River at Anoka—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
21	......	......	......	8,210	11,500	10,300	4,510	11,500	6,020	5,400	6,020	......
22	......	......	......	8,610	11,500	10,700	5,200	10,700	6,340	5,450	5,870	......
23	......	......	......	9,020	11,100	10,700	5,450	9,840	6,340	6,020	6,020	......
24	......	......	......	8,610	11,100	10,700	7,810	10,300	6,510	5,560	5,900	......
25	......	......	......	8,610	11,100	10,700	9,840	10,500	6,340	5,690	6,020	......
26	......	......	......	9,020	11,100	10,300	9,020	10,300	6,680	5,670	6,410	......
27	......	......	......	9,020	11,100	9,840	8,210	10,300	6,510	5,580	6,050	......
28	......	......	10,700	9,020	10,700	9,840	9,020	9,840	6,680	5,670	6,680	......
29	......	......	10,700	9,020	10,700	8,210	8,210	9,020	6,180	5,670	6,510	......
30	......	......	8,610	9,430	10,700	7,420	7,420	9,020	6,020	5,500	6,310	......
31	......	......	9,020	......	10,700	......	7,040	9,020	......	5,720	......	......
1910.												
1	......	......	3,800	9,720	6,860	5,280	4,130	3,220	3,490	3,660	3,380	......
2	......	......	3,800	9,220	6,930	5,450	4,190	3,140	3,490	3,720	3,490	......
3	......	......	3,900	8,210	6,510	5,380	3,880	3,400	3,490	3,880	3,780	......
4	......	......	3,900	8,490	6,240	5,690	3,720	3,170	3,490	4,250	3,920	......
5	......	......	4,000	7,810	6,180	5,870	3,560	3,310	3,490	4,190	3,780	......
6	......	......	4,000	7,930	6,370	5,450	3,400	3,290	3,490	4,300	3,720	......
7	......	......	4,200	8,410	6,240	4,940	3,720	3,450	3,490	4,250	3,580	......
8	......	......	4,200	8,210	6,150	4,980	3,840	3,140	3,490	4,150	3,740	......
9	......	......	4,500	7,690	6,280	5,000	4,470	3,140	3,490	4,130	3,530	......
10	......	......	4,500	7,540	6,150	5,080	4,730	3,110	3,490	3,720	3,580	......
11	......	......	5,000	7,810	5,580	4,620	5,250	3,280	3,490	4,080	3,400	......
12	......	......	5,000	7,540	5,840	4,360	5,250	3,220	3,490	3,840	2,980	......
13	......	......	6,000	7,460	5,960	4,510	5,450	3,280	3,490	3,880	3,310	......
14	......	......	7,620	7,540	6,050	4,320	5,150	3,570	3,490	3,720	3,000	......
15	......	......	11,000	6,650	5,450	4,150	3,570	3,450	3,490	3,530	2,900	......
16	......	......	11,700	6,340	5,420	4,230	3,450	3,530	3,400	3,380	2,800	......
17	......	......	11,800	6,860	6,020	4,170	3,140	3,450	3,680	3,280	2,700	......
18	......	......	14,500	7,040	5,670	4,060	3,310	3,570	3,780	3,490	2,600	......
19	......	......	14,400	7,620	5,400	3,960	3,170	3,570	3,640	3,310	2,500	......
20	......	......	16,100	8,090	5,500	3,880	3,170	3,450	3,760	3,140	2,300	......
21	......	......	16,400	8,610	5,580	3,900	3,310	3,620	3,580	3,170	2,250	......
22	......	......	15,400	8,820	5,580	3,550	3,350	3,400	3,450	3,110	2,250	......
23	......	......	14,600	8,820	6,180	3,940	3,330	3,510	3,420	3,110	2,250	......
24	......	......	12,200	8,610	5,580	3,880	3,110	3,360	3,420	3,060	2,250	......
25	......	......	12,900	8,860	5,380	3,780	3,140	3,580	3,220	3,060	2,250	......
26	......	......	12,800	9,310	5,930	3,880	2,960	3,580	3,400	3,140	2,250	....
27	......	......	12,600	8,490	5,690	3,960	3,110	3,420	3,350	3,110	2,250	......
28	......	......	12,200	8,210	5,690	3,740	3,080	3,640	3,350	2,890	2,250	......
29	......	......	11,300	7,770	5,560	3,510	3,400	3,490	3,640	2,830	2,200	......
30	......	......	11,400	7,460	5,380	4,110	3,170	3,420	3,880	2,890	2,200	......
31	......	......	10,500	......	5,450	......	3,140	3,450	......	3,010	......	......
1911.												
1	......	......	1,790	3,080	3,520	4,660	4,380	3,870	3,380	4,300	3,700	......
2	......	......	1,860	3,050	3,600	4,960	4,360	3,740	3,310	3,880	3,730	......
3	......	......	1,750	3,020	3,600	5,080	4,010	4,010	3,310	4,080	3,700	......
4	......	......	1,776	3,040	3,520	5,720	4,470	3,970	3,250	4,250	3,340	......
5	......	......	1,460	3,180	3,400	5,380	4,250	4,150	3,410	4,340	3,430	......
6	......	......	1,920	3,110	2,960	5,580	4,300	4,100	3,340	4,300	3,700	......
7	......	......	1,860	3,040	2,840	5,080	4,250	4,080	3,880	4,400	3,730	......
8	......	......	1,820	3,140	2,960	5,870	4,250	4,010	4,300	4,400	3,700	......
9	......	......	2,140	3,110	3,060	6,180	4,140	3,790	4,300	4,400	3,700	......
10	......	......	2,280	3,110	3,180	5,640	4,020	3,920	4,300	4,300	3,520	......
11	......	......	2,000	3,110	3,180	5,030	4,040	3,700	4,310	4,300	3,340	......
12	......	......	1,920	2,990	3,260	4,620	3,730	3,600	4,300	4,400	3,340	......
13	......	......	2,550	3,260	3,340	4,840	4,040	3,660	4,100	4,130	3,340	......
14	......	......	2,540	3,180	3,580	4,400	3,750	3,520	4,090	4,130	3,200	......
15	......	......	1,960	3,300	3,810	4,190	3,750	3,600	4,260	4,340	3,100	......
16	......	......	1,700	3,450	4,510	4,400	3,530	3,600	4,390	4,080	3,100	......
17	......	......	2,220	3,600	4,580	4,080	3,310	3,600	4,300	4,510	3,000	......
18	......	......	2,610	4,230	4,730	4,400	3,310	3,480	4,300	4,080	3,000	......
19	......	......	2,410	4,020	5,030	4,400	3,520	3,380	4,350	4,510	2,900	......
20	......	......	3,410	4,660	5,080	4,300	3,660	3,180	4,250	4,510	2,900	......
21	......	......	3,310	3,880	5,600	4,300	3,460	3,310	4,250	4,550	2,900	......
22	......	......	3,180	3,980	6,120	4,300	3,690	3,450	4,490	4,620	2,800	......
23	......	......	3,180	3,520	6,580	4,080	3,810	3,180	4,350	4,470	2,800	......
24	......	......	3,180	3,600	6,080	3,980	3,570	3,260	4,300	4,470	2,800	......
25	......	......	3,050	3,600	6,240	3,600	3,810	3,310	4,170	4,300	2,700	......

Daily discharge, in second-feet, of Mississippi River at Anoka—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
26	......	......	3,100	3,520	5,720	3,830	3,570	3,180	4,170	4,450	2,700	......
27	......	......	3,060	3,600	5,450	3,980	3,690	3,110	4,300	4,080	2,600	......
28	......	......	3,200	3,750	5,200	4,080	4,210	3,110	4,350	4,300	2,600	......
29	......	......	3,110	3,700	5,130	4,620	4,070	3,110	4,490	3,880	2,500	......
30	......	......	2,990	3,520	4,730	4,400	3,800	3,180	4,700	3,880	2,500	......
31	......	......	2,880	......	4,400	......	3,540	3,310	......	3,980	......	......
1912.												
1	......	......	......	6,440	6,110	12,400	4,080	5,240	4,740	4,290	3,690	......
2	......	......	......	6,780	6,110	11,600	4,080	4,980	4,740	4,290	3,690	......
3	......	......	......	7,520	6,780	10,300	4,080	5,510	4,740	4,510	3,690	......
4	......	......	......	8,300	9,100	9,910	4,290	5,510	4,510	4,510	3,690	......
5	......	......	......	8,700	14,200	9,100	4,080	5,510	4,510	4,510	3,690	......
6	......	......	......	9,910	24,600	8,300	4,740	5,510	4,510	4,510	3,510	......
7	......	......	......	9,500	30,700	7,520	4,740	4,510	4,290	4,510	3,510	......
8	......	......	......	8,700	31,800	6,780	4,510	3,880	4,290	4,290	3,690	......
9	......	......	......	7,520	30,700	6,440	6,110	4,290	4,080	4,290	3,510	......
10	......	......	......	6,780	28,700	6,110	4,980	4,510	3,880	4,510	3,340	......
11	......	......	......	6,780	26,600	6,110	4,980	4,290	3,690	4,510	3,340	......
12	......	......	......	6,110	23,600	4,980	5,240	4,290	3,880	4,740	3,510	......
13	......	......	......	5,800	21,200	5,240	5,240	4,510	3,880	4,510	3,340	......
14	......	......	......	5,510	19,300	4,980	4,980	4,510	3,690	4,290	3,180	......
15	......	......	......	5,510	16,000	5,240	4,740	4,740	3,690	4,290	3,340	......
16	......	......	......	5,240	15,500	4,980	4,740	4,740	3,880	4,080	3,340	......
17	......	......	......	5,800	12,800	4,980	4,510	4,510	4,080	4,290	3,340	......
18	......	......	......	6,110	12,000	4,740	4,740	4,740	4,290	4,290	3,180	......
19	......	......	......	5,510	11,200	5,240	4,980	4,740	4,290	4,290	3,340	......
20	......	......	......	5,240	10,700	5,240	4,980	4,510	4,510	4,510	3,340	......
21	......	......	......	5,110	10,300	5,240	4,980	4,510	4,290	4,510	3,340	......
22	......	......	......	4,980	10,700	5,240	4,980	4,510	4,290	4,740	3,340	......
23	......	......	......	4,980	10,300	5,240	6,110	4,510	4,290	4,510	3,340	......
24	......	......	......	4,510	11,600	5,240	5,240	4,510	4,290	4,740	3,180	......
25	......	......	......	4,740	10,700	4,980	6,780	4,510	4,290	4,290	3,030	......
26	......	......	......	4,980	11,200	4,290	6,440	4,290	4,510	4,080	2,760	......
27	......	......	......	4,980	11,600	4,080	6,440	4,360	4,290	3,880	2,890	......
28	......	......	......	5,240	12,400	4,290	6,110	4,430	4,510	3,690	2,760	......
29	......	......	......	5,510	12,400	4,080	5,800	4,510	4,510	3,690	2,760	......
30	......	......	......	5,510	13,300	4,080	5,510	4,980	4,290	3,510	3,030	......
31	......	......	......	......	13,300	......	5,510	4,980	......	3,690	......	......

Daily discharges computed from a well defined rating curve. Discharges July 21 to August 14 and November 20 to 30, 1906, based on hydrograph of flow at Minneapolis.

Monthly discharge of Mississippi River at Anoka.

[Drainage area, 17,100 square miles.]

Month.	Discharge in second-feet.				Run-off.	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	
1897.						
January	3,740	2,490	2,940	0.172	0.20	....
February	3,010	2,230	2,720	.159	.17	....
March	29,700	2,540	5,650	.330	.38	....
April	49,100	17,400	31,300	1.83	2.04	....
May	17,400	7,810	10,900	.637	.73	....
June	13,600	7,310	10,600	.620	.69	....
July	42,800	13,200	27,500	1.61	1.86	....
August	20,700	6,440	11,600	.678	.78	....
September (1-10)	7,460	6,280	6,880	.402	.15	....
1905.						
May (9-31)	32,700	14,800	23,300	1.36	1.16	A
June	32,700	11,500	22,800	1.33	1.48	A
July	44,300	16,400	30,100	1.76	2.03	B
August	19,200	13,700	16,100	.942	1.09	A
September	15,700	11,500	13,100	.766	.85	A
October	13,200	8,820	10,700	.626	.72	A
November	10,700	....	9,010	.527	.59	B
December	....	....	[a]7,190	.420	.48	C
1906.						
January	....	....	[a]6,020	.352	.41	C
February	....	....	[a]5,340	.312	.32	C
March	....	....	[a]6,580	.385	.44	C
April	29,600	11,900	24,500	1.43	1.60	B
May	29,600	15,900	20,500	1.20	1.38	A
June	36,600	22,100	28,000	1.64	1.83	A
July	24,800	6,900	16,600	.971	1.12	B
August	14,100	6,900	9,530	.557	.64	B
September	15,000	8,610	11,900	.696	.78	A
October	17,300	9,840	12,600	.737	.85	A
November	....	....	11,900	.696	.78	B
December	....	....	[a]7,580	.443	.51	C
The year	36,600	....	13,400	.785	10.66	
1907.						
January	....	....	[a]6,700	.392	.45	C
February	....	....	[a]6,480	.379	.39	C
March	....	....	[a]12,300	.719	.88	C
April	37,400	13,700	22,500	1.32	1.47	A
May	19,700	8,610	11,500	.672	.77	A
June	22,600	12,400	17,100	1.00	1.12	A
July	11,900	5,450	7,350	.430	.50	A
August	10,300	5,450	6,960	.407	.47	A
September	10,300	4,730	6,740	.394	.44	A
October	8,210	5,200	6,750	.395	.46	A
November	7,420	5,720	6,290	.368	.41	B
December	....	....	[a]3,600	.211	.24	C
The year	37,400	....	9,520	.557	7.55	
1908.						
January	....	....	[a]2,590	.151	.17	C
February	....	....	[a]2,740	.160	.17	C
March	....	....	[a]4,340	.254	.29	C
April	12,400	6,340	8,600	.503	.56	A
May	25,600	8,610	12,600	.737	.85	A
June	39,000	24,100	28,400	1.66	1.85	A
July	24,100	8,610	13,000	.760	.88	A
August	8,210	5,720	6,750	.395	.46	A
September	6,680	4,960	5,680	.332	.37	B
October	6,680	4,960	5,680	.332	.38	B
November	6,020	4,510	5,030	.294	.33	B
December	....	....	[a]3,380	.198	.23	C
The year	39,000	....	8,230	.481	6.54	

Monthly discharge of Mississippi River at Anoka—Continued.

Month.	Discharge in second-feet.				Run-off.	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	(depth in inches on drainage area).	
1909.						
January			[a]2,750	0.161	0.19	C
February			[a]2,600	.152	.16	C
March			[a]4,300	.251	.29	C
April	15,000	8,210	11,300	.661	.74	A
May	12,400	9,430	11,000	.643	.74	A
June	15,000	7,420	11,200	.655	.73	A
July	9,840	4,510	6,200	.363	.42	A
August	12,400	5,400	8,840	.517	.60	A
September	8,210	5,200	6,280	.367	.41	A
October	6,340	5,400	5,910	.346	.40	A
November	6,680	5,080	5,880	.344	.38	B
December			[a]5,300	.310	.36	C
The year	15,000		6,800	.398	5.42	
1910.						
January			[a]3,980	.233	.27	C
February			[a]3,800	.222	.23	C
March	16,400		9,230	.540	.62	C
April	9,720	6,340	8,040	.470	.52	A
May	6,930	5,380	5,900	.345	.40	A
June	5,870	3,510	4,460	.261	.29	A
July	5,450	2,960	3,730	.218	.25	A
August	3,640	3,110	3,390	.198	.23	A
September	3,880	3,220	3,510	.205	.23	A
October	4,300	2,830	3,320	.206	.24	A
November	3,920	2,200	2,913	.170	.19	A
December			[a]1,930	.113	.13	C
The year	16,400		4,530	.265	3.60	
1911.						
January			[a]1,670	.098	.11	C
February			[a]1,700	.100	.10	C
March	3,410	[b]1,460	2,460	.144	.17	B
April	4,660	2,990	3,440	.201	.22	A
May	6,680	2,840	4,370	.256	.30	A
June	6,180	3,600	4,670	.273	.30	A
July	4,470	3,310	3,880	.227	.26	B
August	[b]4,150	3,110	3,570	.209	.24	A
September	4,700	3,250	4,100	.240	.24	B
October	4,620	3,880	4,280	.250	.29	A
November	3,700	[b]2,500	3,150	.184	.21	B
December			[a]2,120	.124	.14	B
The year	6,680		3,290	.192	2.58	
1912.						
January			[a]2,340	.137	.16	D
February			[a]2,330	.136	.15	D
March			[a]2,640	.154	.18	D
April	9,910	4,510	6,280	.367	.41	B
May	31,800	6,110	15,700	.918	1.06	A
June	12,400	4,080	6,230	.364	.41	A
July	6,780	4,080	5,120	.299	.34	A
August	5,510	3,880	4,680	.274	.32	B
September	4,740	3,690	4,260	.249	.28	B
October	4,740	3,510	4,300	.251	.29	B
November	3,690	2,760	3,320	.194	.22	C

[a] Estimated from the records of the United States Engineer Corps at lock and dam 2, near Minneapolis, records of St. Anthony Falls Water Power Co., and a comparison of the discharge of the Rum at Cambridge.
[b] Estimated.

MISSISSIPPI RIVER AT ST. PAUL.

Location.—Near foot of Wabasha Street, St. Paul; 6 miles below the mouth of Minnesota River.

Records available.—Gage heights by United States Signal Service (later United States Weather Bureau) 1873 to 1912. Many discharge measurements by United States Engineer Corps prior to 1900. Measurements made by United States Geological Survey 1909 to 1912.

Drainage area.—35,700 square miles.

Gage.—Vertical staff; datum unchanged since establishment. In 1911 the gage was moved upstream several hundred yards but it was set to read the same as at the original location. Gage read once a day. Near the same location is the gage of the United States Engineer Corps, having its datum 0.5 foot higher. All data herein refer to the Weather Bureau gage.

Channel.—Somewhat shifting from year to year.

Discharge measurements.—Made from the Omaha Railway bridge 2 miles above the station.

Regulation.—The river is controlled to a certain extent by the government reservoirs on the headwaters, but the effect of these reservoirs is felt very gradually at St. Paul. The nearest dam is at Minneapolis, and it is possible that the shutting of the wheel gates at that point may cause some daily fluctuations of stage at St. Paul during extreme low water.

Winter flow.—From December to March the river is frozen and the open channel rating curve is not applicable. Monthly estimates of flow for this period are based on the records of the St. Anthony Falls Water Power Company at Minneapolis and the records of the United States Engineer Corps at Lock and Dam 2 below Minneapolis—an allowance being made for the flow of the Minnesota River.

Maximum and minimum flow.—The highest recorded discharge occurred July 22, 1867, and amounted to 117,000 second-feet. Since 1892 the highest discharge has been 80,800 second-feet. The winter flow has fallen nearly as low as 1,000 second-feet.

Accuracy.—As the Weather Bureau gage is read once a day, the recorded mean gage height for the day may be somewhat in error, although occasional additional readings have shown this error was not serious, largely because of the natural storage of the river channel between the Minneapolis dam and St. Paul. Previous to 1900 the United States Engineer Corps made many discharge measurements at St. Paul, the results of which are published by the Mississippi River Commission. Although the base data for estimating the daily flow of the river are available for years prior to 1892, the reservoir system was not then in complete operation and as this system has had a marked influence on the regimen of the river, it is evident that the earlier records have lost much of their value as indications of probable future flow.

Daily discharge, in second-feet, of Mississippi River at St. Paul.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892.												
1	......	......	4,000	10,600	8,520	39,500	23,900	15,200	7,520	6,440	5,060	......
2	......	......	4,000	11,400	9,180	37,400	21,600	14,400	7,520	6,620	5,060	......
3	......	......	4,000	12,700	9,400	35,800	20,700	16,000	8,300	6,640	4,920	......
4	......	......	5,000	12,700	9,640	34,300	19,400	16,000	8,100	6,640	4,920	......
5	......	......	5,000	10,600	9,640	32,700	18,000	13,000	7,900	6,280	4,920	......
6	......	......	5,000	10,600	10,600	26,800	16,800	12,300	7,700	6,440	4,920	......
7	......	......	8,100	10,900	11,200	30,200	16,000	11,700	7,700	6,280	4,920	......
8	......	......	6,790	11,200	11,700	28,800	15,200	12,000	7,520	6,280	4,920	......
9	......	......	6,440	10,900	10,600	30,700	14,000	11,400	7,520	6,280	4,920	......
10	......	......	9,180	10,600	14,000	27,300	13,000	11,200	7,520	6,120	4,920	......
11	......	......	10,600	10,100	15,600	29,700	12,000	10,600	7,700	6,120	4,780	......
12	......	......	10,600	9,180	16,400	25,400	11,400	10,400	8,300	6,120	4,780	......
13	......	......	10,600	8,950	16,400	25,400	10,900	9,880	8,300	6,120	4,920	......
14	......	......	8,950	10,600	17,200	25,400	10,400	9,880	8,520	5,960	4,920	......
15	......	......	8,730	10,400	18,000	24,900	9,640	9,400	8,300	5,960	4,780	......
16	......	......	8,300	9,880	18,500	26,800	9,640	9,400	7,900	5,960	4,500	......
17	......	......	7,900	9,400	18,500	29,200	9,400	9,180	7,520	5,800	4,110	......
18	......	......	7,140	8,730	18,900	29,200	9,400	8,730	7,330	6,120	3,980	......
19	......	......	7,140	8,520	19,800	30,200	10,600	8,520	6,960	5,960	4,110	......
20	......	......	6,960	9,180	28,300	30,200	10,600	8,300	6,790	5,800	4,110	......
21	......	......	6,440	8,100	33,800	30,700	10,900	8,100	6,790	5,800	3,980	......
22	......	......	6,620	7,330	36,800	30,200	10,600	7,900	6,790	5,640	3,980	......
23	......	......	6,280	7,330	40,100	29,200	10,900	7,700	6,620	5,640	3,980	......
24	......	......	5,960	6,960	42,800	27,300	10,600	7,520	6,620	5,500	3,610	......
25	......	......	6,120	6,620	45,100	26,300	10,400	7,520	6,440	5,500	3,600	......
26	......	......	4,920	7,140	45,700	25,400	10,400	7,330	6,440	5,500	3,500	......
27	......	......	5,200	6,960	45,100	25,400	15,600	7,140	6,440	5,340	3,500	......
28	......	......	5,500	6,960	44,500	25,800	16,400	7,140	6,280	5,340	3,400	......
29	......	......	5,640	7,700	43,400	25,400	15,200	6,960	6,440	5,200	3,400	......
30	......	......	8,300	8,300	41,700	24,900	15,600	7,520	6,620	5,200	3,400	......
31	......	......	9,880	......	41,200	......	15,600	7,700	......	5,200	......	......
1893.												
1	......	......	......	18,900	47,500	29,200	8,410	4,900	5,740	5,740	6,100	3,980
2	......	......	......	22,500	52,400	27,800	8,000	4,900	6,100	5,920	5,400	3,840
3	......	......	......	24,900	55,600	26,300	7,800	4,900	6,100	5,740	5,920	4,130
4	......	......	......	28,800	57,500	24,900	7,800	4,740	5,740	5,560	5,560	4,130
5	......	......	......	32,700	58,800	23,900	8,000	4,740	5,740	5,740	5,400	3,980
6	......	......	......	34,300	58,800	22,500	7,800	4,740	5,920	6,100	5,400	4,280
7	......	......	......	34,800	58,800	22,100	7,410	4,740	5,740	6,280	5,740	4,280
8	......	......	......	34,800	58,200	21,100	7,800	4,740	5,560	6,280	5,740	4,280
9	......	......	......	35,800	56,800	19,800	7,800	4,430	5,560	6,100	5,560	4,280
10	......	......	......	36,300	54,900	18,500	7,600	4,280	5,920	6,100	5,220	......
11	......	......	......	35,300	52,400	17,600	7,800	4,130	5,740	5,920	5,060	......
12	......	......	......	35,300	49,900	16,800	8,000	4,280	5,920	5,920	5,060	......
13	......	......	......	34,800	47,500	15,900	8,000	4,430	5,920	5,920	4,900	......
14	......	......	......	33,200	46,300	14,700	8,000	4,580	6,100	5,920	4,900	......
15	......	......	......	32,700	43,400	14,000	8,000	4,900	6,100	5,920	4,900	......
16	......	......	......	31,200	41,700	13,200	7,800	4,900	6,100	5,920	4,900	......
17	......	......	......	31,200	40,600	12,800	7,600	4,900	6,100	6,100	4,580	......
18	......	......	......	30,700	39,500	12,200	7,410	4,900	6,100	6,100	4,430	......
19	......	......	......	29,700	37,900	11,500	7,220	4,740	6,280	6,100	4,130	......
20	......	......	......	29,700	36,800	11,200	7,020	4,740	6,280	6,100	3,400	......
21	......	......	......	29,700	35,300	10,900	6,640	4,740	6,100	6,100	3,260	......
22	......	......	......	28,800	33,200	10,600	6,460	4,740	5,920	6,100	3,400	......
23	......	......	......	27,300	31,700	10,100	6,280	4,740	5,920	6,100	3,260	......
24	......	......	......	27,300	30,200	9,800	5,920	4,580	5,920	6,100	3,120	......
25	......	......	......	27,800	30,200	9,550	5,740	4,740	5,920	6,100	2,980	......
26	......	......	......	30,200	31,700	9,550	5,560	4,430	5,920	5,920	2,440	......
27	......	......	......	34,300	32,200	9,550	5,560	4,280	5,920	5,920	3,260	......
28	......	......	......	37,400	32,700	9,550	5,400	4,430	5,920	5,920	4,130	......
29	......	......	......	41,200	32,700	9,070	5,400	5,060	5,740	5,920	4,280	......
30	......	......	......	44,500	31,700	8,840	4,900	5,220	5,920	5,920	4,280	......
31	......	......	......	......	30,700	......	5,060	5,400	......	6,100	......	......
1894.												
1	......	......	4,000	7,220	26,800	18,000	5,740	2,310	3,840	3,980	4,580	3,450
2	......	......	4,000	6,840	27,300	17,200	5,740	2,180	3,540	4,430	4,580	3,400
3	......	......	4,000	6,840	28,300	15,900	5,560	2,180	3,840	4,430	4,740	3,350
4	......	......	5,000	5,920	28,800	15,100	5,400	2,440	3,840	4,430	4,740	3,300
5	......	......	5,000	6,100	28,300	14,700	5,220	2,180	3,840	4,430	4,740	3,200

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1894.												
6	......	......	5,000	6,100	28,800	14,000	5,060	1,920	3,690	4,280	4,580	3,150
7	......	......	6,000	5,920	28,300	12,800	4,900	2,180	3,840	4,580	4,740	3,100
8	......	......	8,620	5,920	28,300	12,200	4,580	2,310	3,980	4,580	4,740	3,050
9	......	......	9,070	5,920	27,800	11,200	4,430	2,050	4,130	4,430	4,580	3,000
10	......	......	8,200	6,460	27,800	10,600	4,430	2,310	4,130	4,430	4,430	2,950
11	......	......	7,800	6,640	27,300	10,100	4,430	3,260	3,980	4,580	4,280	2,820
12	......	......	7,020	7,020	25,800	9,550	4,430	3,540	4,130	4,740	4,130	2,820
13	......	......	6,640	7,220	23,900	9,310	4,280	3,980	4,130	4,580	4,280	2,820
14	......	......	6,840	7,410	23,900	8,840	4,130	4,280	4,130	4,430	4,280	2,820
15	......	......	6,840	7,600	23,500	8,410	4,130	3,980	4,130	4,280	4,280	2,820
16	......	......	6,840	8,200	24,900	8,200	3,980	4,130	4,280	4,130	4,280	2,820
17	......	......	6,840	9,310	28,800	8,000	3,690	3,980	4,280	4,130	2,980	2,820
18	......	......	6,840	11,500	32,200	7,800	3,690	3,690	4,280	3,840	2,980	2,820
19	......	......	7,020	15,500	38,400	7,600	3,690	3,980	3,980	3,840	3,120	2,820
20	......	......	7,600	19,800	40,600	7,410	3,980	4,130	3,840	3,980	4,130	2,820
21	......	......	8,000	24,400	41,200	7,020	3,840	4,130	3,690	4,430	4,430	2,820
22	......	......	8,200	28,300	40,600	7,020	3,400	4,280	3,690	4,130	4,130	2,750
23	......	......	8,200	31,700	38,400	6,640	3,260	4,280	3,840	4,130	3,260	2,690
24	......	......	8,200	33,800	35,300	6,100	3,400	4,430	3,840	3,980	3,260	2,590
25	......	......	6,640	34,800	32,200	6,100	3,400	4,280	3,980	4,130	3,690	2,500
26	......	......	5,560	33,800	29,200	6,100	2,980	4,130	3,980	3,980	3,690	2,400
27	......	......	4,900	32,200	25,800	5,920	2,980	4,130	3,690	3,840	3,540	2,300
28	......	......	4,430	30,200	23,900	5,920	2,840	4,280	3,690	3,840	3,500	2,200
29	......	......	6,100	28,300	21,600	5,740	2,710	3,690	3,690	4,130	3,500	2,100
30	......	......	7,020	27,300	20,200	5,920	1,920	3,840	3,840	4,280	3,500	2,000
31	......	......	8,000	......	19,400	......	2,440	3,980	......	4,580	......	1,900
1895.												
1	1,900	......	......	3,610	3,230	4,640	7,700	4,110	4,640	5,500	4,110	......
2	1,830	......	......	3,610	3,370	4,920	7,900	3,980	4,240	5,060	3,860	......
3	1,760	......	......	3,610	3,490	6,120	7,700	3,610	4,500	5,200	3,860	......
4	1,710	1,060	......	3,490	3,730	5,960	7,140	3,610	4,500	5,200	3,860	......
5	1,680	1,320	......	3,610	3,980	5,800	6,620	3,490	4,640	5,060	4,110	......
6	1,650	1,300	......	3,610	4,110	6,280	6,620	3,730	4,640	5,200	4,240	......
7	1,620	......	......	3,610	4,780	6,120	6,440	3,370	4,780	5,060	3,860	......
8	1,590	......	......	3,490	4,920	6,280	6,440	3,490	4,920	5,200	4,110	......
9	1,560	......	......	3,610	5,060	6,440	6,620	3,610	4,780	5,200	4,240	......
10	1,310	......	......	3,360	5,060	6,620	6,620	3,980	4,920	5,060	4,110	......
11	1,420	1,220	......	3,610	5,640	8,100	6,120	4,370	4,920	5,060	3,980	......
12	1,530	1,370	......	3,860	5,340	8,520	5,960	4,500	4,920	5,060	4,240	......
13	1,590	1,460	......	3,610	5,340	8,520	5,800	4,640	4,920	4,780	4,110	......
14	1,650	1,360	......	3,610	5,200	9,180	5,500	4,780	4,780	4,500	4,110	......
15	1,710	......	......	3,490	4,920	9,400	5,640	5,340	4,500	4,780	4,240	......
16	1,660	......	......	3,490	5,200	9,640	5,500	4,920	4,240	4,640	4,240	......
17	1,610	......	......	3,370	4,920	9,640	5,340	4,920	4,780	4,780	4,110	......
18	1,560	......	......	3,370	4,920	9,400	5,800	5,200	4,500	4,640	3,980	......
19	1,500	......	......	3,230	4,640	8,950	5,640	4,920	4,640	4,500	4,110	......
20	1,540	......	......	3,230	4,240	8,300	5,340	5,200	4,640	4,500	4,240	......
21	1,590	......	......	3,230	4,640	7,900	5,060	4,920	4,780	4,240	3,490	......
22	1,550	......	2,630	3,370	4,500	7,700	4,780	4,640	5,060	4,500	3,110	......
23	1,340	......	2,750	3,490	4,240	7,520	4,780	4,500	5,340	4,240	3,110	......
24	1,400	......	2,990	3,110	4,240	7,330	4,640	4,640	5,640	4,370	2,990	......
25	1,380	......	3,110	2,990	4,240	7,140	4,640	4,640	5,500	4,240	3,110	......
26	1,400	......	3,110	3,110	4,370	7,140	4,640	4,500	5,340	4,240	3,110	......
27	1,420	......	3,610	3,490	4,240	7,140	4,640	4,780	5,200	4,110	3,110	......
28	1,440	......	4,110	3,110	4,500	7,330	4,500	4,640	5,200	3,860	3,000	......
29	1,520	......	3,980	2,750	4,640	7,520	4,240	4,640	5,200	4,240	3,000	......
30	1,250	......	3,980	3,490	4,640	7,700	4,640	4,500	5,060	4,110	3,000	......
31	1,200	......	3,980	......	4,500	......	4,240	4,500	......	4,110	......	......
1896.												
1	......	......	......	3,230	21,600	27,300	12,700	4,780	5,060	5,060	5,640	4.500
2	......	......	......	2,400	23,500	25,400	11,700	4,640	4,640	5,060	5,640	5,000
3	......	......	......	2,280	24,900	24,400	11,400	4,640	4,500	4,920	6,280	4,580
4	......	......	......	2,870	26,300	22,500	11,200	5,060	4,110	5,060	6,120	4,490
5	......	......	......	3,600	27,300	22,100	10,900	4,500	4,110	4,780	6,120	4,550
6	......	......	......	4,110	27,800	20,200	10,100	4,500	3,980	5,200	6,120	4,510
7	......	......	......	4,500	28,300	22,100	9,880	4,640	4,110	4,780	6,280	4,470
8	......	......	......	4,640	27,300	22,500	9,640	5,060	4,370	4,640	6,440	4,430
9	......	......	......	4,640	26,800	23,500	8,950	4,920	4,500	4,640	6,280	4,390
10	......	......	2,170	4,640	25,800	24,900	8,730	4,920	4,780	4,780	6,280	4,300

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
11	......	......	1,950	5,060	25,400	25,800	8,520	5,200	4,920	4,780	5,800	4,290
12	......	......	2,060	5,960	23,900	26,300	8,520	5,340	4,780	5,060	5,200	4,290
13	......	......	2,170	8,100	23,900	26,300	8,300	5,640	4,640	5,200	4,780	4,280
14	......	......	2,400	17,600	23,900	25,400	8,100	5,800	4,640	5,200	4,920	4,280
15	......	......	2,400	23,500	24,400	23,900	7,900	5,800	4,780	5,340	5,060	4,270
16	......	......	1,840	29,200	24,900	22,100	7,330	5,640	5,200	5,200	4,640	4,270
17	......	......	2,170	34,300	27,800	20,200	6,790	5,500	5,340	5,200	4,920	4,260
18	......	......	1,950	35,300	29,700	18,500	6,440	5,340	5,340	5,060	4,920	4,260
19	......	......	1,420	33,800	31,700	17,200	6,280	5,200	5,340	5,060	4,920	4,250
20	......	......	1,420	31,200	33,200	16,400	6,120	5,060	5,200	5,200	4,370	4,250
21	......	......	1,520	29,200	34,300	15,600	6,280	5,060	5,060	5,200	4,240	4,240
22	......	......	1,420	26,800	34,300	14,000	5,960	4,920	4,920	5,060	4,640	4,530
23	......	......	1,520	24,900	33,800	14,400	5,960	5,060	4,920	4,920	4,200	4,150
24	......	......	1,950	23,500	32,700	15,200	5,800	5,060	4,920	4,920	4,200	4,260
25	......	......	1,950	21,100	31,700	16,000	5,800	5,200	4,780	5,060	4,200	4,360
26	......	......	2,170	20,200	30,200	16,400	5,640	4,920	4,920	4,920	4,200	4,460
27	......	......	2,170	19,400	29,200	16,800	5,500	4,920	5,060	4,780	4,000	4,570
28	......	......	2,280	18,000	29,200	16,000	5,060	4,920	5,060	4,920	4,000	4,670
29	......	......	2,520	18,500	29,200	14,400	4,920	4,780	5,060	4,780	4,000	4,550
30	......	......	2,630	19,800	29,200	13,700	4,780	4,640	4,920	5,340	4,000	4,430
31	......	......	3,230	......	28,300	......	4,640	4,780	......	5,640	......	4,500
1897.												
1	5,300	3,400	3,250	60,800	29,800	10,200	14,400	24,600	8,500	10,100	7,600	......
2	5,340	3,450	3,300	68,700	28,800	11,000	14,800	23,700	8,500	9,800	7,800	......
3	5,200	3,320	3,360	74,000	27,900	11,000	15,200	23,300	8,720	9,550	7,800	......
4	5,100	3,330	3,340	76,300	25,600	11,000	15,600	22,400	8,720	9,070	7,800	......
5	4,950	3,400	3,310	80,100	24,200	11,600	20,200	21,500	8,720	9,310	7,600	......
6	4,810	3,400	3,170	80,800	22,800	11,900	24,600	20,600	8,940	9,070	7,600	......
7	5,010	3,420	3,220	79,300	21,500	12,300	29,300	19,300	8,940	9,070	7,600	......
8	5,210	3,440	3,270	78,600	20,200	12,600	40,100	15,700	8,720	8,840	7,600	......
9	5,100	3,460	3,320	79,300	18,900	12,300	45,900	18,900	8,720	8,840	7,600	......
10	5,170	3,480	3,150	78,600	17,600	12,300	47,700	17,200	8,500	8,620	7,410	......
11	5,240	3,500	3,230	77,000	16,800	12,600	49,600	16,000	8,500	8,200	7,220	......
12	4,500	3,550	3,320	74,000	16,400	12,300	48,900	14,800	8,500	8,410	7,220	......
13	4,520	3,490	3,000	70,200	15,600	11,600	47,700	13,700	8,720	8,410	7,220	......
14	4,560	3,450	3,060	67,300	15,200	11,900	45,900	12,600	9,400	8,200	7,220	......
15	4,600	3,410	3,120	63,600	14,800	11,900	43,500	11,900	9,900	8,000	7,220	......
16	4,390	3,380	3,180	60,100	14,400	12,300	47,700	11,300	10,900	8,000	7,220	......
17	4,340	3,270	3,160	58,000	14,100	12,300	39,000	11,000	11,800	8,000	7,020	......
18	4,290	3,170	3,320	56,000	14,100	12,600	36,300	10,700	11,800	7,800	7,020	......
19	4,240	3,130	4,250	52,100	14,100	13,300	33,700	10,700	11,800	8,000	6,840	......
20	4,080	3,180	5,440	50,200	14,100	11,100	31,800	10,400	11,500	8,200	6,640	......
21	3,880	3,230	9,400	47,700	14,100	14,800	30,800	10,200	11,200	8,200	6,460	......
22	3,680	3,280	11,000	45,900	13,300	15,200	29,300	10,200	11,500	8,200	6,460	......
23	3,480	3,350	14,400	44,700	12,600	15,600	28,400	9,900	11,500	8,200	5,920	......
24	3,440	3,390	18,900	42,400	11,900	15,200	27,900	9,650	11,200	8,410	5,400	......
25	3,400	3,270	22,400	40,600	11,600	14,800	27,400	9,650	10,900	8,200	5,220	......
26	3,350	3,190	25,600	38,400	11,300	13,700	28,800	9,650	10,300	8,200	5,060	......
27	3,300	3,120	27,400	36,800	11,300	13,000	28,800	9,160	10,300	8,000	4,900	......
28	3,340	3,200	29,300	34,700	11,000	13,000	27,900	8,940	10,300	7,800	4,900	......
29	3,050	......	30,300	32,700	10,700	13,300	27,000	8,720	10,300	7,800	4,800	......
30	3,200	......	41,200	31,300	10,400	14,100	25,600	8,500	10,100	7,600	4,700	......
31	3,300	......	48,900	......	10,400	......	25,100	8,500	......	7,600	......	......
1898.												
1	......	......	4,000	7,900	6,790	11,200	10,100	7,900	6,790	6,620	8,100	......
2	......	......	4,000	7,520	6,960	11,200	10,600	7,900	6,620	6,280	8,100	......
3	......	......	4,000	7,520	7,140	11,200	10,400	7,520	6,280	6,120	7,900	......
4	......	......	5,000	7,520	7,140	10,600	10,400	7,330	6,120	6,120	7,900	......
5	......	......	5,000	7,900	7,520	10,900	10,600	6,960	6,120	6,120	7,900	......
6	......	......	5,000	8,100	7,520	26,300	11,200	7,900	6,120	6,280	7,700	......
7	......	......	5,000	8,100	7,700	33,200	12,000	7,140	6,120	6,620	7,330	......
8	......	......	7,700	8,100	7,520	35,300	12,300	7,140	5,960	6,790	7,330	......
9	......	......	7,900	8,100	7,140	35,300	12,700	6,960	5,960	6,790	7,330	......
10	......	......	8,520	7,900	7,140	34,300	14,000	6,790	5,960	6,960	7,140	......
11	......	......	8,730	7,900	6,620	32,700	15,200	6,440	6,280	7,520	7,140	......
12	......	......	8,520	8,300	6,620	31,200	16,400	6,440	6,120	7,330	6,960	......
13	......	......	7,520	8,300	6,280	29,700	17,200	6,440	6,120	7,900	6,960	......
14	......	......	6,620	8,100	6,280	28,800	16,000	6,120	6,440	8,300	6,620	......
15	......	......	8,730	8,520	6,620	26,800	14,400	5,960	6,620	8,300	6,620	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898.												
16	......	......	8,100	8,520	6,440	23,900	13,300	6,440	6,620	8,520	6,620	......
17	......	......	7,900	8,300	6,440	21,600	12,000	6,120	6,440	8,520	6,620	......
18	......	......	7,700	8,100	6,440	19,800	11,400	6,120	6,440	8,730	6,620	......
19	......	......	8,300	8,100	6,620	18,500	10,900	6,120	6,120	8,730	6,620	......
20	......	......	8,100	8,100	6,7(0	17,200	10,600	5,960	6,120	8,950	6,790	......
21	......	......	7,(00	7,(00	6,960	16,000	10,100	6,120	6,120	9,180	6,620	......
22	......	......	7,900	7,700	7,900	15,200	9,640	6,120	6,120	9,400	6,620	......
23	......	......	7,700	7,330	8,300	14,800	9,180	6,120	6,280	9,640	6,000	......
24	......	......	6,440	7,140	8,950	13,700	8,950	6,280	6,280	9,640	6,000	......
25	......	......	7,140	6,620	9,640	12,700	8,730	6,440	6,620	9,640	6,000	......
26	......	......	7,900	6,790	9,880	11,400	8,730	6,440	6,620	9,400	5,000	......
27	......	......	8,100	6,440	9,400	10,900	8,730	6,440	6,620	9,400	5,000	......
28	......	......	7,520	6,440	9,880	10,600	8,300	6,620	6,620	9,180	5,000	......
29	......	......	6,120	6,440	10,100	10,100	8,100	6,790	6,620	8,730	5,000	......
30	......	......	6,120	6,440	10,600	9,880	8,100	6,960	6,790	8,520	5,000	......
31	......	......	7,140	......	10,600	......	8,300	6,960	......	8,300	......	......
1899.												
1	......	......	......	8,000	15,200	12,700	25,400	8,300	19,800	9,180	18,500	**9,880**
2	......	......	......	8,000	16,000	16,000	25,400	7,900	18,500	8,950	18,000	**9,880**
3	......	......	......	8,000	16,800	20,700	24,400	7,700	17,200	8,730	17,600	**9,640**
4	......	......	......	9,600	17,600	23,000	23,500	7,700	16,400	8,730	16,800	**9,400**
5	......	......	......	9,000	18,000	24,400	22,100	7,520	15,200	8,730	16,400	**8,730**
6	......	......	......	9,000	18,500	25,400	21',100	7,330	14,400	8,520	16,000	**8,730**
7	......	......	......	9,000	19,800	27,800	19,800	7,330	14,400	8,520	15,600	**5,640**
8	......	......	......	10,600	20,200	29,700	18,900	7,330	14,000	8,520	15,200	**5,640**
9	......	......	......	17,200	19,800	30,200	17,600	7,330	13,300	8,300	14,400	**6,790**
10	......	......	......	19,400	18,500	30,700	16,800	7,700	13,000	8,300	14,000	**6,790**
11	......	......	......	19,800	17,200	31,200	15,600	8,100	12,700	8,300	13,700	**6,790**
12	......	......	......	22,500	16,400	30,200	14,400	8,300	12,700	8,520	13,700	**6,790**
13	......	......	......	30,700	15,600	31,200	13,700	8,520	12,700	8,520	13,300	......
14	......	......	......	34,300	14,400	31,700	13,300	7,900	12,300	8,950	13,000	......
15	......	......	......	33,200	14,000	33,200	13,300	7,900	12,300	9,180	12,700	......
16	......	......	......	33,800	13,700	34,300	13,700	7,900	12,300	9,640	12,300	......
17	......	......	......	33,800	14,000	34,800	12,700	8,300	12,000	11,400	12,000	......
18	......	......	......	33,800	14,000	35,8C0	11,700	8,300	11,400	13,000	11,700	......
19	......	......	......	32,200	13,700	36,200	11,200	8,300	11,200	16,400	11,700	......
20	......	......	......	29,200	13,300	36,300	10,900	8,950	10,900	19,800	11,400	......
21	......	......	......	25,800	13,300	36,300	10,600	9,640	10,600	22,100	11,200	......
22	......	......	......	22,100	13,300	36,806	10,600	13,000	10,600	23,900	10,900	......
23	......	......	......	19,400	13,300	36,800	10,600	16,600	10,600	25,400	10,600	......
24	......	......	......	17,600	13,000	36,300	10,100	22,100	10,600	25,800	10,600	......
25	......	......	......	16,400	13,000	35,300	9,880	25,400	10,400	25,400	10,600	......
26	......	......	......	15,600	13,000	33,200	9,640	25,800	10,400	24,900	10,600	......
27	......	......	......	14,800	12,700	31,200	9,400	25,400	10,100	23,000	10,400	......
28	......	......	......	14,000	13,000	29,200	8,950	24,400	10,100	22,100	10,400	......
29	......	......	......	14,000	13,000	27,800	8,730	23,500	9,880	21,100	10,100	......
30	......	......	......	14,400	12,700	25,800	8,520	22,100	9,400	20,200	10,100	......
31	......	......	......	......	12,700	......	8,300	20,700	......	19,400	......	......
1900.												
1	......	......	......	7,140	7,700	6,790	3,370	3,730	11,700	13,000	9,400	......
2	......	......	......	6,440	7,700	6,440	3,260	3,860	11,400	13,000	9,400	......
3	......	......	......	6,790	7,900	6,280	3,610	3,860	10,600	13,300	9,400	......
4	......	......	......	7,700	7,900	5,960	4,920	3,860	10,100	13,300	9,400	......
5	......	......	......	7,900	7,990	5,800	5,800	3,610	9,880	14,800	9,640	......
6	......	......	......	9,640	7,700	5,640	6,280	3,610	9,400	15,600	9,640	......
7	......	......	......	12,300	7,330	5,640	6,280	3,610	8,730	16,000	9,640	......
8	......	......	......	12,300	7,140	5,500	6,440	3,730	8,300	14,800	9,400	......
9	......	......	......	11,200	6,960	5,500	6,280	3,860	8,100	14,400	9,180	......
10	......	......	......	10,600	7,330	5,500	6,280	4,240	8,700	13,700	8,950	......
11	......	......	......	10,100	6,790	4,640	6,120	5,200	9,180	13,300	8,730	......
12	......	......	......	9,400	6,440	4,640	6,120	6,120	11,400	13,000	8,520	......
13	......	......	......	8,950	6,280	4,780	6,440	6,280	13,000	12,706	8,300	......
14	......	......	......	8,730	6,120	4,780	6,440	7,330	12,700	12,700	7,900	......
15	......	......	......	8,520	6,120	4,240	6,120	7,700	12,000	11,700	7,330	......
16	......	......	......	8,300	6,120	4,240	6,120	8,300	11,400	11,400	5,960	......
17	......	......	......	9,180	6,120	4,110	5,800	8,730	11,200	11,400	5,060	......
18	......	......	......	9,640	6,280	3,980	5,640	8,950	10,900	11,400	4,920	......
19	......	......	......	10,100	6,280	3,980	5,340	8,730	10,600	11,200	4,920	......
20	......	......	......	9,640	5,800	3,860	5,200	8,300	11,200	10,900	5,060	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
21	......	......	......	9,180	5,640	3,860	5,200	7,900	12,000	10,600	5,060	......
22	......	......	......	8,730	5,960	3,860	5,200	7,700	12,700	10,100	5,060	......
23	......	......	......	8,300	6,120	3,860	5,200	7,700	13,300	10,100	4,920	......
24	......	......	......	8,300	6,120	3,860	5,060	8,100	13,300	9,640	4,780	......
25	......	......	......	8,300	6,120	3,610	4,640	8,520	13,700	9,400	4,370	......
26	......	......	......	8,100	5,960	3,610	4,240	9,400	13,700	9,400	3,980	......
27	......	......	......	7,900	6,120	3,610	3,730	9,880	13,700	8,950	4,640	......
28	......	......	......	7,900	6,120	3,490	3,730	10,600	13,700	9,400	5,060	......
29	......	......	......	7,900	6,790	3,490	3,980	11,700	13,300	9,640	4,920	......
30	......	......	......	7,700	6,960	3,370	3,610	12,000	13,000	9,400	4,920	......
31	......	......	......	......	6,960	......	3,610	11,700	......	8,950	......	......
1901.												
1	......	......	......	11,700	13,700	10,600	13,700	7,900	5,800	5,800	5,960	......
2	......	......	......	12,300	13,700	10,400	14,800	7,700	6,120	5,800	5,960	......
3	......	......	......	12,300	14,000	10,100	15,200	7,140	5,960	5,800	6,120	......
4	......	......	......	13,000	14,000	10,100	15,600	6,960	5,960	5,960	5,960	......
5	......	......	......	14,000	16,800	9,880	15,600	6,620	5,800	5,960	5,960	......
6	......	......	......	15,600	17,200	9,880	16,000	6,440	5,800	5,800	5,960	......
7	......	......	......	15,200	18,000	9,400	16,400	6,440	5,800	5,500	5,800	......
8	......	......	......	15,600	18,500	8,950	17,200	6,280	5,640	5,500	5,800	......
9	......	......	......	16,800	18,900	8,730	17,600	6,120	5,500	5,500	5,640	......
10	......	......	......	18,500	18,900	8,520	18,000	5,960	5,640	5,500	5,640	......
11	......	......	......	18,900	18,900	8,730	18,500	5,800	5,800	5,640	5,640	......
12	......	......	......	19,800	18,000	8,950	18,500	5,500	5,960	5,800	5,800	......
13	......	......	......	18,500	17,600	8,950	18,500	5,340	5,640	5,800	5,640	......
14	......	......	......	16,400	17,600	8,520	17,600	5,640	5,640	5,960	5,640	......
15	......	......	......	15,600	17,200	8,950	17,200	5,960	5,500	6,280	5,640	......
16	......	......	......	15,600	16,800	8,950	16,800	6,280	5,340	6,620	5,500	......
17	......	......	......	16,400	16,400	8,520	16,400	6,280	5,340	6,440	4,780	......
18	......	......	......	16,000	16,400	8,300	16,000	6,120	5,200	6,440	4,240	......
19	......	......	......	16,000	16,000	8,300	15,200	5,960	5,060	6,280	4,370	......
20	......	......	......	16,000	15,600	8,730	14,000	5,800	5,060	6,280	4,370	......
21	......	......	......	15,600	15,200	9,180	13,000	5,800	5,060	6,280	4,370	......
22	......	......	......	15,600	14,400	10,600	12,000	5,800	4,920	6,120	4,370	......
23	......	......	......	15,600	14,400	12,000	11,400	5,640	4,920	6,120	4,500	......
24	......	......	......	15,200	14,000	12,300	10,600	5,640	4,920	5,960	4,500	......
25	......	......	11,700	15,200	13,300	12,700	10,100	5,640	5,060	5,960	3,980	......
26	......	......	13,000	14,800	13,000	12,700	9,400	5,500	5,200	5,800	4,370	......
27	......	......	12,700	14,800	12,300	12,700	8,950	5,640	5,340	5,800	4,240	......
28	......	......	11,700	14,800	11,700	12,300	8,520	5,800	5,500	5,800	4,110	......
29	......	......	11,200	14,400	11,400	14,000	8,300	5,800	5,640	5,800	3,980	......
30	......	......	11,400	14,000	11,200	14,400	8,100	5,800	5,500	5,960	4,240	......
31	......	......	11,400	......	10,900	......	8,100	5,800	......	5,960	......	......
1902.												
1	......	......	3,000	5,060	4,780	14,800	9,880	7,140	4,240	4,780	5,500	7,140
2	......	......	3,100	5,060	4,920	14,000	9,640	6,620	4,370	4,920	5,500	6,620
3	......	......	3,200	5,200	4,780	13,700	9,180	6,280	4,920	4,920	5,640	6,440
4	......	......	3,300	5,200	5,060	14,000	8,950	5,800	5,500	5,060	5,800	......
5	......	......	3,400	5,060	5,060	15,200	8,730	5,800	5,960	5,060	5,960	......
6	......	......	3,400	4,920	5,200	16,000	8,730	5,340	6,280	5,060	6,440	......
7	......	......	3,500	4,640	5,200	16,400	8,300	5,340	6,620	5,200	6,790	......
8	......	......	3,500	4,640	5,340	16,400	8,100	5,500	6,280	5,200	7,140	......
9	......	......	3,600	4,780	5,500	16,800	8,100	5,500	6,440	5,200	7,330	......
10	......	......	3,730	4,920	6,120	16,800	8,520	6,120	6,440	5,200	7,330	......
11	......	......	3,860	4,780	8,520	16,400	8,950	5,500	6,280	5,200	7,330	......
12	......	......	3,860	4,640	8,950	16,400	8,950	5,200	5,960	5,200	7,330	......
13	......	......	3,860	4,500	9,400	16,400	8,950	5,200	5,640	4,920	7,520	......
14	......	......	4,240	4,500	9,180	16,000	8,520	5,060	5,200	4,920	7,520	......
15	......	......	4,640	4,370	8,950	15,200	8,100	5,060	4,920	4,920	7,520	......
16	......	......	5,060	4,370	8,730	14,400	7,900	4,920	5,060	4,780	7,520	......
17	......	......	4,400	4,500	8,730	14,000	8,300	4,920	5,200	4,780	7,700	......
18	......	......	4,400	4,240	8,950	13,700	7,900	4,640	5,200	4,640	8,100	......
19	......	......	4,240	4,110	8,950	13,000	7,330	4,500	5,060	4,640	8,520	......
20	......	......	4,780	3,980	9,180	12,300	7,140	4,500	4,920	4,500	8,950	......
21	......	......	5,060	3,860	9,180	12,000	6,440	4,370	5,200	4,500	9,400	......
22	......	......	5,200	3,980	9,400	11,700	6,120	4,640	5,060	4,640	9,400	......
23	......	......	5,200	3,980	12,300	11,200	5,800	4,640	5,200	4,640	9,640	......
24	......	......	5,340	3,860	17,200	10,900	5,640	4,640	5,200	4,640	9,400	......
25	......	......	5,800	3,860	19,400	10,900	5,640	4,240	5,060	4,640	9,400	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
26			5,960	4,500	19,800	10,400	5,960	4,370	4,920	4,640	9,180	......
27			6,120	4,640	19,800	10,100	6,120	4,370	4,920	4,640	9,180	......
28			5,800	4,500	18,900	10,100	6,120	4,240	4,780	4,780	8,730	......
29			5,400	4,500	17,600	10,100	6,280	4,110	4,640	5,060	7,900	......
30			5,340	4,640	16,400	9,880	6,960	4,110	4,640	5,340	7,520	......
31			5,060	......	15,600	......	7,140	4,110	......	5,340	......	......
1903.												
1			2,000	20,600	18,200	34,700	7,170	12,300	8,390	26,300	19,000	......
2			2,000	19,000	18,200	39,100	7,170	13,000	8,390	24,000	17,800	......
3			2,200	18,600	17,800	42,500	7,760	13,700	8,610	22,700	16,600	......
4			2,200	18,600	17,800	42,500	10,000	14,700	8,830	22,700	15,500	......
5			2,400	18,600	17,800	40,200	14,400	15,100	9,300	22,700	15,100	......
6			2,600	18,200	18,200	36,400	16,200	15,500	9,300	21,000	15,100	......
7			3,000	19,400	18,600	33,200	17,400	15,500	9,300	29,600	15,100	......
8			4,000	19,400	19,000	29,600	17,400	15,800	9,540	36,400	14,700	......
9			5,000	19,000	19,400	26,800	17,400	15,500	9,790	40,800	14,700	......
10			6,000	18,200	19,000	24,000	18,600	14,700	9,790	44,200	14,000	......
11			7,000	19,000	19,000	21,000	19,800	14,000	9,540	47,100	13,000	......
12			8,000	20,200	21,000	17,800	21,000	13,300	10,300	48,800	12,600	......
13			9,000	21,800	24,000	14,700	21,400	12,300	19,800	50,600	12,600	......
14			10,000	23,200	27,200	13,000	20,600	11,700	25,400	51,800	12,600	......
15			14,700	24,500	30,100	12,600	19,400	11,400	29,200	51,200	12,600	......
16			15,100	25,400	32,600	12,300	18,600	11,100	32,200	49,400	12,300	......
17			15,800	26,300	34,200	11,700	18,600	10,800	34,700	47,600	12,000	......
18			15,500	26,800	36,400	10,800	18,600	10,800	36,400	45,900	11,400	......
19			15,800	26,300	36,900	10,300	16,600	10,800	38,000	43,600	10,300	......
20			19,000	25,800	36,400	10,000	15,500	10,800	40,200	40,800	8,390	......
21			20,200	24,900	35,300	9,790	14,700	10,800	41,300	38,000	7,170	......
22			21,400	23,600	34,200	9,540	14,400	10,800	42,500	35,800	6,800	......
23			21,400	22,300	32,600	9,300	14,400	10,300	42,500	33,200	6,800	......
24			22,300	21,800	30,100	9,060	14,000	10,000	42,500	31,100	7,360	......
25			23,200	20,600	29,200	8,610	13,700	9,540	41,300	29,200	7,970	......
26			24,000	19,800	28,700	8,390	12,600	9,060	39,100	27,200	8,830	......
27			24,000	19,400	28,700	8,180	12,600	8,610	36,900	25,400	10,300	......
28			24,000	19,400	29,600	7,970	12,000	8,390	34,200	24,000	12,000	......
29			23,200	19,000	29,600	7,970	11,700	8,830	31,600	22,700	13,000	......
30			21,800	19,000	29,600	7,560	11,700	9,060	28,700	21,000	11,400	......
31			21,400	......	31,100	......	12,000	8,610	......	19,800	......	......
1904.												
1				14,000	24,000	13,700	12,000	7,760	6,620	7,170	16,600	......
2				13,300	23,600	13,300	12,000	7,760	6,440	7,760	15,500	......
3				13,000	22,700	13,700	11,700	7,560	7,970	7,970	14,400	......
4				14,000	21,800	14,400	11,700	7,360	9,300	8,180	13,300	......
5				15,500	20,600	15,500	11,400	7,170	9,790	7,760	13,000	......
6				16,600	20,200	15,800	11,100	7,170	10,300	7,560	12,600	......
7				24,500	20,200	17,800	10,800	6,980	11,700	7,560	12,600	......
8				26,300	20,600	19,400	10,800	6,620	12,000	7,970	12,300	......
9				27,200	20,200	20,600	10,800	6,620	12,000	8,180	11,400	......
10				30,600	19,800	21,400	11,400	6,800	12,000	8,830	10,600	......
11				31,600	19,400	21,800	11,100	6,800	12,000	9,300	10,800	......
12				31,600	20,200	21,400	10,600	6,800	11,400	14,000	10,800	......
13				31,100	20,600	21,000	10,000	6,800	10,600	14,700	10,300	......
14				30,100	20,200	20,600	9,790	6,800	9,540	14,700	10,000	......
15				29,200	19,800	19,800	9,300	6,800	8,610	16,200	10,000	......
16				29,200	19,400	18,200	9,060	6,620	8,390	17,400	9,790	......
17				28,200	18,600	17,000	8,840	6,440	8,180	18,200	9,540	......
18				26,800	17,800	15,800	8,610	6,270	7,970	17,800	9,060	......
19				25,800	17,400	14,400	8,610	6,100	7,560	17,800	9,060	......
20				24,900	17,000	13,300	8,610	6,620	7,360	18,600	8,830	......
21				24,500	16,200	12,600	8,390	6,980	6,980	19,000	8,610	......
22				23,600	15,800	12,300	8,180	7,170	6,800	20,600	8,610	......
23				23,600	15,500	11,700	8,390	7,760	6,620	21,400	8,390	......
24				23,200	15,100	11,400	8,390	8,180	6,620	20,600	8,390	......
25				23,200	15,100	11,400	8,180	8,390	6,620	21,000	8,390	......
26				23,200	15,100	11,100	7,970	8,180	6,440	21,400	8,390	......
27				24,500	15,100	11,400	7,760	8,390	6,440	21,800	8,180	......
28				24,900	15,500	11,700	7,560	8,390	6,800	21,800	8,180	......
29				25,400	15,500	12,300	7,360	8,390	6,800	20,600	7,970	......
30				24,900	14,700	12,000	7,560	7,760	6,620	19,400	7,560	......
31					14,000		7,760	7,170	......	17,800	......	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1			2,500	10,800	8,390	21,000	40,800	21,800	15,800	14,400	12,600	
2			2,600	10,800	8,180	19,000	40,200	20,600	15,100	14,000	12,300	
3			2,700	10,800	8,180	18,200	40,800	19,800	15,100	13,300	12,000	
4			2,800	11,100	8,390	18,200	41,300	19,400	14,700	13,300	12,000	
5			3,000	12,600	9,300	18,600	43,000	19,400	14,700	13,300	11,700	
6			5,000	12,000	10,800	18,600	45,900	19,800	14,400	13,000	12,000	
7			12,600	14,000	15,500	20,200	49,400	18,600	14,400	13,000	12,600	
8			11,700	16,200	18,600	22,300	53,600	18,600	14,000	12,600	12,600	
9			11,100	17,000	17,800	23,200	56,700	18,600	14,000	12,300	13,000	
10			13,000	17,400	17,800	23,200	58,500	18,600	14,000	12,300	13,300	
11			10,800	17,400	19,400	24,500	59,800	19,000	13,300	12,000	13,000	
12			8,830	17,400	22,700	24,500	59,200	19,000	13,300	12,000	13,300	
13			8,180	15,800	25,800	24,000	57,900	18,600	13,000	11,700	12,600	
14			7,760	15,100	26,800	24,000	56,700	18,600	12,600	11,400	12,600	
15			7,560	14,000	32,200	23,200	54,800	18,600	13,700	11,400	12,300	
16			7,760	13,700	36,400	22,700	53,000	18,600	13,700	11,100	12,000	
17			7,760	12,000	38,500	24,900	50,000	19,000	14,000	10,800	11,700	
18			7,760	11,700	41,300	26,800	47,100	22,300	13,700	11,700	11,400	
19			7,560	11,100	41,300	29,600	44,800	22,700	16,600	12,300	11,400	
20			7,560	10,800	40,800	32,600	41,900	22,700	18,600	12,600	11,100	
21			8,390	10,600	40,200	34,200	39,600	23,600	20,200	13,300	11,100	
22			9,300	10,000	38,500	34,700	38,000	22,300	19,800	13,700	10,800	
23			10,800	9,790	37,400	34,200	35,800	21,800	19,400	14,400	10,800	
24			12,000	9,300	36,400	33,700	34,200	21,000	18,600	14,400	10,800	
25			12,300	8,830	35,300	33,700	32,600	20,600	18,200	14,400	11,400	
26			12,600	8,610	33,700	34,200	31,100	20,600	17,400	14,700	12,300	
27			13,300	8,610	31,600	35,800	29,600	19,400	16,600	14,400	12,600	
28			14,400	8,390	29,200	38,000	29,200	18,200	15,800	13,000	13,300	
29			12,600	8,390	27,200	39,600	27,200	17,400	15,500	13,700	14,400	
30			11,400	8,390	25,400	40,800	25,800	17,000	14,700	13,700	13,000	
31			10,800		23,200		23,600	16,200		13,300		
1906.												
1				20,600	27,200	43,000	33,700	14,700	24,500	22,700	21,800	
2				19,400	26,300	43,000	33,700	14,400	24,500	22,300	22,300	
3				21,800	26,800	43,000	34,200	14,000	23,600	21,400	22,300	
4				24,000	26,800	41,900	34,700	13,300	22,700	21,000	21,800	
5				27,200	26,300	41,300	34,700	13,600	21,800	20,200	21,400	
6				32,200	26,300	41,900	35,300	12,600	21,000	19,400	21,000	
7				32,200	25,400	43,600	34,200	12,600	20,200	18,600	21,000	
8				37,400	24,500	44,800	33,200	12,300	19,400	17,800	21,000	
9				39,600	24,500	45,900	32,200	13,700	18,600	17,000	21,000	
10				38,500	24,500	47,100	31,100	16,200	17,800	15,800	21,000	
11				36,900	23,600	49,400	29,600	17,400	17,400	15,400	20,600	
12				36,900	22,700	50,600	28,200	17,800	16,600	15,100	20,200	
13				36,400	23,200	50,000	27,200	17,400	16,600	14,400	19,800	
14				36,900	22,700	48,800	25,400	17,400	16,200	14,000	19,400	
15				38,500	22,300	46,500	24,000	17,400	15,800	13,300	18,600	
16				40,200	21,800	44,200	22,700	17,800	15,800	13,000	18,200	
17				41,900	21,400	41,900	21,800	18,200	15,500	12,600	18,200	
18				42,500	21,000	39,100	20,600	18,200	15,500	12,000	18,600	
19				43,000	20,600	36,900	19,800	17,800	15,500	11,700	16,600	
20				42,500	20,600	35,300	19,000	17,400	15,500	11,700	15,500	
21				41,900	21,400	35,300	18,200	16,600	16,600	11,700	13,700	
22				40,200	24,500	34,700	17,800	15,800	17,000	11,400	13,000	
23				38,500	27,200	34,200	17,000	16,600	18,600	11,400	12,000	
24				36,900	31,100	33,700	16,600	17,400	19,400	12,000	12,000	
25				35,300	32,200	33,200	15,500	17,800	21,000	13,300	11,400	
26				33,700	33,700	33,200	15,100	19,400	22,700	15,100	13,700	
27				32,200	36,400	32,600	14,400	21,000	23,600	17,000	14,400	
28				30,100	38,500	33,200	14,700	22,300	24,000	18,200	15,100	
29				29,200	40,800	33,200	15,500	23,200	23,600	19,000	15,500	
30				27,700	41,900	33,700	15,100	24,000	23,200	20,600	15,800	
31					43,000		15,100	24,500		21,400		
1907.												
1				48,800	19,800	26,800	32,600	10,600	12,000	11,400	8,390	
2				50,000	20,200	26,800	31,600	13,000	11,700	11,400	8,610	
3				49,400	20,200	26,300	31,100	12,600	10,800	11,400	8,610	
4				50,600	19,800	25,400	29,200	12,300	10,600	11,400	8,830	
5				48,800	19,000	24,500	27,200	11,700	10,300	11,700	8,830	

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
6	......	......	......	47,600	18,200	24,000	25,400	11,100	10,300	11,100	9,060	......
7	......	......	......	47,100	17,400	23,200	24,500	11,100	9,300	10,800	9,300	......
8	......	......	......	46,500	17,400	22,300	23,200	10,800	8,610	10,800	9,060	......
9	......	......	......	44,200	17,400	21,400	22,300	11,100	8,390	10,600	9,060	......
10	......	......	......	42,500	16,600	21,000	23,200	11,100	8,390	10,600	8,830	......
11	......	......	......	41,300	16,200	23,600	17,800	10,600	8,390	10,300	8,830	......
12	......	......	......	40,800	15,500	26,800	16,200	10,300	8,180	10,000	8,610	......
13	......	......	......	39,100	15,500	29,600	15,100	9,540	7,970	10,000	8,610	......
14	......	......	......	38,000	15,100	32,200	14,700	10,300	7,970	9,540	8,390	......
15	......	......	......	36,400	14,700	34,200	15,800	9,790	7,970	9,300	7,360	......
16	......	......	......	33,700	15,500	35,300	15,500	9,300	7,970	9,060	7,360	......
17	......	......	......	32,200	15,800	36,900	15,500	10,000	8,180	9,060	7,560	......
18	......	......	......	30,600	15,800	37,100	15,500	9,790	9,300	8,830	7,760	......
19	......	......	......	29,200	15,800	37,400	15,500	10,000	10,000	8,830	7,360	......
20	......	......	......	28,200	15,500	36,900	15,500	10,600	11,400	8,830	7,360	......
21	......	......	......	27,200	15,500	36,400	15,500	11,700	12,300	8,830	7,560	......
22	......	......	......	25,800	15,800	36,400	15,800	13,000	13,700	8,830	7,560	......
23	......	......	......	24,900	15,800	36,400	15,500	13,000	14,700	8,610	7,560	......
24	......	......	25,400	24,000	15,500	36,400	15,500	12,600	15,500	8,610	7,560	......
25	......	......	26,300	22,700	15,500	36,900	17,400	12,000	15,800	8,830	7,170	......
26	......	......	27,700	22,300	17,000	36,400	16,600	11,400	15,800	8,830	6,980	......
27	......	......	32,600	21,800	18,600	35,400	16,200	11,100	14,700	8,830	6,800	......
28	......	......	38,000	20,600	20,600	25,800	15,800	11,100	13,700	8,830	6,800	......
29	......	......	39,100	20,600	22,700	35,800	15,500	11,400	13,000	8,610	6,980	......
30	......	......	41,900	19,800	24,900	34,200	14,700	11,400	12,000	8,390	6,440	......
31	......	......	44,800	......	25,800	......	14,400	12,300	......	8,390	......	......
1908.												
1	......	......	......	15,300	20,900	52,500	70,400	20,500	9,030	9,270	9,270	......
2	......	......	......	13,600	21,400	58,000	67,700	19,700	9,520	9,270	9,270	......
3	......	......	......	12,700	21,400	61,900	64,400	18,600	9,270	9,270	9,270	......
4	......	......	......	13,300	20,900	63,200	61,200	17,400	9,270	9,270	9,270	......
5	......	......	......	13,300	19,700	62,500	57,400	17,000	9,270	9,270	9,030	......
6	......	......	......	13,600	19,700	60,600	54,300	16,300	9,520	9,030	9,030	......
7	......	......	......	13,600	18,200	58,000	51,300	15,600	9,270	9,270	9,030	......
8	......	......	......	13,900	17,000	57,400	48,400	15,300	8,560	9,270	9,030	......
9	......	......	......	14,200	16,000	54,900	47,200	14,600	8,560	9,270	9,270	......
10	......	......	......	13,900	15,300	56,200	45,000	13,600	8,340	9,270	7,910	......
11	......	......	......	13,900	14,900	57,400	42,200	12,400	7,910	8,790	7,700	......
12	......	......	......	13,900	14,200	58,700	41,100	13,300	7,760	8,560	8,120	......
13	......	......	......	13,900	14,900	60,600	39,500	12,700	8,560	8,560	7,700	......
14	......	......	......	13,600	14,600	61,200	37,900	12,000	7,700	8,790	7,300	......
15	......	......	......	13,600	15,600	60,000	35,800	11,800	7,700	8,340	7,300	......
16	......	......	9,030	13,300	17,000	58,000	34,300	10,900	7,300	8,120	7,300	......
17	......	......	8,560	12,700	18,500	55,600	33,300	10,900	7,500	8,120	7,110	......
18	......	......	8,120	12,700	19,300	52,500	32,800	10,600	8,120	7,910	6,920	......
19	......	......	10,300	12,400	19,700	50,700	31,400	11,200	8,120	7,300	6,740	......
20	......	......	9,780	12,400	20,500	48,400	30,400	10,900	9,910	8,120	6,740	......
21	......	......	9,780	11,800	22,600	46,100	29,000	10,600	7,700	8,120	6,740	......
22	......	......	10,600	13,000	23,900	44,400	28,500	10,300	7,500	8,120	6,560	......
23	......	......	10,600	12,400	24,400	44,400	28,000	9,780	8,340	8,120	6,560	......
24	......	......	11,200	12,400	25,700	44,300	27,100	9,520	8,340	8,120	6,560	......
25	......	......	11,800	12,700	28,500	45,000	26,200	9,520	8,560	8,340	6,500	......
26	......	......	12,700	13,600	29,900	48,900	24,800	9,270	7,700	8,340	6,500	......
27	......	......	12,700	14,900	32,300	59,300	23,500	9,270	8,560	9,030	6,500	......
28	......	......	13,600	16,300	35,300	69,700	21,800	9,520	8,120	9,270	6,300	......
29	......	......	13,900	18,200	38,400	73,000	21,400	9,270	8,340	9,030	6,300	......
30	......	......	11,600	19,700	42,200	72,400	21,800	9,270	9,030	9,520	6,100	......
31	......	......	14,600	......	46,100		20,900	9,030	......	9,520	......	......
1909.												
1	......	......	......	35,300	20,900	18,900	20,100	10,600	11,500	8,560	6,920	......
2	......	......	......	40,000	20,900	26,900	20,900	10,300	10,900	8,560	7,300	......
3	......	......	......	45,500	20,500	22,600	20,900	9,520	10,900	8,560	7,500	......
4	......	......	......	48,900	20,500	23,900	20,500	9,270	10,300	8,120	7,110	......
5	......	......	......	48,900	20,900	21,400	20,900	9,030	10,000	7,910	7,500	......
6	......	......	......	47,800	20,900	25,700	20,900	9,030	9,520	7,700	8,340	......
7	......	......	......	47,200	20,900	26,600	20,500	8,340	9,270	7,910	8,790	......
8	......	......	......	46,100	21,800	27,100	20,100	8,340	9,270	7,910	8,790	......
9	......	......	......	44,400	21,800	25,700	19,700	8,340	9,030	7,700	8,560	......
10	......	......	......	42,700	21,800	25,300	18,500	8,340	8,790	7,700	8,340	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
11	......	......	......	42,200	21,400	24,400	17,400	8,340	8,340	8,340	8,340	......
12	......	......	......	40,000	20,900	23,100	17,400	8,340	8,120	8,120	7,910	......
13	......	......	......	37,900	20,100	21,800	16,700	9,520	9,030	8,560	8,120	......
14	......	......	......	35,300	19,300	22,600	15,300	10,900	9,520	8,340	8,120	......
15	......	......	12,000	33,800	18,500	23,500	14,200	13,600	9,270	8,120	8,560	......
16	......	......	12,400	31,800	18,500	23,500	12,700	14,600	8,790	7,910	9,030	......
17	......	......	13,300	30,400	18,200	23,900	12,700	16,000	8,560	7,910	9,270	......
18	......	......	12,700	29,400	18,200	24,400	12,400	16,700	8,340	7,700	9,270	......
19	......	......	11,500	28,500	18,500	23,900	11,500	16,700	8,120	7,700	9,030	......
20	......	......	10,600	27,100	18,500	23,500	10,900	16,700	7,700	7,700	9,030	......
21	......	......	10,900	26,200	18,500	23,100	10,900	16,300	7,700	7,700	10,000	......
22	......	......	10,300	24,800	18,500	22,600	10,900	15,600	8,790	7,500	10,000	......
23	......	......	10,900	24,400	18,500	21,800	11,500	14,600	9,520	7,700	10,000	......
24	......	......	12,000	23,500	18,500	20,900	11,500	13,900	9,780	7,700	10,000	......
25	......	......	13,900	22,600	18,500	20,100	13,600	13,600	9,520	7,910	10,000	......
26	......	......	14,900	22,200	18,500	20,100	13,900	13,600	9,520	7,700	10,000	......
27	......	......	17,000	21,800	18,500	20,100	13,300	13,300	9,520	7,910	10,000	......
28	......	......	22,600	21,400	18,500	20,100	13,000	13,000	9,520	7,700	10,000	......
29	......	......	24,800	20,900	18,500	20,100	12,700	12,700	9,270	7,910	10,000	......
30	......	......	26,600	20,900	18,900	20,100	12,400	12,000	8,560	7,910	9,000	......
31	......	......	30,900	......	18,900	......	11,500	11,500	......	7,110	......	......
1910.												
1	......	......	......	19,300	12,400	7,700	4,940	3,650	3,990	4,110	3,320	......
2	......	......	......	17,800	12,000	7,300	5,240	3,650	3,990	4,110	3,320	......
3	......	......	......	17,000	10,900	7,300	4,790	3,870	4,110	4,110	3,540	......
4	......	......	......	15,600	10,300	7,700	4,510	3,870	4,240	4,110	4,240	......
5	......	......	......	15,300	10,000	7,300	4,650	3,650	4,110	4,510	4,110	......
6	......	......	......	14,200	9,780	7,300	4,370	3,650	3,990	4,510	4,240	......
7	......	......	......	14,200	9,780	7,300	3,990	3,760	3,990	5,090	4,140	......
8	......	......	10,900	14,200	9,780	7,300	3,870	3,760	4,110	5,240	4,140	......
9	......	......	13,600	14,600	9,520	7,300	3,870	3,870	4,110	5,240	4,140	......
10	......	......	15,600	13,900	9,520	7,300	4,370	3,760	4,110	5,090	3,990	......
11	......	......	18,500	13,600	9,520	7,300	3,990	3,650	4,110	4,940	3,870	......
12	......	......	20,500	13,600	9,270	6,920	3,990	3,650	3,990	4,940	3,540	......
13	......	......	19,300	13,000	9,030	6,050	4,110	3,760	4,110	4,790	3,430	......
14	......	......	21,400	12,700	9,030	6,740	3,990	3,760	3,990	4,790	3,320	......
15	......	......	27,100	12,700	8,790	6,390	3,990	3,760	3,990	4,790	3,650	......
16	......	......	29,900	12,000	8,340	6,050	4,110	3,870	4,110	4,790	3,540	......
17	......	......	32,300	11,800	8,120	5,560	3,990	3,870	4,110	4,510	3,320	......
18	......	......	34,300	11,800	8,560	6,050	3,870	3,870	4,110	3,990	3,210	......
19	......	......	35,800	11,800	8,560	5,720	3,870	3,870	4,110	3,870	2,690	......
20	......	......	34,800	11,800	8,790	5,560	3,760	3,990	4,110	3,870	2,790	......
21	......	......	35,800	12,700	8,790	5,560	3,650	4,110	4,110	3,870	2,890	......
22	......	......	34,800	13,000	9,030	5,400	3,650	3,999	4,110	3,870	3,100	......
23	......	......	33,800	13,300	8,340	5,240	3,650	4,110	3,990	3,870	3,100	......
24	......	......	32,300	13,300	9,030	4,940	4,240	3,990	3,990	3,760	2,990	......
25	......	......	29,400	13,600	9,030	5,240	3,760	3,990	3,990	3,760	2,990	......
26	......	......	26,600	13,600	8,120	5,240	3,650	3,990	3,990	3,870	2,990	......
27	......	......	25,700	13,900	9,030	5,240	3,550	3,990	3,990	3,650	2,990	......
28	......	......	23,900	13,600	8,120	5,240	3,550	3,990	3,990	3,650	2,990	......
29	......	......	22,600	13,300	8,560	5,090	3,550	3,870	3,990	3,550	2,950	......
30	......	......	21,400	12,700	8,120	4,650	3,870	3,870	4,110	3,550	2,900	......
31	......	......	20,500	......	7,700	......	3,870	3,870	......	3,350	......	......
1911.												
1	......	......	2,710	3,530	3,670	5,720	5,090	4,370	3,650	4,790	6,050	......
2	......	......	2,400	3,670	4,260	5,720	4,940	4,240	3,650	4,790	5,720	......
3	......	......	2,140	3,400	4,260	6,730	4,790	4,510	3,870	4,650	5,560	......
4	......	......	2,310	3,530	3,950	7,150	4,940	4,370	3,540	5,090	5,090	......
5	......	......	2,310	3,670	3,810	6,940	4,940	4,650	3,990	5,400	4,790	......
6	......	......	2,420	4,100	3,810	6,730	5,090	4,650	3,990	5,560	4,240	......
7	......	......	2,530	3,670	3,810	6,940	4,940	5,090	4,110	10,300	4,000	......
8	......	......	2,650	3,810	3,010	5,920	4,910	4,940	4,110	11,800	4,000	......
9	......	......	2,770	3,810	3,530	6,520	4,910	4,720	4,370	10,900	3,950	......
10	......	......	3,140	3,400	3,100	6,730	4,370	4,650	4,510	10,600	3,950	......
11	......	......	3,010	3,670	3,530	6,320	4,650	4,650	4,510	9,780	3,950	......
12	......	......	2,890	3,810	3,670	5,920	4,370	4,240	4,510	9,030	3,900	......
13	......	......	3,010	3,950	3,950	6,120	4,370	4,240	4,370	8,790	3,900	......
14	......	......	3,400	4,100	3,950	5,920	4,240	4,240	4,240	8,340	3,900	......
15	......	......	3,300	4,130	4,960	5,720	4,110	4,510	4,510	8,340	3,900	......

Daily discharge, in second-feet, of Mississippi River at St. Paul—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
16	......	......	2,900	4,430	4,960	5,530	4,240	4,940	4,790	8,120	3,850	......
17	......	2,200	2,530	4,100	5,720	5,920	3,870	4,790	4,650	8,340	3,850	......
18	......	2,090	3,200	4,780	5,530	5,720	3,990	4,510	4,650	9,270	3,850	......
19	......	......	3,810	5,530	5,920	5,340	4,110	4,510	4,650	10,000	3,850	......
20	......	......	3,670	5,340	6,320	5,720	3,870	4,370	4,510	10,300	3,850	......
21	......	......	4,430	5,920	6,730	5,720	3,760	4,110	4,510	9,780	3,800	......
22	......	......	4,600	5,530	7,150	5,340	3,990	4,110	4,790	9,780	3,800	......
23	......	......	4,100	5,150	8,010	5,340	4,110	3,990	4,650	10,000	3,800	......
24	......	1,990	3,810	4,260	8,450	5,150	3,870	3,870	4,510	9,780	3,750	......
25	......	2,310	3,670	4,600	8,450	5,150	4,110	3,760	4,370	9,030	3,750	......
26	......	2,090	3,670	4,780	8,230	4,160	3,870	3,760	4,370	8,560	3,750	......
27	......	2,260	3,670	4,430	7,790	4,650	3,990	3,650	4,510	8,120	3,700	......
28	......	......	3,810	4,260	7,150	4,300	4,510	3,430	4,510	7,700	3,700	......
29	......	......	3,810	4,430	6,520	4,620	4,370	3,540	4,790	7,110	3,700	......
30	......	......	3,810	4,600	6,520	4,950	4,240	3,540	4,940	6,740	3,600	......
31	......	......	3,530	......	6,520	......	3,990	3,540	......	6,220	......	......
1912.												
1	......	......	......	10,900	10,000	15,300	5,000	5,340	6,410	5,170	4,290	......
2	......	......	......	12,400	10,000	15,000	5,510	5,340	6,230	5,170	4,290	......
3	......	......	......	15,300	10,000	14,000	5,340	5,170	6,230	5,170	4,420	......
4	......	......	......	17,400	11,200	13,100	5,340	4,840	6,230	5,000	4,420	......
5	......	......	......	17,000	13,300	11,700	5,870	4,550	6,050	5,170	4,160	......
6	......	......	......	16,700	19,700	11,000	5,690	4,690	6,050	5,170	4,040	......
7	......	......	......	16,300	28,500	10,800	6,230	4,690	5,510	5,000	4,160	......
8	......	......	......	15,300	34,800	10,300	5,870	4,550	5,510	5,000	4,040	......
9	......	......	......	14,600	37,900	9,840	6,230	4,690	5,690	5,000	3,920	......
10	......	......	......	13,000	39,000	9,400	6,780	4,840	5,000	5,000	3,920	......
11	......	......	......	11,800	37,400	8,980	6,230	5,170	4,550	4,840	3,920	......
12	......	......	......	11,500	35,800	8,770	6,230	5,000	4,550	5,170	3,920	......
13	......	......	......	10,900	33,300	7,750	7,350	5,000	4,550	5,170	3,800	......
14	......	......	......	10,600	31,400	7,950	6,780	5,170	4,550	5,170	3,800	......
15	......	......	......	10,000	28,100	8,150	6,410	5,170	4,420	5,000	3,800	......
16	......	......	......	10,300	24,900	7,750	6,230	5,170	4,550	5,000	3,920	......
17	......	......	......	10,000	23,200	7,550	5,870	5,340	4,420	5,000	4,040	......
18	......	......	......	9,780	19,900	7,750	5,340	5,690	4,290	4,840	3,920	......
19	......	......	......	9,520	18,400	7,550	5,510	5,510	4,420	4,690	3,920	......
20	......	......	......	9,270	17,400	7,550	5,510	5,510	4,420	4,840	3,800	......
21	......	......	......	9,030	16,000	7,550	5,170	5,870	4,840	4,840	3,800	......
22	......	......	......	9,270	15,300	7,750	4,840	5,690	5,000	4,840	3,800	......
23	......	......	......	9,270	15,000	7,550	4,840	5,690	4,840	4,550	3,920	......
24	......	......	......	9,520	15,600	7,350	5,870	5,510	4,840	4,550	3,920	......
25	......	......	......	9,520	15,600	7,350	6,410	5,510	5,000	4,690	3,800	......
26	......	......	......	9,520	15,300	7,160	6,780	5,170	5,170	4,840	3,680	......
27	......	......	......	10,000	15,000	6,590	6,590	5,340	5,000	4,690	3,330	......
28	......	......	......	9,780	16,000	5,870	6,230	5,340	5,000	4,690	3,120	......
29	......	......	......	9,270	16,300	5,870	5,690	5,170	5,170	4,840	3,120	......
30	......	......	......	9,520	16,700	5,510	5,870	6,410	5,000	4,550	3,030	......
31	......	......	......	......	16,300	......	5,870	6,590	......	4,420	......	......

From 1892 to 1899 the daily discharge has been computed by means of rating tables based on measurements by the United States Engineer Corps and Weather Bureau gage heights. Between 1899 and 1909 no discharge measurements were **made, but measurements made by the** Geological Survey in 1909 and 1910 show **that the old ratings no longer applied.** Estimates from 1900 to 1908 have been **based on the assumption that the** change between the older and later ratings took **place uniformly.** Estimates for 1909, 1910, 1911 and 1912 are based on fairly **well-defined rating** curves, which were applied indirectly during portions of 1911 **and 1912.**

Monthly discharge of Mississippi River at St. Paul.

[Drainage area, 35,700 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1892.					
March	10,600	4,000	6,940	0.194	0.22
April	12,700	6,620	9,350	.262	.29
May	45,700	8,520	24,300	.682	.79
June	39,500	24,900	29,000	.812	.91
July	23,900	9,400	13,700	.384	.44
August	16,000	6,960	10,000	.280	.32
September	8,520	6,280	7,350	.206	.23
October	6,640	5,200	5,930	.166	.19
November	5,060		4,360	.122	.14
1893.					
April	44,500	18,900	31,900	.894	1.00
May	58,800	30,200	43,500	1.22	1.41
June	29,200	8,840	15,800	.443	.49
July	8,410	4,900	7,040	.197	.23
August	5,400	4,130	4,710	.132	.15
September	6,280	5,560	5,940	.166	.19
October	6,280	5,560	5,990	.168	.19
November	6,100	2,440	4,560	.128	.14
1894.					
March	9,070	4,000	6,590	.185	.21
April	34,800	5,920	15,600	.437	.49
May	41,200	19,400	29,000	.812	.94
June	18,000	5,740	9,650	.270	.30
July	5,740	1,920	4,020	.113	.13
August	4,430	1,920	3,430	.096	.11
September	4,280	3,540	3,930	.110	.12
October	4,740	3,840	4,260	.119	.14
November	4,740	2,980	4,060	.114	.13
December			[1]2,790	.078	.09
1895.					
January	1,900	1,200	1,540	.043	.05
February			[1]1,300	.036	.04
March (22-31)	4,110	2,630	3,420	.096	.04
April	3,860	2,750	3,420	.096	.11
May	5,640	3,230	4,540	.127	.15
June	9,640	4,640	7,440	.208	.23
July	7,900	4,240	5,720	.160	.18
August	5,340	3,370	4,410	.124	.14
September	5,640	4,240	4,860	.136	.15
October	5,500	3,860	4,690	.131	.15
November	4,240	2,990	3,760	.105	.12
1896.					
March (10-31)	3,230	1,420	2,060	.058	.02
April	35,300	2,280	19,900	.557	.62
May	34,300	21,600	28,100	.787	.91
June	27,300	13,700	20,300	.569	.63
July	12,700	4,640	7,740	.217	.25
August	5,800	4,500	5,050	.141	.16
September	5,340	3,980	4,800	.134	.15
October	5,640	4,640	5,020	.141	.16
November	6,440	4,000	5,080	.142	.16
December	5,000	4,150	4,410	.124	.14
1897.					
January	5,340	3,050	4,300	.120	.14
February	3,550	3,120	3,340	.094	.10
March	48,900	3,000	11,200	.314	.36
April	80,800	31,300	59,300	1.66	1.85
May	29,800	10,400	16,600	.465	.54
June	15,600	10,200	12,800	.359	.40
July	49,600	14,400	32,200	.902	1.04
August	24,600	8,500	14,100	.395	.46
September	11,800	8,500	9,910	.278	.31
October	10,100	7,600	8,180	.229	.26
November	7,800	4,700	6,700	.188	.21

[1] Estimated.

Monthly discharge of Mississippi River at St. Paul—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1898.					
March	8,730	4,000	6,980	0.195	0.22
April	8,520	6,440	7,670	.215	.24
May	10,600	6,280	7,740	.217	.25
June	35,300	9,880	19,800	.555	.62
July	17,200	8,100	11,200	.314	.36
August	7,900	5,960	6,680	.187	.22
September	6,790	5,960	6,340	.178	.20
October	9,640	6,120	8,020	.225	.26
November	8,100	5,000	6,680	.187	.21
1899.					
April	34,300	8,000	19,500	.546	.61
May	20,200	12,700	15,200	.426	.49
June	36,800	12,700	30,100	.843	.94
July	25,400	8,300	14,500	.406	.47
August	25,800	7,330	12,500	.350	.40
September	19,800	9,400	12,600	.353	.39
October	25,800	8,300	14,600	.409	.47
November	18,500	10,100	13,100	.367	.41
December	9,880	5,640	8,260	.231	.08
1900.					
January	....	....	[1]3,950	.111	.13
February	....	....	[1]3,100	.087	.09
March	....	....	[1]3,500	.098	.11
April	12,300	6,440	8,900	.249	.28
May	7,900	5,640	6,670	.187	.22
June	6,790	3,370	4,630	.130	.14
July	6,440	3,260	5,160	.145	.17
August	12,000	3,610	7,060	.198	.23
September	13,700	8,100	11,400	.319	.36
October	16,000	8,950	11,800	.331	.38
November	9,640	3,980	6,950	.195	.22
December	....	....	[1]3,500	.098	.11
The year	16,000	....	6,380	.179	2.44
1901.					
January	....	....	[1]2,250	.063	.07
February	....	....	[1]2,200	.062	.06
March	13,000	....	[1]6,550	.183	.21
April	19,800	11,700	15,500	.434	.48
May	18,900	10,900	15,400	.431	.50
June	14,400	8,300	10,200	.286	.32
July	18,500	8,100	14,100	.395	.46
August	7,900	5,340	6,100	.171	.20
September	6,120	4,920	5,490	.154	.17
October	6,620	5,500	5,940	.166	.19
November	6,120	3,980	5,100	.143	.16
1902.					
January	....	....	[1]2,950	.083	.10
February	....	....	[1]2,950	.083	.09
March	6,120	3,000	4,430	.124	.14
April	5,200	3,860	4,530	.127	.14
May	19,800	4,780	10,200	.286	.33
June	16,800	9,880	13,600	.381	.43
July	9,880	5,640	7,690	.215	.25
August	7,140	4,110	5,060	.142	.16
September	6,620	4,240	5,340	.150	.17
October	5,340	4,500	4,900	.137	.16
November	9,640	5,500	7,710	.216	.24
December	....	....	[1]4,000	.112	.13
The year	19,800	....	6,110	.171	2.34

[1] Estimated.

Monthly discharge of Mississippi River at St. Paul—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on frainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1903.					
January			[1]2,850	0.080	0.09
February			[1]2,300	.064	.07
March	24,000	2,000	13,200	.370	.43
April	26,800	18,200	21,300	.597	.67
May	36,900	17,800	26,500	.742	.86
June	42,500	7,560	19,000	.532	.59
July	21,400	7,170	15,100	.423	.49
August	15,800	8,390	11,800	.331	.38
September	42,500	8,390	24,900	.697	.78
October	51,800	19,800	34,800	.975	1.12
November	19,000	6,800	12,200	.342	.38
December			[1]4,550	.127	.15
The year	51,800		15,700	.440	6.01
1904.					
January			[1]3,520	.099	.11
February			[1]2,730	.076	.08
March			[1]4,600	.129	.15
April	31,600	13,000	24,200	.678	.76
May	24,000	14,000	18,400	.515	.59
June	21,800	11,100	15,600	.437	.49
July	12,000	7,360	9,540	.267	.31
August	8,390	6,100	7,250	.203	.23
September	12,000	6,440	8,550	.239	.27
October	21,800	7,170	14,900	.417	.48
November	16,600	7,560	10,400	.291	.32
December			[1]3,980	.111	.13
The year	31,600		10,300	.289	3.92
1905.					
January			3,090	.087	.10
February			2,510	.070	.07
March	14,400	2,500	8,920	.250	.29
April	17,400	8,390	12,100	.339	.38
May	41,300	8,180	26,000	.728	.84
June	40,800	18,200	27,300	.765	.85
July	59,800	23,600	43,300	1.21	1.40
August	23,600	16,200	19,800	.555	.64
September	20,200	12,600	15,500	.434	.48
October	14,700	10,800	13,000	.364	.42
November	14,400	10,800	12,200	.314	.35
December			[1]8,700	.244	.28
The year	59,800		16,000	.447	6.10
1906.					
January			[1]7,100	.199	.23
February			[1]6,350	.178	.19
March			[1]8,000	.224	.26
April	43,000	19,400	34,500	.966	1.08
May	43,000	20,600	27,400	.768	.89
June	50,600	32,600	40,500	1.13	1.26
July	35,300	14,400	24,200	.678	.78
August	24,500	12,300	17,200	.482	.56
September	24,500	15,500	19,500	.546	.61
October	22,700	11,400	16,100	.451	.52
November	22,300	11,400	17,900	.501	.56
December			9,900	.277	.32
The year	50,600		19,100	.533	7.26
1907.					
January			[1]8,480	.238	.27
February			[1]8,050	.225	.23
March	44,800	8,000	15,500	.434	.50
April	50,600	19,800	35,200	.986	1.10
May	25,800	14,700	17,700	.496	.57
June	37,400	21,000	31,100	.871	.97
July	32,600	14,400	19,400	.543	.63
August	13,000	9,300	11,200	.314	.36
September	15,800	7,970	11,000	.308	.34
October	11,700	8,390	9,690	.271	.31
November	9,300	6,440	7,970	.223	.25
December			[1]4,600	.129	.15
The year	50,600		15,000	.420	5.68

[1] Estimated from records kept by the St. Anthony Falls Water Power Co. at Minneapolis.

Monthly discharge of Mississippi River at St. Paul—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1908.					
January			[1]3,500	0.098	0.11
February			[1]3,680	.103	.11
March	14,600		[1]7,800	.218	.25
April	19,700	11,800	13,800	.387	.43
May	46,100	14,200	22,900	.641	.74
June	73,000	44,400	56,500	1.58	1.76
July	70,400	20,900	38,700	1.08	1.24
August	20,500	9,030	12,600	.353	.41
September	9,520	7,300	8,380	.235	.26
October	9,520	7,300	8,730	.245	.28
November	9,270	6,100	7,600	.213	.24
December			[1]5,350	.150	.17
The year	73,000		15,800	.442	6.00
1909.					
January			[1]3,500	.098	.11
February			[1]3,500	.098	.10
March	30,900	4,000	10,400	.291	.34
April	48,900	20,900	33,700	.944	1.05
May	21,800	18,200	19,600	.549	.63
June	27,100	18,900	22,800	.639	.71
July	20,900	10,900	15,500	.434	.50
August	16,700	8,340	12,000	.336	.39
September	11,500	7,700	9,230	.259	29
October	8,560	7,110	7,930	.222	.26
November	10,000	6,920	8,610	.241	.27
December			[2]6,500	.182	.21
The year	48,900		12,800	.358	4.86
1910.					
January			[2]5,100	.143	.16
February			[2]4,650	.130	.14
March	35,800	4,650	21,300	.597	.69
April	19,300	11,800	13,800	.387	.43
May	12,400	7,700	9,220	.258	.30
June	7,700	4,650	6,270	.176	.20
July	5,240	3,550	4,040	.113	.13
August	4,110	3,650	3,850	.108	.12
September	4,240	3,990	4,060	.114	.13
October	5,240	3,350	4,260	.119	.14
November	4,240	2,750	3,410	.096	.11
December			[2]2,250	.063	.07
The year	35,800		6,850	.192	2.62
1911.					
January			[2]1,960	.055	.06
February			[2]2,060	.058	.06
March	4,600	2,140	3,230	.090	.10
April	5,920	3,400	4,290	.120	.13
May	8,450	3,010	5,400	.151	.17
June	7,150	4,160	5,760	.161	.18
July	5,090	3,760	4,340	.122	.14
August	5,090	3,430	4,280	.120	.14
September	4,940	3,540	4,370	.122	.14
October	11,800	4,650	8,290	.232	.27
November	6,050		4,120	.115	.13
December			[2]3,150	.088	10
The year			4,290	.120	1.62

[1] Estimated from records kept by the St. Anthony Falls Water Power Co. at Minneapolis.

[2] Estimated from United States engineer records at Lock and Dam 2, below Minneapolis.

Monthly discharge of Mississippi River at St. Paul—Continued.

Month.	Discharge in second-feet				Run-off (depth in inches in drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1912.						
January			[2]2,800	0.078	0.09	D
February			[2]2,700	.076	.08	D
March			[2]3,800	.106	.12	D
April	17,400	9,030	11,600	.325	.36	C
May	39,000	10,000	21,200	.594	.68	C
June	15,300	5,510	8,960	.251	.28	C
July	7,350	4,840	5,920	.166	.19	C
August	6,590	4,550	5,280	.148	.17	C
September	6,410	4,290	5,120	.143	.16	C
October	5,170	4,420	4,910	.138	.16	C
November	4,420	3,030	3,870	.108	.12	C

[2] Estimated from United States engineer records at Lock and Dam 2, below Minneapolis.

NOTE.—From 1892 to 1899 the monthly mean values are considered good; from 1900 to 1908, fair; and for 1909, 1910, 1911, and 1912, good. All estimates during the frozen period are considered fair.

SANDY RIVER BELOW SANDY LAKE RESERVOIR.

Location.—At Sandy Lake dam, 1 mile above the mouth of the river in Sec. 25, T. 50 N., R. 24 W., near Libby postoffice. This station is maintained by the U. S. Engineer Corps.

Records available.—July 7, 1893, to December 31, 1912. The daily discharge tables are taken from unpublished records in the United States Engineer office at St. Paul.

Drainage area.—424 square miles.

Gage.—Vertical staff.

Channel.—At extreme flood stages the Mississippi drowns out the dam and fills Sandy Lake reservoir as much as 3 feet higher than was intended. If the Mississippi is at a fairly high stage and the dam is open, there is frequently a considerable reverse flow into the reservoir, but the amount of this flow has not been computed in the records.

Regulation.—The flow at this station is wholly controlled (see p. 57 for description of reservoir).

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir.

[0=no flow from reservoir.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1893.												
1	......	......	......	......	......	......	......	0	124	0	42	127
2	......	......	......	......	......	......	......	0	124	0	220	121
3	......	......	......	......	......	......	......	0	93	0	258	107
4	......	......	......	......	......	......	......	0	67	0	250	90
5	......	......	......	......	......	......	......	0	0	0	250	89
6	......	......	......	......	......	......	......	0	0	0	138	66
7	......	......	......	......	......	......	238	0	0	0	146	66
8	......	......	......	......	......	......	219	365	0	0	192	68
9	......	......	......	......	......	......	208	368	0	0	202	80
10	......	......	......	......	......	......	203	361	0	0	148	71
11	......	......	......	......	......	......	188	348	0	0	0	51
12	......	......	......	......	......	......	185	348	0	0	0	51
13	......	......	......	......	......	......	131	381	0	0	89	57
14	......	......	......	......	......	......	0	455	0	0	249	51
15	......	......	......	......	......	......	0	439	0	0	341	51
16	......	......	......	......	......	......	0	293	0	0	331	57
17	......	......	......	......	......	......	36	0	0	0	287	57
18	......	......	......	......	......	......	80	0	0	0	274	47
19	......	......	......	......	......	......	79	0	0	0	298	47
20	......	......	......	......	......	......	116	0	0	0	260	46
21	......	......	......	......	......	......	433	0	0	0	245	46
22	......	......	......	......	......	......	429	0	0	0	224	34
23	......	......	......	......	......	......	420	0	0	0	194	53
24	......	......	......	......	......	......	244	0	0	0	176	36
25	......	......	......	......	......	......	0	59	0	0	172	35
26	......	......	......	......	......	......	0	193	0	0	162	35
27	......	......	......	......	......	......	210	214	0	0	176	26
28	......	......	......	......	......	......	349	164	0	0	152	26
29	......	......	......	......	......	......	459	170	0	31	151	26
30	......	......	......	......	......	......	436	152	0	75	153	26
31	......	......	......	......	......	......	447	81	......	106	......	26
1894.												
1	19	0	0	0	1,241	①	0	0	①	0	0	226
2	0	0	0	0	1,100	①	0	①	①	0	0	230
3	0	0	0	0	1,097	①	0	①	①	0	0	213
4	0	0	0	0	1,097	①	0	①	①	0	0	193
5	0	0	0	0	1,097	①	0	①	0	0	0	176
6	0	0	0	0	1,110	①	0	①	0	0	40	170
7	0	0	0	0	1,100	①	0	①	0	0	84	97
8	0	0	0	0	1,090	0	0	①	①	0	204	0
9	0	0	0	0	1,084	0	0	①	①	0	176	0
10	0	0	0	0	1,144	0	0	①	①	①	155	0
11	0	0	0	0	1,137	0	0	①	①	①	155	0
12	0	0	0	0	1,141	0	0	①	①	①	[2]84	0
13	0	0	0	0	1,111	0	0	①	①	①	0	0
14	0	0	0	0	1,091	0	0	①	①	①	0	0
15	0	0	0	0	992	0	0	①	0	①	0	0
16	0	0	0	0	877	0	0	①	0	①	0	0
17	0	0	0	0	560	0	0	①	0	①	62	0
18	0	0	0	①	1,034	0	0	①	0	①	260	0
19	0	0	0	①	1,013	0	0	①	0	①	233	0
20	0	0	0	①	1,070	0	0	①	0	①	219	0
21	0	0	0	①	1,013	0	0	①	0	①	192	0
22	0	0	0	①	939	0	0	①	0	①	170	0
23	0	0	0	①	859	0	0	①	0	①	198	0
24	0	0	0	①	864	0	0	①	0	①	204	0
25	0	0	0	①	847	0	0	①	0	0	200	0
26	0	0	0	①	852	0	0	①	0	0	237	0
27	0	0	0	①	①	0	0	①	0	0	235	0
28	0	0	0	①	①	0	0	①	0	0	263	0
29	0	......	0	①	①	0	0	①	0	0	254	0
30	0	......	0	①	①	0	0	①	0	0	255	0
31	0	......	0	......	①	......	0	①	......	0	......	0

①Dam open but no record of discharge.
[2]Flow from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1895.												
1	0	0	0	0	①	0	①	112	①	282	201	0
2	0	0	0	0	①	0	①	114	303	309	184	0
3	0	0	0	0	①	0	①	109	①	277	167	0
4	0	0	0	0	①	0	①	125	287	365	167	0
5	0	0	0	0	①	0	①	109	①	330	154	0
6	0	0	0	0	①	0	①	215	①	334	154	0
7	0	0	0	0	①	0	①	322	283	339	123	0
8	0	0	0	0	①	①	①	308	①	324	151	0
9	0	0	0	0	①	①	①	308	①	391	154	0
10	0	0	0	0	①	①	①	297	176	289	167	0
11	0	0	0	0	①	①	①	297	①	288	181	0
12	0	0	0	0	0	①	①	287	333	287	[2]53	0
13	0	0	0	0	0	①	①	302	329	275	0	0
14	0	0	0	0	0	①	①	277	305	263	0	0
15	0	0	0	0	0	①	①	289	①	261	0	0
16	0	0	0	0	0	①	①	277	①	262	109	0
17	0	0	0	0	0	①	①	137	274	263	83	0
18	0	0	0	0	0	①	①	137	①	261	15	0
19	0	0	0	0	0	①	①	137	①	275	0	0
20	0	0	0	0	0	①	①	138	①	272	0	0
21	0	0	0	0	0	0	①	139	①	269	[2]260	0
22	0	0	0	0	0	①	①	139	①	203	[2]318	0
23	0	0	0	0	0	①	①	140	①	210	0	0
24	0	0	0	0	0	①	①	141	①	211	0	0
25	0	0	0	0	0	①	①	142	①	213	0	0
26	0	0	0	0	0	①	①	142	263	249	0	0
27	0	0	0	0	0	①	①	143	289	247	0	0
28	0	0	0	①	0	①	①	144	290	246	0	0
29	0	......	0	①	0	①	①	144	①	244	0	0
30	0	......	0	①	0	0	①	145	①	242	0	0
31	0	......	0	......	0	......	①	145	......	230	......	0
1896.												
1	0	152	0	0	1,012	1,073	0	623	0	468	0	0
2	0	160	0	0	768	1,075	0	174	802	404	0	0
3	0	163	0	0	771	1,095	0	150	791	388	0	0
4	0	112	0	0	782	1,153	0	124	780	372	0	0
5	0	111	0	0	727	1,255	0	101	770	356	0	0
6	0	107	0	0	522	1,347	252	345	756	400	0	0
7	0	109	0	0	460	1,438	1,161	357	742	351	59	0
8	0	108	0	0	506	1,442	142	438	728	351	510	0
9	0	100	0	0	549	1,448	0	420	735	351	531	41
10	0	97	0	0	592	1,534	0	403	743	308	573	329
11	0	96	0	0	642	1,514	85	408	750	281	581	379
12	0	98	0	0	675	0	0	444	727	267	405	362
13	0	97	0	0	711	0	86	346	704	188	399	341
14	0	95	0	0	720	0	0	0	682	203	369	322
15	0	92	0	0	629	0	0	451	659	240	342	302
16	0	89	0	0	615	0	0	437	648	167	273	304
17	0	87	0	0	597	875	0	424	636	146	312	257
18	0	84	0	0	573	1,005	0	510	625	119	325	255
19	0	80	0	0	563	126	0	481	613	84	286	273
20	0	0	0	0	533	0	0	453	604	84	276	238
21	0	0	0	0	483	0	0	445	600	84	301	224
22	0	0	0	0	428	107	0	436	853	84	296	210
23	0	0	0	0	388	0	0	427	780	0	251	195
24	0	0	0	0	388	0	0	418	708	0	128	174
25	0	0	0	0		0	0	465	696	0	0	153
26	0	0	0	0		0	0	513	685	0	0	152
27	0	0	0	0		0	0	299	673	0	0	151
28	0	0	0	0		0	0	0	661	0	0	150
29	0	0	0	①		0	0	0	597	0	0	149
30	0	......	0	①		0	10	0	532	0	0	148
31	0	......	0	..			210	0		0		148

①Dam open but no record of discharge.
[2]Flow from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897.												
1	0	112	71	101	779	384	378	2,894	0	877	0	0
2	0	111	73	82	782	405	369	2,428	0	854	0	0
3	0	110	75	47	786	427	620	2,297	0	830	0	0
4	0	109	76	0	790	448	1,706	2,226	0	538	0	0
5	0	106	75	0	793	511	1,146	1,096	0	783	0	0
6	0	102	76	0	771	575	2,013	0	912	789	0	0
7	0	100	74	0	749	638	3,210	0	826	795	0	0
8	0	97	72	0	726	624	3,063	1	1,071	801	0	0
9	0	100	70	0	703	610	2,792	1	1,056	737	0	0
10	0	102	69	0	680	595	3,675	2	1,041	673	0	0
11	0	102	68	0	896	602	3,709	4	1,026	609	0	0
12	0	103	68	0	647	609	3,738	5	1,009	561	0	0
13	0	103	68	0	614	616	3,697	7	991	514	0	0
14	21	102	67	0	582	618	3,576	9	974	466	0	0
15	205	100	66	0	574	619	3,311	9	990	427	0	0
16	202	95	65	0	566	621	3,086	12	1,007	387	0	0
17	199	89	68	0	557	623	2,841	321	1,022	366	0	0
18	196	88	70	98	550	620	2,634	327	983	344	0	0
19	193	87	72	197	544	616	2,488	333	943	304	0	0
20	190	87	74	295	538	635	2,401	339	903	307	0	0
21	180	83	76	393	531	626	2,368	345	907	156	0	0
22	171	80	77	492	517	617	2,328	352	922	0	0	0
23	161	75	79	590	504	557	2,425	359	897	0	0	0
24	152	72	82	688	490	487	2,329	366	871	0	0	0
25	142	72	83	787	477	421	2,494	372	846	0	0	0
26	137	72	84	1,084	463	356	2,537	0	820	0	0	0
27	131	72	85	1,747	443	368	2,520	0	794	0	0	0
28	126	72	90	1,661	423	379	2,494	0	1,024	0	0	0
29	123		96	1,575	402	368	2,510	0	975	0	0	0
30	119		108	1,489	382	357	2,444	0	926	0	0	0
31	116		120		362		2,700	0		0		0
1898.												
1	0	0	0	0	0	0	0	0	0	385	0	0
2	0	0	0	0	0	0	0	0	0	482	227	0
3	0	0	0	0	0	0	0	0	0	385	219	0
4	0	0	0	0	0	0	0	0	0	382	210	0
5	0	0	0	0	0	0	0	0	0	379	204	0
6	0	0	0	0	0	0	0	0	0	376	198	0
7	0	0	0	0	0	0	0	0	0	375	191	50
8	0	0	0	0	0	0	0	0	0	369	0	201
9	0	0	0	0	0	0	0	0	0	363	0	167
10	0	0	0	0	0	0	0	0	0	357	0	225
11	0	0	0	0	0	0	0	0	0	360	0	276
12	0	0	0	0	0	0	0	0	0	364	0	281
13	0	0	0	0	0	0	0	0	0	420	0	225
14	0	0	0	0	0	0	0	0	0	387	0	276
15	0	0	0	0	0	0	0	0	0	355	0	242
16	0	0	0	0	0	0	0	0	0	332	0	270
17	0	0	0	0	0	0	0	0	0	310	0	298
18	0	0	0	0	0	0	0	0	0	0	0	288
19	0	0	0	0	0	0	0	0	0	0	0	284
20	0	0	0	0	0	0	0	0	0	0	0	264
21	0	0	0	0	0	0	0	0	0	0	0	253
22	0	0	0	0	0	0	0	0	0	0	0	127
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0
29	0		0	0	0	0	0	0	0	0	0	0
30	0		0	0	0	0	0	0	0	0	0	0
31	0		0		0		0	0		0		0

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir
—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1	0	0	0	0	0	0	1,474	0	1,149	0	1,607	0
2	0	0	0	0	0	184	1,451	0	1,115	0	1,497	0
3	0	0	0	0	0	632	1,429	0	1,119	0	1,428	0
4	0	0	0	0	0	573	1,206	0	568	0	1,223	0
5	0	0	0	0	0	847	709	0	585	0	1,332	0
6	0	0	0	0	0	359	300	0	580	0	1,279	0
7	0	0	0	0	0	379	0	0	576	0	1,239	0
8	0	0	0	0	0	637	788	0	572	0	1,191	0
9	0	0	0	0	0	963	768	0	571	0	1,141	0
10	0	0	0	0	0	815	604	0	564	0	1,098	0
11	0	0	0	0	0	506	0	0	555	0	1,053	0
12	0	0	0	0	0	357	0	0	324	0	1,005	0
13	0	0	0	0	0	145	0	0	328	0	1,072	0
14	0	0	0	0	0	357	0	0	328	0	1,027	0
15	0	0	0	0	0	327	0	0	327	616	636	0
16	0	0	0	0	0	887	0	0	332	594	0	0
17	0	0	0	0	0	686	0	152	337	863	0	0
18	0	0	0	0	0	901	0	820	345	968	0	0
19	0	0	0	0	0	903	0	604	349	1,159	0	0
20	0	0	0	0	198	983	0	567	353	2,888	0	0
21	0	0	0	0	727	899	0	702	353	2,072	0	0
22	0	0	0	0	806	1,059	0	918	354	1,154	0	0
23	0	0	0	0	0	978	0	1,244	354	1,716	0	0
24	0	0	0	0	0	974	0	2,073	0	1,684	0	0
25	0	0	0	0	314	967	0	2,099	0	1,635	0	0
26	0	0	0	0	1,257	1,034	0	2,065	0	1,571	0	0
27	0	0	0	0	114	1,336	0	2,067	0	1,490	0	0
28	0	0	0	0	0	1,318	0	2,026	0	1,369	0	0
29	0	......	0	0	0	1,309	0	2,000	0	1,288	0	0
30	0	......	0	0	0	1,499	0	1,123	0	1,703	0	0
31	0	......	0	......	0	......	0	1,155	......	1,622	......	0
1900.												
1	0	0	0	0	0	454	153	0	0	0	0	0
2	0	0	0	0	0	394	149	0	0	300	0	0
3	0	0	0	0	0	446	155	0	0	0	0	0
4	0	0	0	0	0	552	149	0	0	0	0	0
5	0	0	0	0	318	536	119	0	0	0	0	0
6	0	0	0	0	822	473	127	0	0	0	0	0
7	0	0	0	0	873	329	113	0	0	0	0	0
8	0	0	0	0	867	271	123	0	0	0	0	0
9	0	0	0	0	1,041	293	64	0	0	0	0	0
10	0	0	0	0	1,004	299	29	0	0	556	0	0
11	0	0	0	0	955	301	0	0	0	474	0	0
12	0	0	0	0	931	354	79	0	0	0	0	0
13	0	0	0	0	892	387	104	0	0	0	0	0
14	0	0	0	0	743	363	0	0	0	0	0	0
15	0	0	0	0	725	272	75	0	(1)	0	0	0
16	0	0	0	0	685	221	57	0	(1)	0	0	0
17	0	0	0	0	655	235	0	0	(1)	0	0	0
18	0	0	0	0	766	297	0	0	(1)	0	0	0
19	0	0	0	0	738	278	0	0	(1)	0	0	0
20	0	0	0	0	714	85	0	0	(1)	0	0	0
21	0	0	0	0	700	278	0	0	(1)	0	0	0
22	0	0	0	0	668	201	0	0	(1)	0	0	0
23	0	0	0	0	628	203	0	0	(1)	0	0	0
24	0	0	0	0	616	136	0	0	(1)	0	0	0
25	0	0	0	0	566	139	0	0	(1)	0	0	0
26	0	0	0	0	551	0	0	0	(1)	0	0	0
27	0	0	0	0	522	0	0	0	0	0	0	0
28	0	0	0	229	501	42	0	0	0	0	0	0
29	0	0	0	0	580	49	0	0	0	0	0	0
30	0	......	0	0	563	121	0	0	0	0	0	0
31	0	......	0	......	550	......	0	0	......	0	......	0

(1) Dam open and water flowing from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	0	0	206	600	0	479	1,257	606	579	0	0	0
2	0	0	207	593	0	407	1,612	781	534	0	0	0
3	0	0	166	568	0	387	2,144	0	529	0	0	0
4	0	0	166	544	0	381	2,148	0	318	0	0	0
5	0	0	167	516	927	373	2,414	0	314	0	0	0
6	0	0	165	508	964	371	2,414	0	0	0	0	0
7	0	0	166	434	1,075	369	2,490	0	0	0	0	0
8	0	0	219	406	1,149	365	2,666	285	0	0	0	0
9	0	0	219	532	964	371	2,368	833	0	0	0	0
10	0	0	262	485	1,001	0	2,181	827	0	0	0	0
11	0	0	279	465	1,102	0	2,170	1,045	0	0	0	0
12	0	0	276	417	1,001	0	2,129	1,057	0	0	0	0
13	0	0	271	187	1,001	0	2,127	1,124	0	0	0	0
14	0	0	270	0	1,445	0	2,337	1,207	0	0	0	0
15	0	0	268	0	1,001	0	2,278	1,160		0	0	0
16	0	0	265	0	1,267	0	1,775	1,204	0	0	0	0
17	0	0	286	0	1,445	0	1,070	1,192	0	0	0	0
18	0	0	287	0	1,651	0	374	1,125	0	0	0	0
19	0	0	286	0	1,166	0	427	1,231	0	0	0	0
20	0	0	263	0	1,236	109	0	1,290	0	0	0	0
21	0	76	277	0	861	409	0	1,203	0	0	0	0
22	0	145	280	0	1,524	396	0	1,005	0	0	0	0
23	0	148	278	0	1,370	290	745	978	0	0	0	0
24	0	215	670	0	821	0	745	560	0	0	0	0
25	0	210	651	0	681	0	0	497	0	0	0	0
26	0	210	648	0	706	0	0	454	0	0	0	0
27	0	207	642	0	665	0	0	456	0	0	0	0
28	0	207	636	0	665	0	0	449	0	0	0	0
29	0	......	643	0	640	927	0	442	0	0	0	0
30	0	......	626	0	891	927	0	433	0	0	0	0
31	0	......	614	......	416	......	0	593	......	0	......	0
1902.												
1	0	0	0	0	0	954	0	83	0	103	(1)	0
2	0	0	0	0	0	969	0	459	0	0	(1)	0
3	0	0	0	0	0	958	138	498	0	0	(1)	0
4	0	0	0	0	0	921	779	526	0	102	(1)	0
5	0	0	0	0	0	1,003	133	530	0	130	(1)	0
6	0	0	0	0	0	985	0	513	0	132	(1)	0
7	0	0	0	0	0	937	0	496	0	122	(1)	0
8	0	0	0	0	0	987	0	468	0	0	(1)	0
9	0	0	0	0	301	987	0	516	0	0	(1)	0
10	0	0	0	0	0	987	0	505	0	0	(1)	0
11	0	0	0	0	0	948	0	542	0	0	(1)	0
12	0	0	0	0	0	931	352	536	226	0	(1)	0
13	0	0	0	0	0	915	378	517	222	0	(1)	0
14	0	0	0	0	0	1,032	350	508	220	0	0	0
15	0	0	0	0	0	866	0	477	378	0	0	357
16	0	0	0	0	0	874	0	473	212	122	0	347
17	0	0	0	0	512	833	0	478	206	82	0	345
18	0	0	0	0	517	785	0	584	0	0	0	341
19	0	0	0	0	0	785	0	601	0	0	0	338
20	0	0	0	0	0	823	0	534	0	0	0	334
21	0	0	0	0	0	809	0	519	201	0	0	332
22	0	0	0	0	0	749	0	463	201	0	0	324
23	0	0	0	0	0	742	0	449	0	0	0	397
24	0	0	0	442	0	781	0	450	0	138	0	280
25	0	0	0	199	0	710	0	438	0	196	0	544
26	0	0	0	0	498	545	0	516	205	0	0	371
27	0	0	0	0	713	511	0	343	0	0	232	517
28	0	0	0	0	904	555	0	343	0	0	231	507
29	0	0	0	0	871	645	0	0	0	0	229	432
30	0	......	0	0	922	481	0	0	207	0	0	422
31	0	......	0	......	959		0	0		0	......	416

(1) Dam open, water flowing from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1	290	70	63	0	0	408	434	412	377	417	732	0
2	404	0	63	0	0	208	426	415	374	439	804	0
3	282	0	0	0	1,012	0	429	403	366	442	817	0
4	278	0	0	0	801	887	400	403	408	419	839	0
5	245	69	0	0	812	0	399	399	403	394	992	0
6	242	71	62	0	814	302	368	392	388	399	1,220	0
7	240	70	62	0	829	0	365	382	418	373	1,210	0
8	237	70	0	0	1,559	0	392	337	427	332	1,206	0
9	198	0	0	0	1,000	0	385	368	395	308	1,184	0
10	196	0	0	0	1,117	0	443	407	384	303	1,112	0
11	194	69	61	0	1,079	0	446	410	383	320	1,207	0
12	163	0	0	0	1,170	316	416	404	375	432	1,202	0
13	162	0	60	0	1,080	0	422	401	314	469	1,198	0
14	160	68	0	0	1,088	0	430	410	348	509	1,161	0
15	0	68	0	0	1,216	0	434	411	398	654	1,128	0
16	136	67	0	0	1,205	684	428	404	387	600	1,105	0
17	133	0	0	0	1,194	0	394	409	410	724	1,074	0
18	131	67	62	0	1,175	0	392	406	457	781	1,034	0
19	129	66	64	0	1,334	33	381	411	446	787	908	0
20	0	0	65	0	1,324	0	360	404	453	806	820	0
21	128	0	65	0	1,339	0	363	378	414	832	823	0
22	90	65	65	0	1,365	0	362	367	759	967	0	0
23	89	0	65	0	1,094	0	366	391	716	996	0	0
24	88	65	65	0	794	0	378	373	432	1,007	0	0
25	87	64	65	0	794	426	356	396	453	993	0	0
26	89	64	65	369	433	412	392	385	425	962	0	0
27	88	63	65	0	441	406	430	377	454	997	0	90
28	0	63	65	0	445	404	433	433	396	947	0	119
29	88	......	66	0	366	437	431	429	399	971	0	119
30	71	......	66	0	369	434	426	423	400	806	0	118
31	......	......	67	......	375	......	427	384	......	743	......	118
1904.												
1	118	120	208	92	1,204	623	0	0	257	89	131	196
2	131	151	204	91	935	303	0	0	276	87	156	192
3	161	152	200	91	933	723	0	0	269	85	123	192
4	157	151	198	123	925	795	0	326	268	145	123	194
5	156	149	178	167	923	703	0	308	301	136	128	195
6	157	135	173	276	907	822	0	282	329	133	119	190
7	156	134	177	0	903	608	0	268	0	133	115	190
8	153	133	166	0	495	382	0	127	0	128	127	189
9	158	131	161	0	578	588	0	356	0	123	131	190
10	157	141	157	0	786	824	0	359	0	128	129	193
11	154	139	168	0	786	819	0	331	0	133	129	189
12	153	137	164	313	881	1,015	0	231	0	0	133	184
13	152	121	245	362	928	915	0	0	0	0	150	186
14	151	119	232	527	919	864	0	0	0	0	129	186
15	149	118	227	661	915	728	0	0	0	0	133	185
16	144	117	192	714	906	208	0	0	0	0	133	162
17	139	118	178	674	842	448	0	0	106	0	137	165
18	145	116	170	651	791	0	0	0	317	144	139	165
19	144	115	163	556	817	0	0	0	319	151	153	190
20	143	120	154	508	877	0	0	304	316	160	147	189
21	143	170	152	413	1,012	0	0	293	302	166	146	186
22	142	198	132	492	889	0	0	288	279	168	132	186
23	141	190	124	592	619	0	0	144	217	178	134	165
24	139	195	116	712	523	0	0	0	177	170	136	165
25	138	190	134	296	521	0	0	0	366	566	202	162
26	131	183	126	0	329	0	0	0	259	677	203	172
27	129	184	113	307	438	0	0	0	181	322	203	169
28	129	176	09	943	552	0	0	292	181	0	202	159
29	121	174	97	814	480	0	0	282	128	0	201	169
30	120	......	92	814	537	0	0	244	126	123	232	168
31	120	......	92	......	730	......	0	259	......	85	......	168

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	147	102	62	111	0	625	1,152	61	66	494	6	229
2	146	100	63	67	0	351	1,030	61	66	494	6	421
3	146	97	63	0	0	356	1,158	61	75	511	6	404
4	130	96	65	0	0	367	905	81	75	503	6	389
5	136	95	65	①	0	330	738	81	75	499	6	405
6	149	93	65	①	0	329	859	81	75	6	6	395
7	151	92	65	①	0	326	1,026	81	75	6	6	387
8	149	91	63	①	0	326	1,150	437	75	6	6	404
9	139	91	66	①	0	381	1,047	437	75	6	6	389
10	133	89	63	0	0	381	743	437	331	6	6	410
11	134	89	65	0	0	452	744	425	323	6	6	408
12	132	89	64	0	0	454	744	418	310	6	6	408
13	131	86	64	0	0	459	1,173	415	485	6	6	418
14	128	79	65	0	0	441	1,442	83	499	6	6	378
15	126	73	65	245	0	0	1,429	75	494	6	6	384
16	127	75	66	242	0	0	1,155	75	509	6	6	388
17	126	74	64	241	952	0	1,614	75	522	6	6	390
18	123	61	62	0	854	550	1,465	75	539	6	6	390
19	122	68	66	0	982	687	134	75	463	6	6	401
20	131	73	70	0	0	827	134	75	482	410	6	413
21	132	73	70	0	0	757	134	75	477	400	6	339
22	129	71	70	0	0	721	134	75	480	397	6	358
23	125	66	70	408	0	757	134	70	591	398	6	6
24	122	62	70	0	0	754	132	70	555	396	6	6
25	121	68	114	0	0	565	132	70	519	389	6	6
26	120	62	114	0	0	1,709	130	70	477	414	6	71
27	118	48	116	0	0	1,037	130	70	478	404	6	204
28	93	60	126	0	0	997	129	70	477	418	6	201
29	90	......	137	0	0	1,010	958	68	499	418	6	129
30	104	......	135	0	0	1,022	970	66	497	418	6	111
31	104	......	143	......	660	......	787	66	......	6	......	110
1906.												
1	109	106	529	329	230	567	858	10	10	916	370	12
2	109	105	533	329	230	645	992	10	10	741	334	12
3	108	100	479	342	287	354	1,004	10	10	893	344	12
4	108	100	478	342	364	350	823	10	10	791	340	12
5	111	100	480	386	402	300	829	10	10	572	10	12
6	106	98	452	425	497	319	399	10	10	604	10	12
7	106	98	453	459	563	318	362	10	10	787	840	12
8	105	257	441	528	643	522	334	10	10	10	631	12
9	105	285	463	527	703	641	337	10	10	10	10	12
10	104	317	467	454	785	738	352	458	10	10	810	12
11	100	313	410	543	931	815	357	502	10	10	10	12
12	105	293	394	601	917	878	442	495	10	10	10	12
13	105	343	400	525	949	928	483	532	10	10	10	12
14	103	325	387	0	748	911	524	485	10	10	10	20
15	105	504	501	0	544	536	768	475	10	10	10	20
16	105	507	458	0	455	586	823	10	10	10	10	20
17	105	485	442	0	741	606	896	10	10	10	10	20
18	103	474	390	230	730	427	809	10	10	10	10	20
19	100	464	380	220	831	374	821	10	10	10	10	20
20	100	465	364	228	630	370	811	10	517	10	10	20
21	100	573	364	228	609	387	812	10	472	10	10	20
22	100	464	352	230	615	407	775	10	839	823	10	20
23	105	512	308	230	587	439	767	10	828	780	10	20
24	100	479	313	228	611	500	805	10	726	10	10	20
25	100	458	307	220	587	494	221	387	773	317	10	20
26	96	525	287	230	582	564	219	410	804	306	12	20
27	102	454	277	230	610	570	224	10	901	300	12	20
28	103	448	274	228	598	576	251	10	945	692	12	20
29	104		274	230	381	696	10	10	1,016	695	12	20
30	103		286	230	316	706	10	10	876	710	12	20
31	105		315	......	712		10	10	......	727	......	20

① Dam open, water flowing from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1	25	421	604	295	1,020	1,505	761	0	590	612	179	340
2	25	423	581	330	473	1,505	538	0	590	936	0	330
3	25	430	561	287	436	1,530	481	0	538	936	0	300
4	25	429	561	268	400	1,404	590	0	638	936	0	280
5	25	442	574	287	412	1,394	514	0	538	757	0	260
6	25	444	571	287	404	1,403	628	0	481	602	0	250
7	25	443	544	300	412	1,402	513	0	481	641	0	240
8	217	434	515	286	412	1,402	313	0	538	641	0	220
9	225	439	456	286	387	1,402	258	0	590	602	0	210
10	223	439	504	300	400	1,401	182	0	590	602	0	200
11	220	435	472	278	1,050	989	258	0	638	602	0	190
12	217	436	462	286	1,048	938	182	0	313	440	0	180
13	215	449	444	273	972	938	182	0	313	253	0	170
14	214	443	433	278	723	540	182	0	313	0	0	160
15	212	443	433	158	723	380	182	0	0	0	253	150
16	213	445	374	260	686	380	182	0	0	179	0	150
17	211	634	417	246	595	380	258	0	0	0	0	150
18	209	766	422	232	340	492	182	0	0	0	0	150
19	208	748	372	246	340	539	313	0	0	253	0	150
20	206	745	389	286	442	539	313	0	0	358	0	150
21	204	800	350	320	340	583	182	0	0	253	0	140
22	429	755	420	340	395	558	182	0	590	309	655	130
23	396	514	373	340	442	594	(1)	182	638	309	645	120
24	439	767	467	260	484	594	(1)	182	522	358	635	110
25	423	729	413	286	442	731	(1)	182	10	358	620	100
26	414	689	359	340	279	695	(1)	258	590	358	600	90
27	407	659	284	340	340	583	(1)	313	830	358	580	80
28	403	635	284	360	484	744	(1)	538	830	309	570	80
29	405	......	274	473	523	761	(1)	481	864	309	550	80
30	403	......	250	523	624	869	(1)	538	901	309	350	80
31	411	......	238	......	1,332	......	(1)	481	......	253	......	80
1908.												
1	80	70	67	2	2	150	700	10	10	0	40	70
2	80	70	66	2	2	150	650	10	10	0	40	65
3	80	70	65	2	2	150	770	10	10	0	50	65
4	80	70	64	2	2	200	750	10	10	0	50	60
5	80	70	63	2	3	200	730	15	10	0	50	60
6	80	70	62	2	450	200	700	20	10	10	50	55
7	80	70	61	2	500	200	700	20	10	10	60	55
8	80	70	60	2	419	100	650	30	10	10	60	55
9	80	70	60	2	410	0	550	40	10	10	35	55
10	80	70	60	2	400	0	500	50	10	10	30	55
11	80	70	60	2	400	0	376	75	0	10	40	55
12	80	72	60	2	400	0	350	50	0	20	35	55
13	80	73	60	2	2	50	300	60	0	20	35	55
14	80	74	60	2	2	300	250	75	0	20	30	55
15	80	75	60	2	2	500	225	60	10	20	35	55
16	80	75	60	2	200	846	200	60	10	20	50	55
17	80	75	60	400	200	900	200	70	10	20	55	55
18	70	75	60	2	400	925	175	50	0	20	60	55
19	70	76	60	2	400	925	150	30	0	10	60	55
20	70	75	60	2	400	1,005	10	20	0	10	60	55
21	70	74	60	2	400	1,000	10	20	10	10	65	55
22	70	75	60	2	400	975	10	10	20	10	65	55
23	70	76	60	2	400	960	10	10	60	10	70	55
24	70	76	60	2	400	950	10	10	10	10	70	55
25	70	75	60	2	400	950	25	10	10	10	70	55
26	70	74	60	2	350	925	100	10	10	10	70	55
27	70	70	60	2	325	900	100	10	10	19	70	55
28	70	69	60	2	150	900	90	10	20	25	70	55
29	70	68	60	2	150	850	75	10	20	30	70	55
30	70	......	60	2	150	800	50	10	10	30	70	55
31	70	......	60	......	150	......	10	10	......	35	......	55

(1) **Dam open, water flowing from river into reservoir.**

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	55	35	35	20	20	360	40	550	750	0	0	50
2	55	35	35	10	25	320	100	479	900	0	0	50
3	55	35	35	10	30	320	179	420	900	20	0	60
4	55	35	35	20	40	320	170	420	900	20	0	80
5	55	35	35	20	20	477	160	420	900	50	0	80
6	55	35	35	10	10	477	145	400	800	40	0	90
7	55	35	35	15	15	465	130	300	800	80	0	90
8	55	35	35	15	30	465	0	300	700	90	0	85
9	55	35	35	20	40	470	0	200	602	150	0	85
10	55	35	35	15	60	475	0	200	550	200	0	80
11	50	35	35	15	75	475	0	0	700	250	0	65
12	50	35	25	20	80	312	0	0	750	320	0	60
13	50	35	0	20	80	312	0	0	500	250	0	60
14	50	35	0	20	125	310	55	0	300	330	0	60
15	40	35	15	30	291	300	20	40	250	350	0	60
16	35	35	15	35	310	300	50	30	200	351	400	70
17	30	35	15	40	310	290	60	100	100	300	700	80
18	30	35	15	40	310	300	40	75	150	100	650	85
19	30	35	0	40	320	249	20	75	150	0	600	90
20	30	35	0	40	330	249	15	75	200	0	0	95
21	30	35	0	40	300	250	15	30	175	0	0	95
22	30	35	15	15	290	245	20	30	50	0	0	95
23	30	35	20	35	300	240	30	15	0	20	0	95
24	30	35	20	40	290	235	20	0	0	0	30	100
25	30	35	20	40	290	230	10	0	0	0	0	100
26	30	35	0	40	285	20	180	15	0	0	0	100
27	30	35	0	40	285	0	460	100	0	0	0	100
28	35	35	15	40	280	0	550	220	0	0	60	100
29	35	......	15	40	369	10	600	220	0	0	81	100
30	35	......	15	30	369	20	500	250	0	0	45	100
31	35	......	20	......	360	......	550	741	......	0	......	100
1910.												
1	100	75	20	160	260	0	①	①	0	0	0	10
2	100	75	20	160	250	0	0	①	0	0	0	10
3	100	75	25	175	320	0	0	①	0	0	0	10
4	100	75	25	180	290	20	0	①	0	0	0	10
5	100	75	25	200	330	20	0	①	0	0	0	10
6	100	75	25	200	360	20	①	①	0	0	0	10
7	100	75	25	290	340	20	①	①	0	0	175	10
8	100	75	25	390	350	10	①	①	0	0	150	10
9	100	75	25	390	340	10	①	①	0	0	150	10
10	95	75	25	390	340	10	①	①	0	0	150	10
11	95	70	25	390	360	10	①	①	0	0	17	10
12	95	70	0	390	340	10	①	①	0	0	0	10
13	95	70	0	400	330	10	①	①	0	0	0	10
14	95	70	0	400	437	10	①	①	0	0	0	10
15	95	70	0	400	415	10	①	①	0	0	0	10
16	95	70	0	504	400	10	①	①	0	0	0	10
17	100	70	0	500	0	10	①	①	0	0	0	10
18	100	70	0	480	①	10	①	①	0	0	0	10
19	100	70	0	475	①	10	①	①	0	0	0	10
20	90	65	0	470	①	10	①	①	0	0	0	10
21	90	65	0	445	①	10	①	①	0	0	0	10
22	90	65	0	420	①	10	①	①	0	0	0	10
23	90	60	0	390	①	10	①	①	0	0	0	10
24	90	60	0	370	①	10	①	①	0	0	0	10
25	90	50	0	360	①	①	①	①	0	50	0	10
26	80	35	0	360	①	①	①	①	0	0	0	10
27	80	20	80	360	20	①	①	①	0	0	0	10
28	80	20	150	360	20	①	①	①	0	0	0	10
29	80	......	160	320	20	①	①	①	0	0	0	10
30	80	......	170	269	0	①	①	0	0	0	0	10
31	80	......	175	......	0	......	①	0	......	0	......	10

① Dam open, water flowing from river into reservoir.

Daily discharge, in second-feet, of Sandy River below Sandy Lake Reservoir —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1	5	5	5	5	5	284	152	5	0	5	75	10
2	5	5	5	5	5	283	122	5	5	5	75	10
3	5	5	5	5	5	282	92	5	5	5	75	10
4	5	5	5	5	5	292	61	5	0	5	50	10
5	5	5	5	5	5	301	30	5	0	5	50	10
6	5	5	5	5	5	311	0	5	0	5	50	10
7	5	5	5	5	5	321	50	5	0	5	50	10
8	5	5	5	5	5	331	50	5	0	5	50	10
9	5	5	5	5	242	328	100	5	0	5	50	10
10	5	5	5	5	303	325	75	5	0	5	50	10
11	5	5	5	5	300	321	5	5	0	5	50	10
12	5	5	5	5	296	318	5	5	0	5	50	10
13	5	5	5	5	291	315	5	5	0	5	50	10
14	5	5	5	5	287	312	5	5	0	268	50	10
15	5	5	5	5	294	308	0	5	0	275	10	10
16	5	5	5	5	301	305	0	5	0	282	10	10
17	5	5	5	5	308	303	0	300	0	281	10	10
18	5	5	5	5	316	301	0	307	5	272	10	10
19	5	5	5	5	324	300	0	296	5	263	10	10
20	5	5	5	5	328	467	0	285	5	255	10	10
21	5	5	5	5	332	475	0	274	5	225	10	10
22	5	5	5	5	283	483	0	263	5	195	10	10
23	5	5	5	5	104	492	0	251	5	166	10	10
24	5	5	5	5	109	501	0	239	5	162	10	10
25	5	5	5	5	114	448	0	227	5	157	10	10
26	5	5	5	5	118	395	0	198	5	153	10	10
27	5	5	5	5	123	342	0	169	5	148	10	10
28	5	5	5	5	111	289	0	140	5	144	10	10
29	5	......	5	5	100	236	0	110	5	139	10	10
30	5	......	5	5	293	182	0	80	5	134	10	10
31	5	......	5	......	285	......	0	50	......	129	......	10
1912.												
1	10	10	10	10	10	10	502	502	205	0	5	......
2	10	10	10	10	10	10	500	501	212	0	5	......
3	10	10	10	10	10	10	501	498	192	5	5	......
4	10	10	10	10	10	10	503	500	166	5	5	......
5	10	10	10	10	10	10	500	500	170	5	5	......
6	10	10	10	10	10	10	502	500	165	5	5	......
7	10	10	10	10	10	10	500	501	144	5	5	......
8	10	10	10	10	10	10	499	498	120	5	5	......
9	10	10	10	10	10	10	502	502	125	5	5	......
10	10	10	10	10	10	10	500	500	62	5	5	......
11	10	10	10	10	10	10	501	499	0	5	5	......
12	10	10	10	10	10	10	501	501	0	5	5	......
13	10	10	10	10	10	10	499	501	0	5	5	......
14	10	10	10	10	10	10	502	499	0	5	5	......
15	10	10	10	10	10	10	501	502	0	5	5	......
16	10	10	10	10	10	10	498	499	0	5	5	......
17	10	10	10	10	10	10	500	502	0	5	5	......
18	10	10	10	10	10	10	500	500	0	5	5	......
19	10	10	10	10	10	10	499	500	0	5	5	......
20	10	10	10	10	10	10	501	501	0	5	5	......
21	10	10	10	10	10	10	502	450	0	5	5	......
22	10	10	10	10	10	10	498	264	0	5	5	......
23	10	10	10	10	10	10	502	280	0	5	5	......
24	10	10	10	10	319	328	501	326	0	5	5	......
25	10	10	10	10	497	492	500	288	0	5	5	......
26	10	10	10	10	483	505	501	258	0	5	5	......
27	10	10	10	10	480	499	501	270	0	5	5	......
28	10	10	10	10	76	507	499	242	0	5	5	......
29	10	10	10	10	474	503	502	212	0	5	5	......
30	10	......	10	10	475	499	500	245	0	5	5	......
31	10	......	10	......	120	......	501	218	......	5	......	......

Monthly outflow from Sandy Lake reservoir.

Month.	Discharge in second-feet.			Run-off (in millions of cubic feet)
	Maximum.	Minimum.	Mean.	
1893.				
July (25 days)	459	0	204	441
August	455	0	142	380
September	124	0	13.6	35.2
October	106	0	6.8	18.2
November	341	0	193	500
December	127	26	56.7	152
The period				1,530
1894.				
January	19	0	.6	1.6
February	0	0	0	0
March	0	0	0	0
April (17 days)	0	0	0	0
May (26 days)	1,241	560	1,020	2,290
June (23 days)	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	263	0	127	329
December	230	0	42.1	113
The period				2,730
1895.				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April (27 days)	0	0	0	0
May (20 days)	0	0	0	0
June (9 days)	0	0	0	0
August	322	109	189	506
September (11 days)	333	176	285	271
October	365	210	275	736
November	201	0	67	174
December	0	0	0	0
The period				1,690
1896.				
January	0	0	0	0
February	163	0	70.2	176
March	0	0	0	0
April (28 days)	0	0	0	0
May (24 days)	1,012	388	610	1,260
June	1,534	0	550	1,430
July	1,161	0	63	169
August	623	0	326	873
September	853	0	676	1,750
October	468	0	184	493
November	581	0	207	537
December	379	0	169	453
The period				7,140
1897.				
January	205	0	89.2	239
February	112	72	93	225
March	120	65	77.3	207
April	1,747	0	378	980
May	896	362	601	1,610
June	638	356	531	1,380
July	3,738	369	2,500	6,690
August	2,894	0	455	1,220
September	1,071	0	791	2,050
October	877	0	391	1,050
November	0	0	0	0
December	0	0	0	0
The year	3,738	0	492	15,700

Monthly outflow from Sandy Lake reservoir—Continued.

Month.	Discharge in second-feet.			Run-off (in millions of cubic feet)
	Maximum.	Minimum.	Mean.	
1898.				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	482	0	206	552
November	227	0	41.6	108
December	298	0	120	321
The year	482	0	30.6	981
1899.				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	1,257	0	110	296
June	1,499	0	761	1,970
July	1,474	0	282	755
August	2,099	0	633	1,700
September	1,149	0	572	1,480
October	2,888	0	788	2,110
November	1,607	0	594	1,540
December	0	0	0	0
The year	2,888	0	312	9,850
1900.				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	229	0	7.6	19.8
May	1,041	0	619	1,660
June	552	0	267	692
July	155	0	48.3	129
August	0	0	0	0
September (18 days)	0	0	0	0
October	556	0	42.9	115
November	0	0	0	0
December	0	0	0	0
The year	1,041	0	82.1	2,620
1901.				
January	0	0	0	0
February	215	0	50.6	122
March	670	165	344	921
April	600	0	208	539
May	1,651	0	891	2,390
June	927	0	219	568
July	2,660	0	1,220	3,270
August	1,290	0	711	1,900
September	579	0	75.8	196
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
The year	2,660	0	310	9,910
1902.				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	442	0	21.4	55.4
May	959	0	200	536
June	1,032	481	834	2,160
July	779	0	68.7	184
August	601	0	431	1,150
September	378	0	75.9	197
October	196	0	36.4	97.5
November	232	0	40.7	56.3
December	544	0	213	570
The year	1,032	0	160	5,010

Monthly outflow from Sandy Lake reservoir—Continued.

Month.	Discharge in second-feet.			Run-off (in millions of cubic feet)
	Maximum.	Minimum.	Mean.	
1903.				
January	404	0	155	415
February	71	0	40.7	98.5
March	67	0	41.3	111
April	369	0	12 3	31.9
May	1,559	0	891	2,390
June	887	0	179	464
July	446	356	403	1,080
August	433	337	398	1,070
September	759	314	425	1,100
October	1,007	303	649	1,740
November	1,220	0	726	1,880
December	119	0	18.2	48.7
The year	1,559	0	328	10,400
1904.				
January	161	118	143	383
February	198	115	147	368
March	245	92	160	428
April	943	0	373	967
May	1,204	438	770	2,060
June	1,015	0	379	982
July	0	0	0	0
August	359	0	151	404
September	366	0	166	430
October	677	0	136	364
November	232	115	148	384
December	196	159	180	482
The year	1,204	0	229	7,250
1905.				
January	151	90	128	343
February	102	48	79.4	192
March	143	62	79.2	212
April	408	0	43.8	114
May	982	0	111	297
June	1,709	0	566	1,470
July	1,614	129	762	2,040
August	437	61	141	378
September	591	66	355	920
October	511	6	228	611
November	6	6	6	15.6
December	421	6	302	809
The year	1,709	0	233	7,400
1906.				
January	111	96	104	279
February	573	98	345	835
March	533	274	395	1,060
April	601	0	292	757
May	949	230	593	1,590.
June	928	300	551	1,430
July	1,004	10	553	1,480
August	532	10	128	343
September	1,016	10	296	767
October	916	10	349	935
November	840	10	130	337
December	20	12	16	42.8
The year	1,004	0	313	9,860
1907.				
January	439	25	235	629
February	800	421	551	1,330
March	604	238	432	1,160
April	523	158	302	783
May	1,332	279	560	1,500
June	1,530	380	906	2,350
July	761	182	238	637
August	538	0	102	273
September	901	0	431	1,120
October	936	0	414	1,110
November	655	0	188	487
December	340	80	172	461
The year	1,530	0	378	11,800

Monthly outflow from Sandy Lake reservoir—Continued.

Month.	Discharge in second-feet Maximum.	Minimum.	Mean.	Run-off (in millions of cubic feet)
1908.				
January	80	70	75.5	202
February	76	68	72.3	181
March	67	60	60.9	163
April	400	2	15.3	39.7
May	500	2	251	672
June	1,005	0	533	1,382
July	770	10	304	814
August	75	10	28.6	76.6
September	60	0	10.3	26.7
October	36	0	13.2	35.3
November	70	30	53.8	139
December	70	55	56.5	151
The year	1,005	0	123	3,880
1909.				
January	55	30	41.8	112
February	35	35	35	84.7
March	35	0	19.7	52.8
April	40	10	27.2	71.1
May	369	10	192	514
June	477	0	283	734
July	600	0	133	356
August	741	0	184	493
September	900	0	378	980
October	351	0	94.2	262
November	700	0	85.6	222
December	100	50	82.6	221
The year	900	0	130	4,160
1910.				
January	100	80	93.1	252
February	75	20	65.0	157
March	175	0	32.3	86.5
April	504	160	353	915
May	437	0	178	477
June	20	0	8.3	21.8
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	50	0	16.1	4.3
November	175	0	21.4	55.5
December	10	10	10	26.8
The year	504	0	64.8	2,000
1911.				
January	5	5	5.0	13.4
February	5	5	5.0	12.1
March	5	5	5.0	13.4
April	5	5	5.0	13.0
May	332	5	181	485
June	501	182	338	876
July	152	0	24.3	65.1
August	307	5	105	281
September	5	0	2.5	6.48
October	282	5	120	321
November	75	10	31.2	80.9
December	10	10	10.0	26.8
The year	501	0	69.6	2,190
1912.				
January	10	10	10	26.8
February	10	10	10	25.1
March	10	10	10	26.8
April	10	10	10	25.9
May	497	10	102	273
June	507	10	119	308
July	503	498	501	1,340
August	502	212	421	1,130
September	212	0	52	135
October	5	0	4.7	12.6
November	5	5	5	13.0

NOTE.—Above table computed by engineers of the United States Geological Survey from records of daily discharge furnished by the United States Engineer Corps.

PINE RIVER BELOW PINE RIVER RESERVOIR.

Location.—Just below the dam at the outlet of Cross Lake, 15 miles above the mouth of the river, in Sec. 21, T. 137 N., R. 27 W.

Records available.—January 1, 1895, to December 31, 1912. The daily discharge tables taken from unpublished records in the United States Engineer office at St. Paul.

Drainage area.—452 square miles.

Gage.—Vertical staff representing the head of water at the dam.

Channel.—The discharge is estimated by the head and size of openings in the sluiceways.

Regulation.—The flow at this station is wholly controlled (see p. — for description of reservoir).

Cooperation.—This station is maintained by the United States Engineer Corps.

Daily discharge, in second-feet, of Pine River, below Pine River Reservoir.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1895.												
1	3	3	5	5	537	536	477	7	423	229	97	2
2	3	3	5	5	464	376	274	7	426	222	95	2
3	3	3	5	5	507	425	259	399	419	214	92	2
4	3	3	5	5	481	419	261	604	417	207	104	2
5	3	3	5	175	469	177	262	639	418	202	124	2
6	3	3	5	174	498	9	263	637	418	198	134	2
7	3	3	5	174	440	9	260	640	418	191	134	2
8	3	3	5	174	478	9	8	700	415	186	130	2
9	3	3	5	174	469	9	8	772	416	180	123	2
10	3	3	4	174	493	9	348	837	413	180	123	2
11	3	3	4	175	463	9	476	796	408	178	123	2
12	3	3	4	176	457	9	314	845	402	174	144	2
13	3	3	4	177	464	9	8	656	397	178	144	2
14	3	3	4	177	443	9	7	648	399	168	141	2
15	3	3	4	177	443	9	7	641	399	163	138	2
16	3	3	4	177	438	9	7	634	393	156	123	2
17	3	5	4	177	438	9	7	646	286	150	124	2
18	3	5	4	176	438	9	7	657	279	152	124	2
19	3	5	4	176	236	9	7	751	271	142	120	2
20	3	5	4	176	244	9	7	566	261	133	118	2
21	3	5	4	194	518	9	7	512	257	124	3	2
22	3	5	24	194	577	452	7	543	257	114	3	3
23	3	5	67	194	62	520	7	510	281	109	3	3
24	2	5	4	326	9	18	7	431	264	106	2	3
25	3	5	4	625	9	254	7	398	250	105	2	3
26	3	5	4	224	10	412	7	424	247	102	2	3
27	3	5	4	189	10	329	7	421	223	108	2	3
28	3	5	4	190	10	445	7	422	243	105	2	3
29	3		4	190	10	50	7	417	244	103	2	2
30	3		4	191	441	451	7	416	237	103	2	2
31	3		4		524		7	417		99		2
1896.												
1	2	103	114	66	5	33	(1)	648	190	142	187	171
2	2	103	113	66	5	33	(1)	622	197	142	187	168
3	2	103	113	66	5	33	(1)	646	190	142	220	171
4	2	103	95	67	5	33	(1)	611	186	124	228	178
5	3	102	113	66	5	33	(1)	704	201	127	228	186
6	3	102	113	66	5	33	(1)	698	202	127	228	198
7	3	102	114	66	5	33	(1)	752	193	127	232	198
8	3	102	110	66	5	30	(1)	511	193	127	231	194
9	3	107	110	66	5	30	(1)	665	191	130	235	194
10	3	107	109	66	9	30	(1)	470	191	175	235	194

(1) Crevasse formed on June 17. Only part of water passed through dam. This continued into July.

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
11	3	107	109	66	9	30	877	439	191	177	232	194
12	3	107	109	66	9	30	710	389	187	177	232	190
13	3	107	109	66	9	30	722	354	187	171	227	181
14	3	107	109	68	9	20	714	340	183	171	227	181
15	3	107	119	62	9	20	719	338	187	171	250	193
16	3	119	119	64	9	20	735	409	190	169	245	198
17	3	119	119	64	9	①	704	389	187	171	245	103
18	3	119	119	65	9	①	657	366	187	171	241	189
19	3	119	119	4	9	①	684	351	187	171	241	181
20	3	118	118	4	9	①	758	341	207	171	236	181
21	3	118	118	4	9	①	447	320	202	169	232	177
22	3	118	69	4	9	①	401	287	194	169	222	185
23	3	113	70	4	9	①	300	307	181	164	222	185
24	3	113	70	4	17	①	166	291	168	161	214	181
25	3	113	65	4	17	①	14	286	159	150	211	177
26	3	113	65	5	17	①	14	281	157	147	219	177
27	3	113	65	5	17	①	302	263	152	147	214	177
28	3	113	65	5	17	①	528	253	149	143	211	174
29	3	113	65	5	21	①	519	239	140	143	202	174
30	3	......	65	5	21	①	541	229	137	180	190	170
31	57	......	66	......	21	①	649	220	......	183	......	170
1897.												
1	170	238	204	303	778	428	653	9	9	9	14	11
2	177	235	204	317	760	475	574	9	9	9	14	11
3	179	230	201	383	728	556	784	9	9	9	14	11
4	196	230	201	534	698	465	530	9	9	9	14	11
5	215	223	201	827	629	325	235	9	9	9	14	11
6	215	215	201	843	612	238	5	9	9	9	14	11
7	206	211	201	847	600	189	5	9	9	9	14	11
8	206	207	204	890	614	217	5	9	9	9	14	11
9	199	204	204	959	579	333	5	9	9	9	14	11
10	195	200	201	1,043	581	473	5	9	9	9	14	11
11	195	212	197	1,131	583	530	5	9	9	9	14	11
12	199	207	201	1,206	582	533	5	9	9	9	14	11
13	195	200	201	1,165	611	561	5	9	9	9	14	11
14	192	232	207	1,117	629	193	5	9	9	9	14	10
15	192	236	207	1,117	634	191	5	9	9	9	14	10
16	188	232	204	1,181	611	403	5	9	9	9	14	10
17	195	232	200	1,048	563	657	5	9	9	9	14	10
18	266	228	220	1,010	5	715	6	9	9	9	14	10
19	447	228	234	971	5	652	6	9	9	9	14	10
20	430	225	256	905	5	733	6	9	9	9	14	10
21	401	221	270	854	5	549	6	9	9	9	14	10
22	357	217	270	817	5	492	6	9	337	9	14	10
23	328	217	266	786	5	724	6	9	767	9	11	10
24	308	217	266	757	5	705	6	9	622	11	11	10
25	288	213	259	751	832	690	6	9	610	11	11	10
26	262	209	255	741	844	636	6	9	506	11	11	10
27	247	204	259	725	490	667	6	9	35	11	11	10
28	240	204	260	753	387	635	6	9	9	11	11	10
29	239	......	264	743	327	621	6	9	9	11	11	13
30	234	......	280	737	465	755	6	9	9	11	11	13
31	234	......	290	......	377	......	6	9	......	11	......	13
1898.												
1	13	14	18	19	19	19	27	145	930	740	415	3
2	13	14	18	19	19	19	27	146	913	793	396	3
3	13	14	18	19	19	193	27	146	896	774	349	3
4	13	14	18	19	19	852	96	146	880	763	340	3
5	13	14	18	19	19	988	197	145	864	764	332	3
6	13	14	18	19	19	1,398	981	146	849	750	315	4
7	13	14	18	19	19	1,475	932	400	836	745	302	4
8	13	14	18	19	19	1,479	1,292	426	821	719	324	4
9	13	17	18	19	19	1,479	1,379	134	804	703	315	4
10	13	17	18	19	19	1,478	1,054	437	789	685	308	4
11	13	17	18	19	19	331	895	647	775	661	295	4
12	13	17	18	19	19	30	714	728	761	703	289	4
13	13	17	18	19	19	30	624	618	749	509	280	
14	13	17	18	19	19	30	723	714	740	657	277	4
15	13	17	19	19	19	30	729	777	731	666	263	4

① Crevasse formed on June 17. Only part of water passed through dam. This continued into July.

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898.												
16	13	17	19	19	19	30	419	802	721	622	261	4
17	13	17	19	19	19	30	419	791	708	557	258	4
18	14	17	19	19	19	27	418	809	699	572	253	4
19	14	17	19	19	19	27	421	795	734	582	221	4
20	14	17	19	19	19	27	595	787	772	568	217	4
21	14	17	19	19	19	27	320	840	754	552	161	4
22	14	17	19	19	19	27	320	1,085	770	531	3	4
23	14	18	19	19	19	27	458	1,064	784	509	3	4
24	14	18	19	19	19	27	1,099	1,056	776	493	3	6
25	14	18	19	19	19	27	895	1,043	773	449	3	6
26	14	18	19	19	19	27	854	1,022	757	433	3	6
27	14	18	19	19	19	27	361	1,001	754	416	3	6
28	14	18	19	19	19	27	356	988	745	406	3	6
29	14		19	19	19	27	353	972	778	442	3	6
30	14		19	19	19	27	263	957	758	435	3	6
31	14		19		19		145	944		425		6
1899.												
1	6	9	13	16	19	19	306	651	38	60	268	48
2	6	9	13	16	19	19	579	840	193	60	270	87
3	6	11	13	16	19	19	578	826	192	55	270	208
4	6	11	13	16	19	19	581	709	193	55	270	206
5	6	11	13	16	19	19	581	529	192	55	270	206
6	6	11	13	16	19	19	579	40	192	55	270	173
7	6	11	13	16	19	19	295	40	574	119	310	48
8	6	11	13	16	19	19	73	40	614	208	310	48
9	6	11	13	16	19	19	568	40	546	208	310	75
10	6	11	13	16	19	19	565	366	288	208	190	156
11	6	11	16	18	19	19	449	561	288	208	48	156
12	9	11	16	18	19	19	30	580	208	363	48	156
13	9	11	16	18	19	19	30	622	69	363	48	154
14	9	11	16	18	19	19	30	614	38	363	48	101
15	9	11	16	18	19	19	54	369	38	363	48	48
16	9	11	16	18	19	19	620	35	38	1,171	113	48
17	9	11	16	18	19	19	646	159	144	1,168	490	48
18	9	11	16	18	19	19	641	625	270	1,167	668	48
19	9	11	16	18	19	19	457	632	270	1,161	666	48
20	9	11	16	18	19	19	436	639	270	965	503	48
21	9	13	16	18	19	19	375	777	296	359	310	48
22	9	13	16	18	19	19	40	905	115	495	182	48
23	9	13	16	18	19	19	35	918	415	629	48	93
24	9	13	16	18	19	19	35	863	415	629	48	156
25	9	13	16	19	19	19	498	688	313	629	48	156
26	9	13	16	19	19	19	581	366	208	627	48	156
27	9	13	16	19	19	19	576	35	208	627	48	156
28	9	13	16	19	19	348	576	35	130	627	48	156
29	9		16	19	19	425	561	35	60	627	48	156
30	9		16	19	19	30	546	30	60	625	48	156
31	9		16				537	30		625		156
1900.												
1	156	52	41	41	39	589	531	764	429	601	406	52
2	154	52	41	41	199	52	381	747	432	444	406	52
3	154	52	41	41	579	52	52	730	433	65	406	52
4	154	52	41	41	578	52	52	717	428	65	406	52
5	154	52	41	41	576	52	795	718	425	55	406	52
6	112	52	41	101	575	52	794	742	423	55	406	52
7	52	52	41	206	576	52	860	487	420	55	406	52
8	52	52	41	206	575	52	943	489	709	55	405	52
9	52	52	41	309	575	52	913	496	704	307	405	52
10	52	52	41	313	575	52	891	514	706	561	403	52
11	52	52	41	414	735	52	877	526	706	561	403	52
12	52	52	41	414	611	52	870	528	690	559	403	52
13	52	52	41	414	608	510	870	531	688	558	271	52
14	52	52	41	414	769	727	861	533	675	558	52	52
15	52	52	41	328	602	52	850	533	691	281	52	52
16	52	52	41	208	445	52	842	531	730	285	52	52
17	52	52	41	132	284	52	830	457	727	285	52	52
18	52	52	41	42	282	52	813	462	723	285	52	52
19	52	52	41	42	321	273	807	467	792	285	52	52
20	52	41	41	42	735	631	795	474	869	285	52	52

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
21	52	41	41	42	654	628	783	481	985	285	52	52
22	52	41	41	42	172	627	781	422	1,109	285	52	52
23	52	41	41	42	52	622	777	488	902	286	52	52
24	52	41	41	42	52	890	769	492	718	286	52	52
25	52	41	41	42	52	911	759	518	674	285	52	52
26	52	41	41	42	52	963	742	520	615	406	52	52
27	52	41	41	42	52	1,011	804	526	613	406	52	52
28	52	41	41	42	52	773	795	778	611	406	52	52
29	52	......	41	42	52	553	791	769	606	406	52	52
30	52	......	41	42	377	541	785	770	605	406	52	52
31	52	......	41	......	783	......	777	565	......	406	......	52
1901.												
1	52	56	56	56	53	460	1,280	56	397	738	452	241
2	52	56	56	56	53	78	1,239	56	498	669	435	240
3	52	56	56	56	53	78	1,002	53	520	802	419	240
4	52	56	56	56	53	72	1,045	53	507	796	418	238
5	52	56	56	56	53	72	1,230	53	493	789	383	238
6	52	56	56	56	53	65	1,222	53	533	774	372	235
7	52	56	56	56	53	65	1,216	519	481	831	361	236
8	52	56	56	56	53	65	1,271	873	573	814	356	238
9	52	56	56	56	53	65	1,271	862	667	856	347	237
10	52	56	56	56	53	65	1,262	853	793	897	339	232
11	52	56	56	56	53	512	1,249	778	852	928	327	227
12	52	56	56	56	53	544	1,239	425	657	924	321	217
13	52	56	56	56	53	576	1,037	422	647	896	327	211
14	52	56	56	56	53	610	1,033	421	635	925	327	207
15	52	56	56	56	53	70	541	427	625	938	313	202
16	52	56	56	56	53	72	714	421	619	956	307	201
17	52	56	56	56	53	628	767	420	608	910	297	200
18	52	56	56	56	53	896	803	421	601	844	294	199
19	52	56	56	56	53	931	784	421	579	820	112	196
20	52	56	56	56	53	932	495	420	651	790	301	195
21	52	56	56	56	53	952	604	418	821	893	277	197
22	52	56	56	56	53	1,054	477	418	871	838	272	184
23	52	56	56	53	53	1,167	579	416	844	816	272	189
24	52	56	56	53	53	1,245	451	414	824	781	266	192
25	52	56	56	53	379	1,346	453	413	814	711	265	192
26	52	56	56	53	657	1,342	446	411	808	662	264	198
27	52	56	56	53	653	1,337	73	408	794	619	258	199
28	52	56	56	53	647	1,357	73	406	780	573	252	203
29	56	......	56	53	650	1,586	396	404	765	535	247	201
30	56	......	56	53	371	1,293	498	402	744	505	242	197
31	56	......	56	......	372	......	277	399	......	476	......	192
1902.												
1	188	181	183	36	43	57	61	568	334	319	296	295
2	185	181	183	36	43	57	61	553	334	318	295	295
3	189	181	184	36	36	537	61	541	333	318	295	293
4	179	181	184	36	36	536	62	510	333	319	296	293
5	181	180	186	36	36	525	62	501	332	318	297	292
6	180	180	186	37	148	516	62	491	323	317	297	308
7	179	180	184	37	148	525	63	464	322	316	298	308
8	178	180	184	37	148	286	63	468	322	314	300	306
9	176	182	185	37	38	57	206	533	322	313	300	306
10	175	182	186	37	38	58	345	537	322	312	300	305
11	177	182	187	37	38	312	334	537	322	331	301	305
12	179	181	189	37	38	565	195	531	321	330	301	304
13	179	179	189	38	38	574	175	531	323	328	302	297
14	180	179	192	38	39	317	61	526	323	327	305	295
15	182	177	190	38	39	583	61	526	323	326	305	291
16	182	179	191	38	39	574	61	500	321	325	305	291
17	179	179	193	38	50	768	61	492	321	322	305	291
18	184	180	193	38	50	760	61	273	320	314	305	291
19	186	179	195	36	51	759	61	273	318	312	305	291
20	186	179	195	36	51	749	61	274	332	311	305	297
21	186	179	20	36	57	58	284	273	329	309	305	296
22	186	179	21	36	61	59	489	274	328	307	306	296
23	184	179	22	36	61	59	488	326	328	306	306	295
24	184	179	27	36	62	59	478	326	328	306	306	295
25	186	178	32	36	62	59	470	326	327	308	305	294

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
26	186	180	33	43	64	59	657	325	325	307	305	294
27	186	180	34	43	64	60	648	325	319	308	305	295
28	184	183	35	43	64	60	628	323	319	308	305	294
29	184	......	36	43	65	61	628	322	318	308	297	294
30	183	......	36	43	65	61	616	332	319	308	297	294
31	183	......	36	......	56	......	606	332	......	308	......	294
1903.												
1	293	239	211	21	45	280	528	643	92	516	110	106
2	290	238	211	22	39	41	526	639	92	516	110	106
3	298	238	211	23	41	41	528	583	92	103	110	106
4	298	236	212	39	41	41	522	35	93	105	110	106
5	297	235	213	41	41	41	514	36	95	106	110	110
6	296	234	214	42	41	42	504	36	95	107	110	110
7	295	231	223	43	42	42	497	36	96	109	109	110
8	295	230	224	44	42	43	292	89	96	110	109	110
9	294	227	225	45	40	43	713	89	97	111	109	110
10	287	224	226	47	40	43	706	89	98	105	109	110
11	285	222	227	39	40	43	695	89	99	106	109	110
12	283	217	229	41	41	43	684	89	89	107	110	106
13	283	211	231	43	41	43	449	90	91	107	110	106
14	283	230	229	46	41	331	438	90	92	108	110	106
15	281	224	227	48	43	607	234	91	92	108	110	106
16	279	223	228	49	39	602	36	91	93	109	110	106
17	285	223	229	49	40	592	37	91	94	111	110	106
18	281	221	231	40	40	587	37	91	95	111	110	106
19	284	221	232	40	287	312	37	91	88	112	110	106
20	284	221	235	40	527	274	37	91	89	112	110	106
21	283	219	237	41	523	497	37	91	89	113	107	106
22	280	221	237	41	278	493	461	92	89	113	107	106
23	278	221	238	41	40	485	37	92	89	113	107	106
24	244	222	238	42	41	478	37	92	89	107	107	106
25	229	222	239	41	41	470	37	92	89	107	107	106
26	228	222	241	42	302	563	37	93	89	107	107	106
27	227	222	242	43	556	558	38	93	89	107	107	106
28	226	214	244	43	553	553	38	94	89	108	105	106
29	225	......	244	44	553	543	527	92	90	108	106	106
30	224	......	244	44	548	536	619	92	90	108	106	106
31	239	......	245	......	543	......	604	92	......	109	......	106
1904.												
1	106	263	416	420	483	121	127	159	354	503	284	302
2	104	306	416	420	483	121	594	159	359	500	286	291
3	104	345	416	420	483	128	581	158	361	498	286	291
4	104	374	422	414	483	129	572	158	359	498	296	289
5	104	400	422	413	483	130	565	153	359	497	296	289
6	104	395	421	413	490	130	561	153	357	848	296	289
7	104	391	407	413	491	337	124	153	361	841	296	289
8	105	306	407	449	491	596	124	153	223	838	296	289
9	104	108	406	481	491	595	124	152	139	838	296	283
10	104	108	406	486	264	592	126	152	139	839	296	283
11	104	108	407	496	108	588	578	195	139	839	290	283
12	104	108	406	496	108	545	572	356	139	836	288	281
13	104	111	406	496	168	610	561	470	139	833	288	281
14	104	111	409	496	167	603	554	531	139	831	288	281
15	104	111	409	501	167	597	554	529	139	813	288	281
16	106	111	407	502	166	591	554	529	141	811	288	279
17	106	111	407	502	167	583	553	529	530	810	288	279
18	106	111	399	491	168	576	558	528	529	807	298	279
19	106	111	399	491	168	567	556	523	527	806	298	279
20	106	113	397	491	115	559	549	523	525	804	298	277
21	106	113	414	491	115	123	674	523	522	803	298	277
22	106	152	431	483	115	123	778	523	520	800	298	277
23	107	191	430	483	116	123	731	689	527	815	298	272
24	107	191	430	483	116	124	727	685	525	589	296	272
25	107	254	427	498	116	125	119	455	525	587	304	272
26	107	315	427	498	117	126	120	510	506	596	304	272
27	107	367	427	498	120	126	120	306	506	595	304	272
28	116	418	428	498	120	127	120	304	504	593	304	272
29	154	416	428	485	120	127	159	354	504	410	304	272
30	186	......	426	485	120	127	159	354	504	228	302	267
31	217	......	426	......	120	......	159	354	......	284	......	267

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	267	253	245	649	70	700	900	1,400	1,080	445	385	230
2	267	253	245	649	65	680	900	1,400	1,046	425	380	291
3	267	251	244	655	65	675	900	1,350	1,046	420	380	290
4	267	248	244	655	70	681	910	1,350	1,040	415	362	290
5	267	248	244	653	70	680	950	1,315	1,040	410	360	295
6	271	248	244	675	65	680	1,000	1,315	1,020	450	355	300
7	271	248	244	673	75	670	1,220	1,300	1,000	470	355	305
8	271	247	244	670	80	675	1,220	1,300	779	470	345	465
9	271	247	244	668	70	680	1,220	1,300	775	465	340	470
10	271	245	241	666	65	673	1,250	1,250	770	460	340	470
11	271	245	241	662	60	670	1,250	1,152	770	450	329	470
12	271	245	241	658	50	660	1,250	1,300	760	440	325	460
13	263	245	241	667	50	660	1,250	1,402	750	430	320	450
14	261	245	241	660	50	606	1,405	1,400	725	345	315	430
15	261	245	241	654	50	600	1,400	1,200	612	340	310	410
16	261	245	241	646	60	600	1,400	1,100	612	340	310	400
17	261	241	238	640	70	700	1,400	1,050	600	345	310	390
18	261	241	462	634	85	700	1,400	1,350	578	340	299	380
19	261	241	458	350	660	700	1,400	1,227	600	330	295	370
20	257	241	579	94	700	700	1,400	1,227	575	320	290	360
21	257	241	576	61	738	720	1,375	1,227	570	388	285	350
22	257	241	572	63	740	720	1,375	1,350	564	375	280	352
23	257	241	650	65	740	720	1,375	1,248	564	370	275	350
24	257	245	646	66	735	790	1,375	1,248	564	365	270	340
25	257	245	643	67	740	790	1,400	1,200	560	365	239	330
26	257	245	638	67	700	790	1,520	1,200	550	365	133	320
27	253	245	634	67	675	800	1,500	1,180	540	365	245	310
28	253	245	632	68	675	800	1,500	1,175	530	396	240	300
29	253		631	68	670	800	1,492	1,150	520	390	235	324
30	253		657	68	665	908	1,450	1,140	450	390	230	320
31	253		652		739		1,400	1,100		390		316
1906.												
1	312	304	270	270	360	800	516	20	20	32	50	175
2	308	302	262	270	360	701	527	20	20	30	50	180
3	305	302	270	273	365	10	723	20	20	28	50	180
4	300	300	274	280	380	6	725	20	400	20	45	180
5	311	299	275	310	486	200	725	20	500	22	45	180
6	308	298	277	327	854	4	725	20	750	20	40	185
7	306	298	278	340	570	3	730	20	750	[1]600	40	185
8	304	298	280	350	700	0	725	20	750	[1]650	40	196
9	302	281	295	360	500	0	500	20	740	[1]650	40	198
10	300	280	295	420	597	0	760	20	740	[1]650	40	198
11	300	280	293	480	350	0	761	20	730	[1]650	40	200
12	307	280	293	560	530	0	500	20	730	[1]650	40	200
13	307	280	293	690	575	0	500	20	730	700	40	205
14	306	277	293	700	575	0	750	20	730	802	834	210
15	306	276	288	720	600	0	750	20	614	800	805	261
16	305	260	286	740	600	4	740	20	720	700	815	261
17	304	259	285	765	650	0	730	20	700	750	805	261
18	304	258	285	785	1,048	5	870	20	690	790	795	262
19	305	256	278	790	612	0	840	20	200	609	110	262
20	305	256	278	867	1,000	0	432	30	200	749	105	262
21	305	254	277	870	625	581	50	20	200	846	100	262
22	305	252	277	870	650	600	30	20	200	678	89	254
23	305	275	272	840	650	590	30	20	200	670	92	254
24	305	275	272	815	1,000	580	30	20	200	150	95	250
25	305	273	273	795	1,010	300	30	20	150	75	105	250
26	306	272	273	800	890	0	28	20	180	65	125	250
27	306	272	273	801	950	669	25	20	30	60	131	250
28	306	270	270	785	960	731	20	20	30	60	157	250
29	306		268	760	960	700	20	20	35	55	165	252
30	306		269	375	950	600	20	20	35	55	170	252
31	305		269		955		20	20		55		250
1907.												
1	252	365	585	1,011	30	321	40	25	20	490	613	316
2	255	378	604	1,012	30	327	35	25	20	490	613	315
3	256	376	556	1,012	30	333	35	35	20	489	612	312
4	256	372	541	1,012	30	339	35	35	20	490	603	310
5	249	372	656	1,055	30	50	35	35	20	489	607	308

[1] **Repairing gates, estimate probably too low.**

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
6	249	372	643	1,012	30	40	33	35	20	513	602	306
7	249	370	620	1,013	30	35	30	35	20	513	583	305
8	248	270	617	1,046	30	344	30	35	20	513	582	305
9	248	355	639	1,047	30	575	30	35	20	513	583	304
10	240	352	639	1,047	30	622	30	35	500	673	582	303
11	238	351	1,028	1,047	30	772	30	400	459	665	582	302
12	246	350	1,020	1,047	30	780	30	770	455	665	580	300
13	246	350	1,011	1,059	30	400	30	760	455	660	580	298
14	246	347	1,005	1,046	30	525	30	755	455	661	582	296
15	246	347	996	1,035	30	410	30	750	454	662	581	294
16	396	335	993	1,035	30	400	30	748	454	657	322	296
17	390	335	1,023	1,034	30	540	30	745	452	658	322	295
18	383	335	1,023	1,012	30	775	30	780	452	653	324	294
19	383	338	1,012	1,012	30	778	30	785	452	654	326	293
20	383	338	1,012	1,045	30	775	30	1,032	455	648	326	292
21	383	338	1,001	1,011	30	300	30	1,020	536	648	327	292
22	380	338	971	1,000	30	150	30	1,005	535	649	327	291
23	380	301	990	150	30	780	405	1,072	534	648	328	290
24	375	300	979	125	30	350	770	1,060	530	642	326	289
25	375	298	1,012	100	30	785	765	1,050	528	638	324	288
26	385	298	1,012	75	30	778	775	1,040	525	638	322	287
27	385	298	1,011	60	30	785	770	1,030	520	867	321	288
28	380	361	1,000	50	318	360	765	30	518	861	320	287
29	375	......	1,000	50	465	50	760	20	515	861	319	289
30	370	......	1,002	40	465	50	755	20	512	613	317	290
31	368	......	1,000	......	315	......	35	20	......	613	......	292
1908.												
1	291	263	314	290	119	136	123	130	580	800	330	142
2	290	265	312	143	120	137	727	130	575	455	332	143
3	289	270	310	145	121	137	124	129	570	450	333	143
4	288	276	308	130	121	138	125	128	20	448	335	144
5	287	282	306	132	122	138	125	126	520	446	337	144
6	287	300	304	135	122	139	124	124	525	444	338	144
7	285	310	309	138	121	137	124	122	535	440	339	144
8	283	324	309	125	121	134	123	120	540	436	338	144
9	281	324	308	128	120	129	123	120	546	432	337	143
10	280	325	308	130	120	126	122	120	700	429	336	143
11	281	326	307	123	121	124	121	120	699	427	335	143
12	279	326	306	124	122	122	121	120	698	426	332	143
13	278	325	305	126	123	120	122	120	705	424	331	143
14	277	326	306	128	123	120	122	120	720	421	329	144
15	276	327	306	130	124	120	927	120	750	418	327	144
16	275	325	305	131	125	121	127	122	770	415	325	143
17	274	324	305	132	125	121	126	122	835	413	323	143
18	275	323	304	115	124	120	126	825	830	415	321	144
19	274	322	303	116	125	120	128	820	832	417	319	144
20	272	321	302	117	126	121	130	818	826	600	317	145
21	270	320	302	118	126	121	132	815	820	610	142	146
22	269	319	303	120	127	122	785	808	815	618	142	146
23	268	318	304	122	128	122	780	970	812	622	141	147
24	266	317	305	124	129	121	775	960	810	627	141	148
25	267	316	300	127	130	121	773	950	806	625	140	149
26	266	315	298	126	131	120	770	940	804	620	140	149
27	265	314	295	125	132	121	768	960	805	615	141	149
28	264	313	300	124	133	121	765	583	806	610	141	149
29	263	344	299	123	134	122	129	585	805	336	141	149
30	262	......	298	121	135	122	128	588	803	332	142	149
31	263	......	295	......	136	......	127	585	......	328	......	149
1909.												
1	149	147	245	406	210	219	120	72	76	528	131	134
2	148	148	247	404	212	220	118	73	75	527	131	134
3	150	147	248	402	214	221	115	74	74	526	130	135
4	152	147	249	405	215	222	115	75	73	524	130	134
5	154	148	250	409	216	223	114	76	75	522	131	136
6	156	148	316	412	217	223	114	77	77	520	130	138
7	158	148	315	415	218	224	115	78	80	518	131	190
8	210	149	314	418	219	225	114	78	475	516	132	192
9	214	149	313	421	221	224	113	79	480	511	133	194
10	214	150	312	424	224	224	113	79	485	516	134	196

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
11	213	150	311	424	226	225	115	80	490	518	134	198
12	213	151	310	423	228	225	118	80	495	520	135	198
13	212	152	308	423	230	226	120	81	500	522	136	198
14	212	154	310	424	232	665	124	82	510	524	135	199
15	211	156	312	423	233	700	126	82	115	526	135	199
16	210	158	314	422	230	725	128	82	110	540	134	199
17	209	160	316	422	224	960	532	83	514	538	133	200
18	208	248	422	423	221	855	530	83	513	536	132	200
19	148	249	424	424	218	815	528	83	520	130	131	200
20	147	250	426	425	215	731	526	83	541	127	132	201
21	146	249	424	425	212	705	524	83	540	125	132	201
22	145	248	422	426	210	700	360	84	539	123	133	201
23	144	247	420	426	211	690	75	84	538	121	133	202
24	144	246	418	427	212	500	72	85	537	123	134	202
25	144	245	416	428	213	230	72	85	536	125	133	202
26	145	244	415	429	214	228	73	86	535	126	134	203
27	145	243	413	202	215	225	74	87	534	127	134	204
28	146	243	412	204	216	223	73	88	533	128	134	206
29	146		410	206	217	224	73	88	532	130	135	208
30	147		409	208	218	225	73	89	530	131	135	210
31	147		408		219		73	88		131		212
1910.												
1	212	500	675	675	642	640	123	275	65	470	71	68
2	213	505	672	679	644	646	120	180	10	473	71	69
3	214	510	668	678	646	651	121	69	10	474	72	70
4	214	515	665	676	648	658	123	68	10	475	72	70
5	215	519	662	675	650	657	125	67	10	474	73	70
6	215	519	656	673	652	656	127	66	10	475	73	70
7	216	519	652	671	654	654	129	66	10	440	73	70
8	216	515	648	669	655	653	130	66	10	400	73	70
9	216	515	642	667	656	651	133	67	10	395	73	70
10	217	560	635	665	657	650	133	67	10	360	73	70
11	217	615	630	663	658	649	134	67	10	310	73	70
12	218	655	622	662	659	650	134	68	10	290	73	71
13	218	656	625	660	660	651	135	68	62	71	73	71
14	219	657	628	658	661	655	135	68	62	70	72	71
15	219	658	630	656	658	658	136	67	62	69	72	72
16	222	660	632	654	656	662	136	67	62	69	72	72
17	225	662	636	652	652	665	132	67	67	70	71	72
18	230	664	640	650	650	670	128	66	67	70	71	73
19	235	666	643	646	645	660	125	66	67	70	71	73
20	400	668	647	643	640	640	122	66	67	71	70	74
21	415	672	655	640	637	600	120	66	68	71	69	75
22	419	674	660	635	637	575	117	66	68	71	69	75
23	430	676	675	632	637	525	115	66	68	71	68	76
24	450	678	682	633	637	450	118	67	68	71	68	77
25	460	680	688	634	636	426	120	67	69	71	67	77
26	470	681	693	634	637	420	125	67	70	71	67	78
27	480	680	690	635	636	430	300	67	160	71	67	77
28	490	678	685	636	636	426	287	67	590	71	68	78
29	493		680	638	635	125	285	66	688	71	68	77
30	495		675	640	636	125	283	66	630	71	67	78
31	498		670		637		283	66		71		78
1911.												
1	78	91	102	117	131	225	486	55	219	68	53	55
2	79	92	103	117	132	230	475	60	215	50	53	54
3	79	92	101	118	132	233	465	62	214	10	53	54
4	80	93	104	118	133	220	455	64	212	10	53	54
5	80	93	104	119	133	218	440	65	210	10	53	54
6	79	94	104	119	134	216	425	63	80	50	53	53
7	80	94	104	120	134	214	405	62	78	51	25	53
8	80	95	104	121	135	212	403	60	75	51	53	53
9	81	95	104	121	136	210	390	58	73	50	53	53
10	81	96	104	122	414	209	370	56	73	50	53	53
11	82	97	104	123	416	212	350	54	72	49	53	54
12	82	97	105	123	418	215	325	52	72	48	53	54
13	83	98	105	124	421	218	300	54	71	10	53	54
14	83	98	106	124	420	220	300	56	71	47	53	55
15	83	99	108	125	418	523	290	58	70	47	53	55

Daily discharge, in second-feet, of Pine River below Pine River reservoir—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
16	84	99	108	125	417	525	280	60	70	47	52	55
17	84	100	109	126	415	528	275	210	70	47	52	55
18	85	100	110	126	415	528	265	212	69	47	52	56
19	85	100	110	127	414	527	260	214	69	47	53	56
20	86	101	111	127	412	527	240	218	69	47	54	56
21	86	101	111	128	420	526	225	222	68	47	55	57
22	87	102	113	128	475	526	173	226	68	48	54	57
23	87	102	113	129	500	525	170	228	68	48	55	57
24	88	102	114	129	510	525	165	230	67	49	56	57
25	89	102	114	130	520	520	165	231	67	49	57	58
26	89	103	114	130	525	515	164	232	66	50	57	58
27	90	103	115	131	520	510	164	230	66	51	56	58
28	90	103	115	130	515	505	163	228	65	53	56	59
29	90	......	116	131	510	495	163	226	50	53	55	59
30	91	......	116	131	500	486	50	224	50	52	56	59
31	91	......	115	......	400	......	50	222	......	53	......	59
1912.												
1	59	65	70	66	320	59	507	490	295	145	59	......
2	59	65	69	66	322	59	508	485	290	144	59	......
3	60	65	69	67	324	60	509	479	285	144	59	......
4	59	65	69	67	327	60	510	480	275	143	59	......
5	60	66	70	67	325	61	511	485	265	143	59	......
6	60	66	70	67	320	61	512	488	255	142	61	......
7	60	66	70	67	80	62	510	490	249	141	61	......
8	60	67	71	67	75	63	508	492	249	141	61	......
9	60	67	71	68	72	62	506	495	249	140	48	......
10	60	68	66	68	70	62	504	502	250	140	49	......
11	60	68	65	68	68	61	502	495	250	139	49	......
12	60	68	65	69	68	60	500	490	250	138	50	......
13	60	68	64	69	68	59	498	485	251	135	50	......
14	61	68	64	69	69	59	495	480	251	130	50	......
15	61	68	63	70	69	58	490	478	248	57	51	......
16	61	69	63	524	69	58	488	475	245	58	51	......
17	61	69	63	485	70	59	484	471	241	59	51	......
18	62	69	64	488	70	59	480	410	237	60	51	......
19	62	69	64	384	70	60	475	400	235	59	52	......
20	62	70	64	175	71	60	473	380	234	59	52	......
21	63	70	65	317	71	61	468	375	234	30	52	......
22	63	70	65	317	71	61	460	370	205	21	52	......
23	63	71	65	317	72	63	458	365	195	12	52	......
24	64	71	65	317	72	65	456	362	180	15	53	......
25	64	71	65	318	72	515	454	355	170	16	53	......
26	64	71	65	318	72	512	450	350	160	17	53	......
27	65	71	65	318	73	510	447	340	156	78	54	......
28	65	72	66	318	73	508	445	330	154	80	54	......
29	65	72	66	319	73	506	442	320	150	81	54	......
30	66		66	319	74	506	440	310	145	81	54	......
31	66		66		74		438	300		82	......	......

Monthly discharge of Pine River below Pine River Reservoir.

[Drainage area, 452 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Millions of cubic feet.
1895.						
January	3	3	3.0	0.0066	0.008	8.03
February	5	3	3.9	.0086	.009	9.43
March	67	4	7.0	.015	.02	18.7
April	625	5	178	.394	.44	462
May	577	9	357	.789	.91	956
June	536	9	167	.369	.41	433
July	477	7	108	.239	.28	289
August	837	7	548	1.21	1.38	1,468
September	426	223	339	.749	.84	878
October	229	99	154	.341	.39	112
November	144	2	83	.184	.21	215
December	3	2	2.2	.0048	.006	5.89
The year	837	2	162	.359	4.90	5,160
1896.						
January	57	2	4.6	.010	.01	12.3
February	119	102	110.	.243	.26	276
March	119	65	97.9	.216	.25	262
April	68	4	41.2	.091	.10	107
May	21	5	10.3	.023	.03	27.6
June (1-17)	33	20	29.4	.065	.41	43.2
July (11-31)	877	14	558	1.23	.96	1,012
August	704	220	420	.930	1.07	1,125
September	207	137	182	.403	.45	472
October	183	127	156	.345	.40	418
November	250	187	224	.496	.55	581
December	198	168	183	.405	.47	490
The period						4,830
1897.						
January	447	170	245	.542	.62	656
February	238	200	219	.485	.50	530
March	290	197	229	.507	.58	613
April	1,206	303	849	1.88	2.10	2,200
May	844	5	469	1.04	1.20	1,260
June	755	191	511	1.13	1.26	1,320
July	784	5	94.1	.208	.24	252
August	9	9	9.0	.020	.02	24.1
September	767	9	103	.228	.03	267
October	11	9	9.5	.021	.02	25.4
November	14	11	13.2	.029	.03	34.2
December	13	10	10.7	.024	.03	28.6
The year	1,206	5	230	.509	6.63	7,210
1898.						
January	14	13	13.5	.030	.03	36.2
February	18	14	16.4	.036	.04	39.7
March	19	18	18.6	.041	.05	49.8
April	19	19	19.0	.042	.05	49.2
May	19	19	19.0	.042	.05	50.9
June	1,479	19	341	.754	.84	884
July	1,379	27	561	1.24	1.43	1,500
August	1,085	134	668	1.48	1.71	1,790
September	930	699	787	1.74	1.94	2,040
October	793	406	601	1.33	1.53	1,610
November	415	3	207	.458	.51	537
December	6	3	4.4	.097	.11	11.8
The year	1,479	3	271	.600	8.29	8,600

Monthly discharge of Pine River below Pine River reservoir—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Millions of cubic feet.
1899.						
January	9	6	7.9	0.017	0.02	21.2
February	13	9	11.4	.025	.03	27.6
March	16	13	15.0	.033	.04	40.2
April	19	16	17.5	.039	.04	45.4
May	19	19	19.0	.042	.05	50.9
June	425	19	43.9	.097	.11	114
July	646	30	402	.889	1.02	1,080
August	918	30	439	.972	1.12	1,180
September	614	38	239	.529	.59	619
October	1,171	55	480	1.06	1.22	1,290
November	668	48	210	.465	.52	544
December	208	48	114	.252	.29	305
The year	1,171	6	167	.369	5.05	5,320
1900.						
January	156	52	70.5	.156	.18	189
February	52	41	48.4	.107	.11	117
March	41	41	41.0	.091	.10	110
April	414	41	140	.310	.35	363
May	769	39	406	.898	1.04	1,090
June	1,011	52	368	.814	.91	954
July	943	52	748	1.66	1.91	2,000
August	778	422	573	1.27	1.46	1,530
September	1,109	420	661	1.46	1.63	1,710
October	601	55	325	.719	.83	870
November	406	52	201	.445	.50	521
December	52	52	52	.115	.13	139
The year	1,109	39	303	.670	9.15	9,590
1901.						
January	56	52	52.4	.116	.13	140
February	56	56	56	.124	.13	135
March	56	56	56	.124	.14	150
April	56	53	55.2	.122	.14	142
May	657	53	161	.356	.41	431
June	1,586	65	651	1.44	1.61	1,690
July	1,280	73	807	1.79	2.06	2,160
August	873	53	404	.894	1.03	1,080
September	871	397	667	1.48	1.65	1,730
October	938	476	784	1.74	2.00	2,100
November	452	112	314	.695	.78	814
December	241	184	212	.469	.54	568
The year	1,586	52	352	.779	10.62	11,100
1902.						
January	189	175	182	.403	.46	487
February	183	178	180	.398	.41	435
March	195	20	132	.292	.34	353
April	43	36	37.8	.084	.09	98
May	148	36	59	.131	.15	158
June	768	57	32.4	.072	.08	84
July	657	61	263	.582	.67	704
August	568	273	423	.938	1.08	1,130
September	334	318	325	.719	.80	842
October	331	306	315	.697	.80	844
November	306	295	302	.668	.74	783
December	308	291	297	.657	.76	795
The year	768	20	212	.470	6.38	6,710

Monthly discharge of Pine River below Pine River reservoir—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Millions of cubic feet.
1903.						
January	298	224	273	0.604	0.70	731
February	239	211	225	.498	.52	544
March	245	211	230	.509	.59	616
April	49	21	40.8	.090	.10	106
May	556	39	178	.394	.45	477
June	607	41	309	.684	.76	801
July	713	36	338	.748	.86	905
August	643	35	135	.299	.34	362
September	99	88	92	.204	.23	238
October	516	103	135	.299	.34	362
November	110	105	109	.241	.27	283
December	110	106	107	.237	.27	287
The year	713	21	181	.399	5.43	5,710
1904.						
January	217	104	113	.250	.29	303
February	418	108	225	.498	.54	564
March	431	397	415	.918	1.06	1,110
April	502	413	473	1.05	1.17	1,230
May	491	108	240	.531	.61	643
June	610	121	332	.735	.82	861
July	778	119	418	.925	1.07	1,120
August	689	152	365	.808	.93	977
September	530	139	370	.819	.91	959
October	848	228	684	1.52	1.75	1,830
November	304	284	295	.653	.73	765
December	302	267	280	.620	.72	750
The year	848	104	351	.777	10.60	11,100
1905.						
January	271	253	262	.580	.67	702
February	253	241	245	.542	.56	593
March	657	238	405	.896	1.03	1,080
April	675	61	431	.954	1.06	1,120
May	740	50	334	.739	.85	894
June	908	600	707	1.56	1.74	1,830
July	1,520	900	1,280	2.83	3.26	3,430
August	1,402	1,050	1,260	2.79	3.22	3,370
September	1,080	450	720	1.59	1.77	1,870
October	470	320	396	.876	1.01	1,060
November	385	133	304	.673	.75	788
December	470	230	359	.794	.92	961
The year	1,520	50	558	1.24	16.84	17,700
1906.						
January	312	300	305	.675	.78	817
February	304	252	278	.615	.64	672
March	295	262	279	.617	.71	747
April	870	270	600	1.33	1.48	1,560
May	1,010	350	687	1.52	1.75	1,840
June	800	0	236	.522	.58	612
July	870	20	446	.987	1.14	1,190
August	30	20	20.3	.045	.05	54.1
September	750	20	400	.885	.99	1,040
October	846	20	409	.905	1.04	1,100
November	834	40	202	.447	.50	524
December	262	175	226	.500	.58	605
The year	1,010	0	241	.754	10.24	10,800

Monthly discharge of Pine River below Pine River reservoir—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Millions of cubic feet.
1907.						
January	396	238	317	0.701	0.81	849
February	378	298	344	.761	.79	832
March	1,028	585	877	1.94	2.24	2,350
April	1,059	40	777	1.72	1.92	2,010
May	465	30	76.6	.170	.20	205
June	798	35	451	1.00	1.12	1,170
July	775	30	209	.462	.53	560
August	1,072	20	491	1.09	1.26	1,310
September	536	20	349	.772	.86	905
October	867	489	627	1.39	1.60	1,680
November	613	371	458	1.01	1.13	1,190
December	316	287	298	.659	.76	798
The year	1,072	20	440	.973	13.22	13,900
1908.						
January	291	262	276	.611	.70	739
February	327	263	312	.690	.74	782
March	314	295	304	.673	.78	814
April	290	115	132	.292	.33	342
May	136	119	125	.277	.32	335
June	139	120	126	.279	.31	327
July	927	121	317	.701	.81	849
August	970	120	429	.949	1.09	1,150
September	835	20	695	1.54	1.72	1,800
October	800	328	487	1.08	1.24	1,300
November	339	140	268	.593	.66	695
December	149	142	145	.321	.37	388
The year	970	20	301	.667	9.07	9,520
1909.						
January	214	144	171	.378	.44	458
February	250	147	190	.420	.44	460
March	426*	245	349	.772	.89	935
April	429	202	391	.865	.97	1,010
May	233	210	219	.484	.56	586
June	960	219	410	.907	1.01	1,060
July	532	72	179	.396	.46	479
August	89	72	81.5	.180	.21	218
September	541	73	388	.859	.96	1,010
October	540	121	358	.792	.91	959
November	136	130	133	.294	.33	345
December	212	134	188	.416	.48	503
The year	960	72	255	.564	7.66	8,020
1910.						
January	498	212	311	.688	.79	833
February	681	500	613	1.36	1.42	1,480
March	693	622	657	1.45	1.67	1,760
April	679	632	654	1.45	1.62	1,700
May	661	635	647	1.43	1.65	1,730
June	670	125	573	1.27	1.42	1,490
July	300	115	153	.338	.39	410
August	275	66	77.2	.171	.20	207
September	688	10	106	.235	.26	275
October	475	69	206	.456	.53	552
November	73	67	70.7	.156	.17	183
December	78	68	73	.162	.19	195
The year	693	10	345	.764	10.31	10,800

Monthly discharge of Pine River below Pine River reservoir—Continued.

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum	Mean.	Per square mile.	Depth in inches on drainage area.	Millions of cubic feet.
1911.						
January	91	78	84.3	0.187	0.22	226
February	103	91	97.9	.217	.23	237
March	116	102	109	.241	.28	292
April	131	117	125	.277	.31	324
May	525	131	360	.796	.92	964
June	528	209	378	.836	.93	980
July	486	50	286	.633	.73	766
August	232	52	138	.305	.35	370
September	219	50	92.9	.206	.23	241
October	68	10	44.8	.099	.11	120
November	57	25	52.9	.117	.13	137
December	59	53	55.6	.123	.14	149
The year	528	10	152	.336	4.58	4,800
1912.						
January	66	59	61.8	.137	.16	166
February	72	65	68.4	.151	.16	171
March	71	63	66.2	.146	.17	177
April	524	66	208	.460	.51	539
May	327	68	120	.265	.31	321
June	515	58	150	.332	.37	389
July	512	438	482	1.07	1.23	1,290
August	502	300	427	.945	1.09	1,140
September	295	145	228	.504	.56	591
October	145	12	91.3	.202	.23	245
November	61	48	53.8	.119	.13	139

NOTE.—Above table computed by engineers of the United States Geological Survey from records of daily discharge furnished by the United States Engineer Corps.

DEVELOPED WATER POWER.

Water power is developed at seven power dams on the river, the total installed horsepower being 77,100. The developments are described in the following paragraphs:

Five miles below Lake Bemidji, in Section 3, T. 146 N., R. 32 W. —The Beltrami Electric Light and Power Co. has constructed a reinforced concrete dam which creates a head of 22 feet. This dam keeps the water at high stage in Lake Bemidji, which can be drawn down 2 feet and thus affords considerable storage. At one end of the dam is the power house which contains five turbines set in open forebay. These wheels comprise four 33-inch S. Morgan Smith turbines of 264 horsepower capacity each, and one 18-inch turbine of the same make, having a capacity of 78 horsepower. This latter turbine is used to run the exciter generator. The four 33-inch turbines are on a horizontal shaft direct connected to a 500 kilowatt General Electric 3-phase, 60-cycle alternating current generator of 2,300 volts. Two Woodward automatic governors operate the turbines. The power at the plant is leased to the Warfield Electric Light Co. and used in Bemidji. The transmission line is 9 miles long and its voltage is 16,500.

The plant is operated 23 hours per day, being closed one hour at noon. An auxiliary steam plant of 600 horsepower is used in emergencies. The average power developed at this plant is 300.

Grand Rapids.—The Itasca Paper Co. has a power plant at Grand Rapids a short distance below the Pokegama dam of the United States Government. By means of a dam at the head of Pokegama Rapids an average head of 17½ feet is available. There are eight 30-inch Leffel wheels, six 36-inch and twenty 27½-inch New American wheels, giving a total of 34 wheels used in running the grinders and other machinery in the mill. In addition there is a 25-inch New American wheel which is used in lighting the plant. Although the installed power of the 34 wheels is about 4,000 horsepower, not more than 1,200 average horsepower can be developed, owing largely to the proximity of the plant to the Pokegama dam. There is very little pondage between the dam and the plant and as the flow is regulated primarily in the interest of navigation, the winter flow is largely cut down. It is stated that 350 steam horsepower are used throughout the year. The plants further down the river are not handicapped to such an extent, as the natural storage of the river channel helps to equalize the flow.

One and one-half miles above Brainerd.—Near Brainerd the Northwest Paper Co. has a 15-foot timber crib dam of the A type, which has a sluiceway for logs. At the right end of the dam and supplied with water by means of a flume are seven 35-inch New American turbines of 115 horsepower capacity each, arranged on three horizontal shafts. There are two pairs of turbines on one shaft, one pair on the second, and a single wheel on the third shaft. Each shaft is direct connected to grinders used in the pulp mill. Governors are not needed as the wheels are controlled by the grinders. The plant operates 24 hours per day of six days per week and develops an average of 800 horsepower. The Brainerd Electric Light plant was formerly located at the other end of the dam. The company leased water from the Northwest Paper Company, but the plant was destroyed in 1910 and has not been rebuilt.

Little Falls.—The Little Falls Water Power Co. has a power site in Little Falls which gives an average head of 21 feet. It is stated that the dam can be raised, increasing the head to 25 feet when needed. The power company sells both power and water. In its power plant are one 48-inch and one 36-inch New American wheels and nine 36-inch S. Morgan Smith wheels. The 36-inch New American wheel is used to operate a pump; the rest of the wheels are connected to Westinghouse generators, which furnish light and power for the city. The installed horsepower is about 2,570; the average amount used is 1,550.

In addition to the above plant a first water right is sold to the Northwestern Milling Co., which operates a 50-inch Risdon-Alcott wheel in developing an average of 150 horsepower used in running the mill. A second water right is sold to the Hennepin Paper Company, whose plant, located about 900 feet below the intake, is supplied with water by means of an earth canal about 80 feet wide and 850 feet long. The equipment consists of one 54-inch and eight 30-inch Trump, one 45-inch New American and one 39-inch, one 30-inch and one 26-inch Hunt Standard wheels, all of which are used in running the pulp mill.

Sartell.—The Watab Pulp and Paper Co. has recently built a pulp mill at Sartell, which utilizes an average head of 15 feet. Although flashboards are used on the dam, little storage is available, as the head is kept at a nearly constant stage. This necessitates closing down some of the wheels at times to avoid drawing down the head. The power house is situated at one end of the dam and contains three 23-inch and forty-eight 32½-inch Samson wheels. Of the 32½-inch wheels, 36 are direct connected in pairs (two pairs to a shaft) to 9 grinders in the mill, and the remaining 12 wheels are direct connected to two 500 K W generators, which furnish light and power in the mill. The three 23-inch wheels are connected to a horizontal shaft which runs an exciter generator. All the wheels are set in an open concrete forebay and discharge downward into a large discharge pit under the wheel house.

It is stated that the water supply is sufficient to run all the wheels under full head only a small portion of the year, as during high stages the backwater reduces the head, and in ordinary and low stages the supply is insufficient. The installed horsepower is 6,900 while the average power developed is about 5,000 horsepower.

St. Cloud.—The Public Service Co. has a timber crib dam at St. Cloud giving an available head of 14½ feet. Near the right end of the dam are located the two power houses containing the turbines which generate power and light used in St. Cloud. The water reaches the turbines through a flume. In the power houses are located one 50-inch Samson-Leffel turbine of 280 horsepower capacity, one 66-inch Trump turbine of 545 horsepower capacity, two 36-inch Morgan Smith turbines of 165 horsepower each and five 39-inch S. Morgan Smith turbines of 195 horsepower capacity each. These turbines are controlled by Lombard automatic governors. The electrical equipment consists of one 300 K W Allis-Chalmers alternating current, 3-phase generator of 2,300 volts; one 300 K W General Electric generator of same type and capacity; one 300 K W Triumph direct current generator; one 100 K W Triumph direct current generator, and one 90 K W General Electric direct current generator. This plant operates 24 hours per day, though with a varying number of turbines. Water is also supplied by means of a second flume to the mill of Geo. Tileson & Co. located a short distance below the dam. This mill contains a 56-inch Samson-Leffel turbine of 350 horsepower capacity used in running the mill. There is an auxiliary steam plant for emergency use.

St. Anthony Falls at Minneapolis.—The natural fall at Minneapolis called St. Anthony Falls is utilized by two dams. The upper one is owned jointly by the St. Anthony Falls Water Power Co. and the Minneapolis Mill Co., the former located on the east side of the river and the latter on the west side. These companies both supply water to many industries located in the immediate vicinity of the dam, among which are included flouring mills, feed and cereal mills, woolen mills, etc.

In addition to the consumers of water power, the St. Anthony Falls Water Power Co. supplies water to the Minneapolis General Electric Co. and also to a large hydro-electric plant owned by the water power company itself. Exclusive of this plant there are installed in the various mills about forty turbine units which are operated under heads varying from thirty-five to fifty feet, aggregating about 35,000 horsepower installed. The hydro-electric plant is designed to use the surplus water at the upper dam and the power is taken by the Twin City Rapid Transit Company. Practically all of the lessees of both companies have auxiliary steam plants, not only because of the scarcity of water during certain seasons of the year, but also because some of the wheels have not sufficient power capacity to supply the requirements of the mills.

The lower dam is owned by the St. Anthony Falls Water Power Co., where a gross head of 20 feet is obtained.

The total installed power at Minneapolis is as follows:

	Horsepower.
By the Mills	35,000
By the St. Anthony Falls W. P. Co.	
Upper dam and power house	12,000
Lower dam and power house	10,000
Total	57,000

The average developed power is about 48,000 horsepower.

AVAILABLE HORSEPOWER.

The following table shows the available horsepower (80 per cent efficiency) at each power site, based on the records of flow given herewith:

Available horsepower at developed power sites.

Developed Site.	Head in feet	Minimum Run-off.			Horsepower (80 per cent Efficiency.)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
5 miles below Lake Bemidji	22	a					
Grand Rapids	17.5	107	185	822	170	294	1,308
1.5 miles above Brainerd	15	600	1,500	3,000	818	2,050	4,090
Little Falls	21	840	1,810	3,620	1,600	3,450	6,910
Sartell	15	850	1,850	3,730	1,160	2,520	5,090
St. Cloud	14.5	860	1,860	3,750	1,130	2,450	4,940
St. Anthony Falls:							
Upper dam	50	1,000	2,050	4,300	4,550	9,320	19,500
Lower dam	20	1,000	2,050	4,300	1,820	3,730	7,820

[a] Data lacking for estimate.

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

The Mississippi River between the mouth of Crow Wing River and St. Anthony Falls has more undeveloped power than any other river in Minnesota. The country through which it flows is the most thickly settled portion of the State, affording the best markets for power.

The Mississippi River Commission has made a survey of the entire portion of the river lying in or adjacent to Minnesota. The results of that survey are published in a series of charts which may be obtained from the secretary of the Commission in St. Louis, Mo. A profile of the river is published in Plates IV. and V. of this report. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Mississippi River from Lake Itasca to Minnesota State Line.

Stations.	Distance		Elevation above sea level	Descent between Points	
	From Lake Itasca	Point to point		Total feet	Feet per mile.
Lake Itasca	0	......	1,472	......	......
Upper end Lake Bemidji	32	32	1,340	132	4.1
Bemidji dam: crest	42	10	1,340	0	0.0
foot	42	0	1,319	21	......
Upper end of Cass Lake	48	6	1,305	14	2.3
Winnibigoshish dam: crest	85	37	1,304	1	0.0
foot	85	0	1,296	8	......
Leech Lake River	117	32	1,285	11	0.3
Ball Club River	120	3	1,282	3	1.0
Vermilion River	142	22	1,278	4	0.2
Pokegama dam: crest	158	16	1,277	1	0.1
foot	158	0	1,270	7	......
Grand Rapids dam: crest	161	3	1,268	2	0.7
foot	161	0	1,251	17	......
Prairie River	164	3	1,246	5	1.7
Swan River	203	39	1,229	17	0.4
Dinky Rapids	215	12	1,225	4	0.3
Oxbow Rapids	226	11	1,217	8	0.7
Sandy River	231	8	1,212	5	0.6
Willow River	262	28	1,203	9	0.3
Aitkin	282	20	1,194	9	0.4
Indian Lake Outlet	309	27	1,189	5	0.2
Pine River	313	4	1,180	9	2.5
Upper end pond of Brainerd dam	321	8	1,172	8	1.0
Brainerd dam: crest	334	13	1,172	0	0.0
foot	334	0	1,157	15	......
Buffalo Creek	340	6	1,152	5	0.9
Crow Wing River	347	7	1,149	3	0.4
Pipe Island	358	11	1,138	11	1.0
Upper end pond of Little Falls dam	369	11	1,102	36	3.3
Little Falls dam: crest	372	3	1,102	0	0.0
foot	372	0	1,083	19	......
Pike Creek	374	2	1,078	5	2.5
Two Rivers	383	9	1,032	46	5.1
Upper end pond of Sartell dam	396	13	1,014	18	1.4
Sartell dam: crest	404	8	1,014	0	0.0
foot	404	0	998	16	......
Upper end pond of St. Cloud dam	408	4	978	20	5.0
St. Cloud dam: crest	410	2	978	0	0.0
foot	410	0	964	14	......
Clearwater River	422	12	936	28	2.3
Silver Creek	430	8	929	7	0.9
Monticello	439	9	897	32	3.6
Elk River	450	11	859	38	3.5
Crow River	456	6	843	16	2.7
Rum River	464	8	827	16	2.0
Coon Creek	471	7	815	12	1.7
Upper end pond St. Anthony Falls	478	7	796	19	2.7
Upper dam St. Anthony Falls: crest	482	4	796	0	0.0
foot	482	0	728	68	......
Upper end pond U. S. lock and dam 2	483	1	718	10	10.0
U. S. lock and dam 2: crest	485	2	718	0	0.0
foot	485	0	703	15	......
Minnesota River	490	5	692	11	2.2
St. Paul	496	6	689	3	0.5
Lake St. Croix	522	26	673	16	0.6
Red Wing	542	20	668	5	0.2
Frontenac	553	11	667	1	0.1
Chippewa River	570	17	664	3	0.2
Wabasha	574	4	663	1	0.2
Whitewater River	590	16	652	11	0.7
Winona	608	18	643	9	0.5
Root River	638	30	628	15	0.5
State Line	658	20	615	13	0.6

The foregoing table and the topography as shown on the Mississippi River charts indicate the following dam sites, all of which are between the Crow Wing and Minnesota rivers. Above the former the river has a gentle slope, except where power has already been developed, and the water supply is small, especially near the source. Between the Minnesota River and the Iowa State Line the fall is too slight for feasible development.

At the head of Topeka Island, 9 miles above Little Falls.—A 20-foot dam, 1,500 feet long at the crest, would form a pond about 6 miles long and overflow 300 acres of land. Between the dam site at this point and the pond formed by the Little Falls dam, the river falls about 16 feet in 7 miles.

Just above Blanchards Rapids 2 miles above Two Rivers.—A 40-foot dam with a crest length of 2,000 feet and a base length of 600 feet would form a pond 8 miles long, which would extend within 2 miles of the dam at Little Falls and overflow 250 acres of land. Between this dam site and the pond formed by the Sartell dam the fall is about 20 feet.

At the foot of Sauk Rapids, 3 miles above St. Cloud.—A 15-foot dam with a crest length of 900 feet would form a pond 3 miles long, extending to Watab River and overflowing 50 acres of land. There is very little fall between this dam site and the crest of the St. Cloud dam.

At a point 2 miles below Johnson Creek.—A 20-foot dam with a crest length of 800 feet would back the water upstream 6 miles, or nearly to the St. Cloud dam, and would overflow 550 acres of land.

Just below Thompson Island and 2 miles above Monticello.—A 28-foot dam with a crest length of 800 feet would back the water 20 miles upstream, nearly to the dam site below Johnson Creek. It would overflow 900 acres of land.

At the foot of Spring Rapids, 3 miles above Otsego.—A 30-foot dam with a crest length of 800 feet would back the water 9 miles upstream to the dam site below Thompson Island. It would overflow 200 acres of land.

At the foot of Haley's Rapids, 1 mile above Crow River.—A 15-foot dam would form a pond 5 miles long extending to a point 1½ miles above Elk River, and overflowing 400 acres of land. Between this dam site and Rum River, a distance of 9 miles, there is a fall of 16 feet.

Just above Rice Creek, 8 miles above St. Anthony Falls.—A 22-foot dam with a crest length of 800 feet would form a pond nearly 10 miles long, extending to the mouth of Rum River or above.

It would overflow 550 acres of land. Between this dam site and the pond above St. Anthony Falls there is a fall of about 12 feet.

At Fort Snelling, just above Minnesota River.—The Federal Government is building a 30-foot dam at Fort Snelling, chiefly for the purpose of making the Mississippi navigable between Minneapolis and St. Paul. It will back the water upstream nearly to the foot of the lower dam at St. Anthony Falls. As the river flows through a deep gorge, very little land will be overflowed. When this dam is completed it will completely submerge the existing lock and dam No. 2 about 5 miles upstream.

AVAILABLE HORSEPOWER.

The following table shows the available horsepower at the sites just described, as determined from the records of flow presented herewith:

Available undeveloped horsepower.

Site	Head in feet	Minimum Run-off.			Horsepower (80 per cent Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Topeka Island	20	830	1,800	3,600	1,510	3,270	6,540
Blanchards Rapids	40	830	1,800	3,600	3,020	6,540	13,080
Sauk Rapids	15	860	1,860	3,750	1,170	2,540	5,110
Johnson Creek	20	860	1,870	3,750	1,560	3,100	6,820
Thompson Island	28	870	1,890	3,850	2,210	4,810	9,800
Spring Rapids	30	870	1,890	3,850	2,370	5,150	10,500
Haleys Rapids	15	910	1,950	4,100	1,240	2,660	5,600
Rice Creek	22	1,000	2,050	4,300	2,000	4,100	8,600
Fort Snelling	30	1,000	2,060	4,370	2,730	5,620	11,900

SANITARY STATISTICS.

To show the sanitary quality of the water in the Mississippi River and the extent this water is used for municipal supplies, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on the Mississippi or its tributaries. These data have been tabulated in order of location, beginning near the source of the river. The data for towns on the tributaries will be found under the descriptions of those tributaries, as only the location of the mouth of such streams is given here. Data showing the population per square mile exclusive of the towns listed, for various portions of the drainage basin, have also been compiled.

Municipal water supply and sewage disposal of towns on the Mississippi River.

Town	Distance below Lake Itasca	Population 1910	Water Works System			Sewerage System		Rural population per sq. mile above
			Source of supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
Bemidji	32	5,099	deep wells	no	200,000	river	Septic tank	
Cass Lake	80	2,011	shallow wells	no	100,000	tributary	no	
Grand Rapids	161	2,239	Hale Lake	no	160,000	river	no	3.3
Mouth Swan River	203							
Aitkin	282	1,112	deep wells	no	110,000	river	no	
Brainerd	336	8,526	river	calcium hypochlorite	1,267,000	river	no	
Mouth Crow Wing	347							4.8
Little Falls	372	6,078	river	no	550,000	river	no	
Mouth Sauk River	406							
Sauk Rapids	407	1,700	deep well	no	35,000	none		
St. Cloud	410	10,600	river	no	900,000	river	no	
Monticello	439	858	deep well	no	13,000	river	no	
Elk River	450	787	no system			none		
Mouth Crow River	456							11.4
Mouth Rum River	464							
Minneapolis	482	301,408	river	yes	22,000,000	river	no	
Fort Snelling	490	800	artesian well	no	170,000	river	no	
Mouth Minnesota	490							
St. Paul	496	214,744	lakes and artesian wells	no	13 500,000	river	no	
South St. Paul	500	4,510	artesian well	no	2,250,000	river	no	
St. Paul Park	503	832	no system			none		
Hastings	521	3,983	well	no	40,000	river	no	
Mouth St. Croix River	522							15.0
Mouth Cannon River	539							
Red Wing	542	9,048	deep well	no	500,000	river	no	
Lake City	558	3,000	shallow well	no	175,000	river	no	
Mouth Chippewa River	569							
Wabasha	574	2,622	no system			none		
Alma	581		deep well	no		none		
Mouth Zumbro River	583							
Winona	608	18,583	wells	no	1,375,000	river	no	
La Crosse	633	30,417	river	no	2,729,000	river	no	
Mouth Root River	638							

From the preceding table it appears that above Grand Rapids no untreated sewage from towns enters the river. The rural population for that portion of the basin is extremely small, being 3.3 per square mile. The slope of the river is very flat, much of the channel being in lakes, and therefore the chance of bacteria from sewage being found in the water is slight.

Between Grand Rapids and the Crow Wing, a distance of 186 miles by river, the Mississippi receives untreated sewage from Grand Rapids, Aitkin, and Brainerd—representing a population of 12,000. The rural population averages 4.8 per square mile for the entire drainage basin above the Crow Wing. The average fall of the river in this stretch is 0.5 foot per mile. For 13 miles the course of the river is through the pond created by the Brainerd dam, and here sedimentation is an active factor. No untreated river water is used for municipal supplies.

At the mouth of the Crow Wing, the Mississippi receives the drainage of 3,580 square miles from that source. This drainage contains no untreated urban sewage. The rural population is about 14.1 per square mile.

From the Crow Wing to the mouth of the Crow, a distance of 109 miles, the Mississippi receives untreated sewage from Little Falls, St. Cloud, and Monticello—representing a population of 18,000. The rural population is considerably greater than in the upper portions, and averages 11.4 per square mile for the entire basin above Crow River. The average fall of the river is 2.8 feet per mile. For 13 miles the course of the river is through the ponds created by dams at Little Falls, Sartell, and St. Cloud. In this portion of the river, unfiltered river water is used by Little Falls and St. Cloud. At the mouth of Sauk River the drainage is received from 821 square miles having a rural population of 24.4 per square mile. Untreated sewage from an urban population of 4,600, is discharged into the Sauk. Elk River discharges the runoff from 670 square miles. No untreated urban sewage is carried by this stream.

At the mouth of Crow River the drainage from 2,590 square miles is received. One hundred and fifty miles above the mouth untreated sewage from an urban population of 2,368 enters the South Fork. The rural population of the Crow basin is about 28 per square mile.

From Crow River to the St. Croix, a distance of 66 miles, the Mississippi receives untreated sewage from Minneapolis, Fort Snelling, St. Paul, South St. Paul, and Hastings—representing a population of 525,000. In this stretch the average fall of the river is 2.6 feet per mile, and as there is little retardation from pondage with an accompaniment of sedimentation, the river is highly charged with bacteria from sewage. No untreated water is used for municipal supplies below Crow River. In addition to the above sources of sewage, the Rum and the Minnesota discharge into the Mississippi. The former drains an area of 1,550 square miles having a rural population of 20 per square mile. It also receives raw sewage from an urban population of 2,800. The Minnesota drains 16,600 square miles having a rural population of 20 per square mile. Untreated sewage from an urban population of 26,500 enters the Minnesota.

At the mouth of the St. Croix, the Mississippi receives the drainage from 7,290 square miles. Untreated sewage from an urban population of 13,500 enters the St. Croix, but as the lower 30 miles of the river has a very slight fall,—being within Lake St. Croix,—it is probable that little sewage bacteria finally reach the Mississippi except perhaps during high water.

Between the St. Croix and the State line, a distance of 136 miles, the Mississippi receives untreated sewage from Red Wing, Lake City, Winona, and La Crosse,—representing a population of 61,000. The average fall of the river in this stretch is 0.4 foot per mile. For about 25 miles the course of the river between Red Wing and Winona, is through Lake Pepin which has a width of several miles. In this stretch, sedimentation is an active agent, and it is probable that many sewage bacteria are removed so that the water is purer at the outlet than at the inlet to the lake. Cannon River which enters above Lake Pepin drains an area of 1,490 square miles having a rural population of 17.7 per square mile. It carries untreated sewage from an urban population of 19,000.

Below Lake Pepin, Zumbro and Root rivers enter from the Minnesota side. The former drains an area of 1,390 square miles having a rural population of 24.7 per square mile, and it carries the raw sewage from an urban population of 11,700. The latter river drains an area of 1,660 square miles, having a rural population of 22.1 per square mile, and carries the raw sewage from an urban population of 3,600.

CROW WING RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The area drained by Crow Wing River lies a little northwest of the center of Minnesota and embraces part or all of Cass, Hubbard, Wadena, Becker, Ottertail, Douglas, and Todd counties. The source of Crow Wing River is found in the southern part of Hubbard County in a remarkable chain of lakes of considerable size, extending about 30 miles in a northeast-southwest direction. These lakes occupy a river-like valley with abrupt sides 20 to 40 feet high. From the outlet of the lakes the Crow Wing flows southward and after crossing the line into Wadena County receives the waters of Shell River which heads in Shell Lake in Becker County. Below Shell River the Crow Wing takes a general southerly though very winding course until it is joined by Leaf and Partridge rivers; it then turns and flows southeastward to its junction with the Mississippi on the boundary between Cass and Morrison counties. The length of the river from the outlet of the lakes to the mouth is 89 miles.

Its only important tributaries, aside from those mentioned are Long Prairie River, which enters from the south, and Gull River which enters from the north near its mouth.

For 20 miles below the lake outlet, the river winds between low swampy banks about 175 feet apart. Farther down the height of the banks and the width of the river gradually increase. In its lower course the stream flows 400 feet wide between banks some 30 feet high.

TOPOGRAPHY, GEOLOGY, AND FORESTATION.

Altitudes within the basin range from 1,200 to 1,500 feet above sea level, and the gently undulating surface lies no great distance above the streams.

The entire basin is covered with blue till, consisting chiefly of sand, gravel, and clay, resting on sedimentary rocks in the northern part and on the granites, gneisses, slates, and quartzites in the southern. In some parts of the area are deposits of sand and gravel from which the clay has been removed and these deposits yield water to the many springs found along the ravines and valleys and on the banks of the lakes. Nowhere in the basin does rock outcrop. There are 100 lakes in the basin, nearly all in the 850 square miles above Shell River where they comprise 5 to 10 per cent of the total area.

The upper part of the basin is heavily forested with white and Norway pine, spruce, cedar, balsam, and tamarack; the lower part is less densely timbered with jack pine. Lumbering has been carried on for many years, but although much of the area has been cut over little of the land has been cleared.

RAINFALL AND RUNOFF.

Rainfall records in the basin, extending back to 1885 indicate a mean annual precipitation of 28 inches. Of this amount 3 inches occur during the winter months in the form of snow. Since 1885, the wettest year was 1906 when the precipitation was 37 inches. The driest year was 1910, when the rainfall varied from 9.4 to 14.4 inches at different points. Runoff records of Crow Wing River have been maintained continuously since 1909, and during that time the annual runoff has varied from 2.26 to 3.52 inches or from 9.2 to 23.9 per cent of the rainfall.

FLOODS AND REGULATION OF FLOW.

The many lakes in the upper portion of the basin and the swamp areas tend to regulate the flow naturally, so that Crow Wing River is not subject to severe floods. The river is used extensively for log driving, and a logging dam has been built at the outlet of the Crow Wing lakes which raises the water level 8 feet in the lowest lake. The operation of this dam increases the inequality of flow of the river instead of tending to equalize it, as the water is stored during the winter months (the natural low water period) for the purpose of increasing the spring and early summer flow. After the driving is finished the dam is not used for storage until the fall or winter. The Minnesota Forest Service has made the following estimate of log driving on Crow Wing River: 1909, 6,900,000; 1910, 2,000,000; 1911, 2,800,000 feet B. M.

The flow of Gull River, the lowest tributary, is controlled by a reservoir recently constructed as one unit in the Mississippi reservoir system of the Federal Government.

DRAINAGE WORK.

Above Shell River there are no drainage ditches as there is very little swamp land, and that chiefly in small patches. Below Shell River there are larger areas of swamp. Five State ditches draining 26,000 acres empty into Crow Wing River from the west between Shell and Wing rivers. County ditches draining about 20,000 acres enter Crow Wing River. A sixth State ditch draining 3,000 acres has its outlet in Wing River. County and judicial ditches draining 330,000 acres empty into Wing River.

DRAINAGE AREAS.

The following drainage areas have been measured on the Crow Wing and its tributaries:

Drainage areas in Crow Wing River basin.

River.	Above.	Drainage area.
		Square miles.
Crow Wing	Shell River	242
Do	Nimrod	1,010
Do	Oyelen	1,160
Do	Motley	2,140
Do	Pillager	3,230
Do	Mouth	3,580
Shell	do	612
Fish Hook	do	215
Leaf	Wing River	338
Do	Mouth	755
Wing	do	183
Red Eye	do	184
Partridge	do	81
Do	Crooked Lake Outlet	358
Long Prairie River	Gaging Station	973
Do	do	975
Gull	Gull Lake Outlet	238
Do	Mouth	312

GAGING STATION RECORDS.

CROW WING RIVER AT NIMROD.

Location.—At the steel highway bridge at Nimrod post office in Sec. 32, T. 137 N., R. 33 W.; about 12 miles east of Sebeka, the nearest railroad point, 1 mile above the mouth of Cat River and a mile below the mouth of Willow Creek.

Records available.—April 15, 1910, to November 30, 1912.

Drainage area.—1,010 square miles.

Gage.—Chain gage attached to the bridge. On May 19, 1910, the gage datum was lowered 1.20 feet, and the readings prior to that date were corrected to the present datum.

Channel.—Probably permanent.

Discharge measurements.—Made from the bridge.

Regulation.—The river is used for log driving, and a dam at the outlet of Lower Crow Wing Lake controls the water from that portion of the drainage area. Since the establishment of the station there has been no trouble from log jams. Crow Wing River has considerable fall near the station and one mile above makes a descent of 12 feet, known as Westers Rapids.

Winter flow.—From November to March the river is frozen over and observations are discontinued.

Daily discharge, in second-feet, of Crow Wing River at Nimrod.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1					486	923	184	160	140	758	276	
2					472	923	184	160	140	758	276	
3					515	1,140	184	160	140	758	276	
4					530	880	184	160	140	758	270	
5					530	494	208	160	152	694	264	
6					530	356	208	160	144	619	264	
7					515	324	208	160	140	567		
8					494	312	253	160	140	530		
9					486	270	253	160	140	523		
10					472	264	236	160	140	486		
11					464	264	264	160	140	429		
12					457	264	236	179	140	402		
13					457	264	208	198	375	395		
14					457	253	208	198	718	388		
15				530	457	219	203	184	822	362		
16				567	486	208	203	165	798	330		
17				619	537	208	160	152	457	300		
18				686	545	208	160	140	160	276		
19				742	523	208	160	140	140	312		
20				758	530	203	160	136	140	324		
21				710	574	189	160	128	128	356		
22				678	597	179	160	144	103	375		
23				678	589	165	170	140	120	375		
24				678	742	160	184	128	120	362		
25				678	906	179	184	128	422	356		
26				648	1,060	170	184	128	758	350		
27				611	1,140	184	179	128	774	337		
28				574	1,170	184	170	128	774	324		
29				523	1,280	184	170	128	774	318		
30				501	993	184	160	128	758	300		
31					923		160	128		294		

Daily discharge, in second-feet, of Crow Wing River at Nimrod—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1	......	......	......	140	184	219	486	165	170	671	457	......
2	......	......	......	140	170	219	464	198	170	634	678	......
3	......	......	......	140	160	219	443	198	179	604	641	......
4	......	......	......	144	152	236	457	208	184	567	604	......
5	......	......	......	160	165	264	429	198	184	567	494	......
6	......	......	......	152	165	264	422	184	189	567	402	......
7	......	......	......	140	160	264	416	198	214	537	388	......
8	......	......	......	140	160	253	402	208	219	501	375	......
9	......	......	......	140	160	236	318	208	219	472	362	......
10	......	......	......	152	160	236	300	208	219	457	356	......
11	......	......	......	179	160	236	264	208	214	443	356	......
12	......	......	......	203	160	236	156	203	208	457	......	......
13	......	......	......	242	160	258	136	198	219	457	......	......
14	......	......	......	253	160	641	120	198	236	457	......	......
15	......	......	......	264	165	923	120	189	236	457	......	......
16	......	......	......	264	165	923	120	184	236	457	......	......
17	......	......	......	264	219	855	120	184	219	443	......	......
18	......	......	......	264	219	790	120	184	219	443	......	......
19	......	......	......	270	208	758	113	184	219	422	......	......
20	......	......	......	270	208	726	106	184	236	402	......	......
21	......	......	......	264	208	686	89	184	966	402	......	......
22	......	......	......	253	198	710	86	198	1,100	402	......	......
23	......	......	......	230	198	798	120	198	1,060	402	......	......
24	......	......	......	203	184	830	156	198	993	388	......	......
25	......	......	......	198	184	774	160	198	914	388	......	......
26	......	......	......	198	184	726	156	184	872	388	......	......
27	......	......	......	198	184	671	152	184	806	375	......	......
28	......	......	......	198	184	634	152	179	742	375	......	......
29	......	......	......	198	203	597	152	170	718	375	......	......
30	......	......	......	198	219	523	152	170	694	356	......	......
31	......	......	......	......	219	......	152	170	......	356	......	......
1912.												
1	......	......	......	......	324	457	208	253	429	457	324	......
2	......	......	......	......	356	443	208	264	395	457	324	......
3	......	......	......	......	362	388	208	264	382	457	324	......
4	......	......	......	......	457	416	230	264	375	457	324	......
5	......	......	......	......	530	388	236	264	375	457	324	......
6	......	......	......	567	567	388	214	270	375	457	324	......
7	......	......	......	530	567	388	208	300	375	457	324	......
8	......	......	......	530	604	375	208	337	375	457	324	......
9	......	......	......	530	604	375	208	356	375	457	324	......
10	......	......	......	530	567	356	219	337	375	443	324	......
11	......	......	......	494	530	337	236	324	375	422	324	......
12	......	......	......	457	530	324	264	312	362	443	324	......
13	......	......	......	457	567	324	264	312	395	443	337	......
14	......	......	......	422	494	324	270	312	416	422	356	......
15	......	......	......	416	457	337	288	318	382	422	382	......
16	......	......	......	388	457	356	276	324	375	402	362	......
17	......	......	......	388	443	337	264	350	382	388	337	......
18	......	......	......	382	422	324	253	330	388	375	324	......
19	......	......	......	362	402	324	253	337	388	375	324	......
20	......	......	......	337	402	324	242	337	388	375	312	......
21	......	......	......	312	388	324	236	337	388	375	312	......
22	......	......	......	294	388	324	236	330	402	375	294	......
23	......	......	......	294	402	324	236	324	422	356	294	......
24	......	......	......	294	429	312	236	324	422	356	......	......
25	......	......	......	300	457	300	236	324	443	356	......	......
26	......	......	......	324	457	294	236	324	457	356	......	......
27	......	......	......	350	494	270	236	324	457	337	......	......
28	......	......	......	356	494	242	236	375	457	337	......	......
29	......	......	......	337	457	219	236	416	457	324	......	......
30	......	......	......	324	457	219	236	457	457	324	......	......
31	......	......	......	......	457	......	236	457	......	324	......	......

Daily discharge computed from a well-defined rating curve.

Monthly discharge of Crow Wing River at Nimrod.

[Drainage area, 1,010 square miles.]

Month.	Discharge in second-feet.				Run-off.	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	
1910.						
April (15-30)	758	501	636	0.630	0.37	A
May	1,280	457	642	.636	.73	A
June	1,140	160	332	.329	.37	A
July	264	160	192	.190	.22	A
August	198	128	151	.150	.17	B
September	822	103	335	.332	.37	B
October	758	276	442	.438	.50	B
November (1-6)	276	264	271	.268	.06	B
1911.						
April	270	140	202	.200	.22	B
May	219	152	181	.179	.21	B
June	923	219	524	.510	.58	B
July	486	86	227	.225	.26	A
August	208	165	191	.189	.22	A
September	1,100	170	435	.431	.48	B
October	671	356	459	.454	.52	A
November (1-11)	678	356	465	.462	.19	B
1912.						
April (6-30)	567	294	399	.395	.37	A
May	604	324	468	.463	.53	A
June	457	219	337	.334	.37	A
July	288	208	237	.235	.27	A
August	457	253	328	.325	.37	A
September	457	362	401	.397	.44	A
October	457	324	401	.397	.46	A
November	382	....	319	.316	.35	C

CROW WING RIVER AT MOTLEY.

Location.—At the highway bridge at Motley. The nearest tributary is Long Prairie River which enters 2 miles below.

Records available.—June 10 to November 30, 1909.

Drainage area.—2,140 square miles.

Gage.—Chain gage.

Channel.—Logs jammed at the bridge, and below, causing such unsatisfactory conditions that the station was discontinued.

Discharge measurements.—Made from bridge.

Accuracy.—Conditions were so unsatisfactory that no estimates of discharge have been made, and only the base data are given.

Discharge measurements of Crow Wing River at Motley.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
1909.		Ft.	Sq. ft.	Ft.	Sec.-ft.
June 24	G. A. Gray	228	656	6.70	1,230
August 4	Robert Follansbee	228	662	6.74	1,000
September 1	C. J. Emerson	236	569	6.92	1,130
September 10	G. A. Gray	225	428	6.55	745
October 20	Robert Follansbee	225	537	6.60	918

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

(Observer, S. W. Jacobs.)

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							6.42	6.84	6.91	6.65	6.60	
2							6.40	6.79	6.90	6.59	6.60	
3							6.32	6.72	6.85	6.54	6.60	
4							6.18	6.72	6.80	6.50	6.58	
5							6.05	6.72	6.75	6.50	6.58	
6							6.00	6.71	6.69	6.50	6.58	
7							5.92	6.71	6.65	6.50	6.55	
8							5.88	6.86	6.65	6.50	6.55	
9							5.90	7.01	6.62	6.51	6.55	
10						6.50	5.88	7.00	6.62	6.66	6.58	
11						6.42	5.81	7.36	6.60	6.75	6.56	
12						6.40	5.81	7.84	6.60	6.72	6.55	
13						6.45	5.84	8.00	6.58	6.70	6.55	
14						6.58	5.85	8.06	6.56	6.68	6.58	
15						6.82	5.85	8.26	6.55	6.65	6.44	
16						6.88	6.00	8.50	6.55	6.65	6.19	
17						6.85	6.29	8.48	6.52	6.62	6.52	
18						6.82	7.00	8.34	6.48	6.62	6.82	
19						6.90	7.00	8.14	6.49	6.60	6.70	
20						6.90	7.28	7.80	6.50	6.60	6.64	
21						6.85	7.44	7.58	6.62	6.65	6.88	
22						6.88	7.56	7.51	6.82	6.75	6.89	
23						7.12	7.85	7.40	6.88	6.75	6.75	
24						7.02	7.62	7.45	6.84	6.75	6.60	
25						6.68	7.55	7.44	6.81	6.75	6.62	
26						6.59	7.58	7.41	6.80	6.72	6.85	
27						6.54	7.44	7.36	6.71	6.70	6.84	
28						6.50	7.22	7.22	6.70	6.65	6.85	
29						6.50	7.10	7.11	6.68	6.60	7.01	
30						6.46	7.04	7.02	6.66	6.60	6.80	
31							6.96	6.96		6.60		

CROW WING RIVER AT PILLAGER.

Location.—At highway bridge one-half mile south of Pillager in Sec. 20, T. 133 N., R. 30 W., a short distance above the mouth of Pillager Creek.

Records available.—June 11, 1909, to December 31, 1912.

Drainage area.—3,230 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Fairly permanent except during high water.

Discharge measurements.—Made from the bridge.

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

Winter flow.—The river is frozen over at the gage from December to March, and during that period measurements are made through the ice to determine the winter discharge.

Accuracy.—Conditions at this station are favorable for good results, although the shifting of the river bed during high water may necessitate the use of more than one rating curve. Therefore the records should be reliable.

Daily discharge, in second-feet, of Crow Wing River at Pillager.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909[a].												
1							1,050	1,370	1,360	920	980	
2							1,040	1,290	1,320	920	980	
3							887	1,250	1,250	890	965	
4							770	1,200	1,230	862	965	
5							722	1,200	1,150	855	935	
6							699	1,160	1,130	827	928	
7							660	1,110	1,080	855	928	
8							628	1,200	1,030	876	905	
9							600	1,610	995	920	890	
10							611	1,650	972	1,020	890	
11						1,610	611	2,170	928	1,140	890	
12						1,380	600	2,810	890	1,170	890	
13						1,330	600	3,320	876	1,130	935	
14						1,290	600	3,580	876	1,120	1,070	
15						1,610	595	3,800	890	1,100	614	
16						1,760	622	3,960	890	1,080	698	
17						1,760	740	3,840	876	1,080	1,060	
18						1,700	600	3,540	827	1,050	1,200	
19						1,800	575	3,120	890	1,030	1,270	
20						1,760	710	2,620	958	1,030	1,200	
21						1,780	1,380	2,320	1,020	1,090	1,040	
22						1,700	2,260	2,100	1,280	1,150	1,220	
23						1,660	3,020	1,940	1,380	1,160	1,200	
24						1,640	2,900	1,980	1,330	1,120	1,190	
25						1,560	2,720	2,020	1,290	1,140	1,180	
26						1,430	2,670	1,920	1,270	1,120	1,160	
27						1,310	2,390	1,800	1,180	1,080	1,200	
28						1,260	2,040	1,700	1,130	1,030	1,350	
29						1,170	1,800	1,570	1,050	1,020	1,220	
30						1,110	1,580	1,480	972	1,000	1,140	
31							1,480	1,410		980		
1910[b].												
1		776	600	1,830	1,390	1,150	351	291	253	876	548	
2			615	1,730	1,290	1,120	339	285	285	813	537	
3			615	1,640	1,270	1,140	335	285	305	848	520	
4			625	1,740	1,220	1,220	346	282	335	764	515	
5			625	1,860	1,190	1,230	356	278	339	724	500	
6			650	1,760	1,170	1,160	367	282	335	685	500	
7			700	1,600	1,130	862	359	295	335	685	500	
8			800	1,540	1,090	806	411	291	316	692	500	
9			1,000	1,470	1,040	741	429	291	295	679	500	
10			1,250	1,410	1,020	698	424	282	302	603	500	
11			1,500	1,330	995	679	424	278	298	581	500	
12			2,000	1,280	958	655	420	262	298	581	500	
13			2,620	1,160	935	620	438	285	285	570	500	
14			3,140	1,140	920	592	465	285	285	570	500	
15			3,320	1,450	890	559	465	305	542	548	500	
16			3,780	1,860	950	520	438	313	698	542	500	
17			4,140	2,320	1,010	510	398	312	778	510	500	
18			4,350	2,540	1,110	475	367	295	778	515	500	
19			4,580	2,790	1,110	465	339	272	470	570	500	
20			3,980	3,000	1,060	460	335	265	339	592	500	
21			3,790	3,080	1,020	438	351	262	320	603	500	
22			3,340	2,960	935	420	331	262	302	625	500	383
23			3,140	2,780	950	416	331	268	305	620	500	
24			2,930	2,580	972	411	335	295	335	598	500	
25		591	2,690	2,420	1,030	402	335	291	343	614	500	
26			2,530	2,170	1,100	398	328	285	429	598	500	
27			2,350	1,930	1,230	393	320	278	785	576	500	
28			2,220	1,790	1,280	384	302	268	855	570	500	
29			2,100	1,600	1,220	380	298	259	876	559	500	
30			2,040	1,440	1,220	371	295	305	883	564	500	
31			1,930		1,220		285	268		564		

[a] Daily discharge computed from two well-defined rating curves except that from Nov. 15-30, which was estimated on account of presence of ice.

[b] Daily discharge computed from a well-defined curve, except that for Mar. 1-12 and Nov. 1-30, which is estimated.

Daily discharge, in second-feet, of Crow Wing River at Pillager—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911. [c]												
1				644	627	615	691	443	328	877	467	
2				615	627	615	627	410	328	877	467	
3				615	593	722	571	434	328	897	644	
4				615	560	797	615	467	336	877	638	
5				560	560	797	621	518	359	830	734	
6				588	560	784	604	507	380	823	747	
7				588	549	747	549	507	419	810	784	
8				571	534	685	507	482	457	797	797	
9				571	534	627	497	467	472	797	810	
10				560	549	627	434	457	457	797	734	
11				644	560	604	388	457	448	747	457	
12				734	560	549	336	457	438	734		
13				830	555	518	299	448	477	830		
14				877	560	507	266	410	467	810		
15				917	615	747	266	507	477	863		
16				850	722	945	257	434	497	917		
17				810	863	1,010	249	410	410	931		
18				784	810	987	260	410	448	945		
19				797	784	877	260	367	492	931		
20				784	747	863	260	367	507	897		
21				747	673	797	260	367	507	850		
22				734	644	734	266	367	1,000	843		
23				704	615	740	310	367	1,070	850		
24				685	604	784	388	367	1,070	863		
25				627	615	734	410	359	1,060	863		
26			797	644	549	784	388	328	966	797		
27			588	627	502	734	388	336	931	766		
28			704	615	487	734	367	348	931	734		
29			797	627	457	734	348	344	931	734		
30			673	627	507	734	328	367	931	734		
31			673		492		336	359		534		
1912. [d]												
1				1,500	1,230	1,920	490	544	940	865	601	
2				1,500	1,150	1,810	1,190	544	902	865	544	
3				1,800	1,390	1,700	601	544	865	865	544	
4				2,400	3,330	1,490	544	517	829	793	572	
5				2,840	5,640	1,390	544	544	759	759	601	
6				2,480	6,920	1,290	572	601	725	759	601	
7				1,940	5,500	1,190	572	661	661	725	601	
8				1,560	5,220	1,020	601	725	661	725	601	
9				1,470	4,660	940	661	865	661	725	601	
10				1,390	4,240	940	793	980	661	725	601	
11				1,230	4,110	865	793	1,020	631	725	601	
12				1,150	3,330	865	793	1,020	661	725	601	
13				1,150	2,840	793	793	940	661	725	601	
14				1,150	2,720	793	725	902	661	693	572	
15				1,150	2,600	865	661	865	661	661	544	
16				1,150	2,360	1,100	725	829	725	661	631	
17				1,070	1,810	1,290	661	829	759	661	601	
18				1,070	1,700	1,290	661	793	725	661	572	
19				1,040	1,590	1,190	601	793	693	661	544	
20				1,000	1,590	1,100	601	793	693	631	544	
21				966	1,590	1,020	601	793	693	631	572	
22				966	1,490	940	601	725	725	631	572	
23				863	1,490	865	661	693	759	631	544	
24				863	1,490	725	661	661	759	631	490	
25				863	1,490	725	601	601	865	631	517	
26				1,000	1,490	661	544	601	865	631		
27				1,190	1,590	601	544	601	865	601		
28				1,310	1,920	601	544	572	865	631		
29				1,230	1,920	601	572	601	902	631		
30				1,270	1,810	544	544	865	865	631		
31					1,810		544	865		631		

[c] Daily discharge computed from fairly well-defined curve.

[d] Daily discharge computed from two fairly well-defined curves made necessary by a shift during the May high water.

Monthly discharge of Crow Wing River at Pillager.

[Drainage area, 3,230 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
January						
February						
March						
April						
May						
June 11-30	1,800	1,110	1,530	0.474	0.34	B
July	3,020	575	1,230	.381	.44	B
August	3,960	1,110	2,130	.659	.76	B
September	1,380	827	1,080	.334	.37	A
October	1,170	827	1 020	.316	.36	A
November	1,350	614	1,040	.322	.36	B
December			[1]925	.286	.33	C
1910						
January			[1]770	.238	.27	C
February			[1]670	.207	.22	C
March	4,580	600	2,260	.700	.81	B
April	3,080	1,140	1,940	.601	.67	B
May	1,390	890	1,100	.341	.39	B
June	1,230	371	656	.203	.23	A
July	465	285	365	.113	.13	A
August	313	259	283	.088	.10	A
September	883	253	443	.137	.15	A
October	876	510	627	.194	.22	A
November	548	500	504	.156	.17	B
December			[1]440	.136	.16	C
The year	4,580		838	.260	3.52	
1911.						
January			[1]370	.115	.13	D
February			[1]360	.111	.12	D
March			[1]540	.167	.19	D
April	917	560	686	.212	.24	B
May	863	457	600	.186	.21	B
June	1,010	507	738	.228	.25	B
July	691	249	398	.123	.14	C
August	518	328	415	.128	.15	C
September	1,070	328	597	.185	.21	B
October	945	534	824	.255	.29	B
November	810		[1]518	.160	.18	C
December			[1]450	.139	.16	C
The year	1,070		539	.167	2.27	
1912.						
January			[1]350	.108	.12	C
February			[1]340	.105	.11	C
March			[1]390	.121	.14	C
April	2,840	863	1,350	.418	.47	C
May	6,920	1,150	2,650	.820	.95	B
June	1,920	544	1,040	.322	.36	A
July	1,190	490	645	.200	.23	B
August	1,020	517	738	.228	.26	A
September	940	631	757	.234	.26	A
October	865	601	694	.215	.25	B
November	631		557	.172	.19	C

[1]Estimated from discharge measurements, gage heights and climatological records.

CROW WING RIVER NEAR MOUTH.

Location.—A short distance above the mouth of the river, and below all tributaries.

Records available.—November 3, 1881, to November 2, 1882; June 26, 1884, to November 21, 1884; October 1, 1896, to August 31, 1897. These records have been compiled from unpublished data in the U. S. Engineer Office at St. Paul.

Drainage area.—3,580 square miles.

Gage.—No data. This was of relatively little importance as discharge measurements were made almost daily, and the estimates based directly on these.

Winter flow.—The river is frozen over during the winter months but measurements were made to determine the flow.

Cooperation.—Station was maintained by the United States Engineer Corps.

Daily discharge, in second-feet, of Crow Wing River near mouth.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1881												
1												1,599
2												1,525
3											2,965	1,515
4											2,931	1,565
5											2,891	1,585
6											2,800	1,567
7											2,758	1,400
8											2,870	1,380
9											2,811	1,307
10											2,760	1,284
11											2,456	1,383
12											2,640	1,355
13											2,560	1,286
14											2,479	1,187
15											2,398	1,205
16											2,317	1,297
17											2,236	1,286
18											2,155	1,267
19											2,074	1,247
20											1,993	1,232
21											1,912	1,197
22											1,831	1,224
23											1,750	1,195
24											1,669	1,198
25											1,589	1,163
26											1,461	1,128
27											1,535	1,109
28											1,529	1,196
29											1,543	1,074
30											1,451	1,030
31												987
1882.												
1	994	960	1,047	1,294	5,486	6,265	7,922	2,348	4,582	1,666	2,618	
2	1,030	960	1,122	2,500	5,310	6,370	7,511	2,240	4,146	1,796	2,522	
3	993	960	1,097	3,000	5,296	6,388	7,047	2,178	3,892	1,775		
4	1,000	960	1,203	4,000	5,185	6,228	6,456	2,098	3,564	1,948		
5	981	960	1,206	4,500	4,676	5,980	5,830	1,954	3,218	2,336		
6	968	960	1,206	5,000	4,455	5,760	5,766	1,908	2,889	2,448		
7	955	960	1,175	6,000	4,332	5,373	5,775	1,867	2,539	3,233		
8	955	960	1,172	7,000	4,381	5,103	5,677	1,727	2,437	4,133		
9	943	960	1,175	8,000	4,867	4,665	5,653	1,663	2,341	4,476		
10	936	960	1,150	10,000	6,238	4,256	5,511	1,558	2,238	4,988		

Daily discharge, in second-feet, of Crow Wing River near mouth—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882.												
11	940	960	1,180	9,770	8,224	3,986	5,273	1,550	2,155	4,918	......	......
12	949	960	1,168	9,540	9,509	3,650	5,057	1,545	2,064	5,126	......	......
13	952	960	1,228	9,310	10,160	3,314	4,876	1,625	1,987	5,212	......	......
14	949	960	1,185	9,080	10,043	2,949	4,558	1,625	1,889	5,317	......	......
15	960	969	1,167	8,851	8,901	2,716	4,286	1,486	1,792	5,295	......	......
16	960	983	1,160	7,816	8,234	2,511	4,195	1,519	1,808	5,228	......	......
17	960	1,008	1,133	7,695	7,211	2,453	4,034	1,488	1,822	5,023	......	......
18	960	982	1,157	7,290	7,338	2,801	3,932	1,417	1,836	4,716	......	......
19	960	982	1,186	7,404	7,169	3,932	3,716	1,438	1,671	4,392	......	......
20	960	982	1,219	7,161	6,935	4,332	3,388	1,479	1,726	4,092	......	......
21	960	942	1,270	6,999	7,226	4,456	3,178	2,175	1,623	3,773	......	......
22	960	907	1,366	6,536	7,558	4,873	2,927	3,419	1,597	3,810	......	......
23	960	890	1,299	6,420	7,581	5,156	2,921	5,339	1,548	3,724	......	......
24	960	939	1,297	6,339	7,574	5,774	2,915	7,683	1,544	3,535	......	......
25	960	959	1,275	5,988	7,413	6,242	2,910	8,209	1,544	3,391	......	......
26	960	959	1,257	5,875	7,156	6,830	3,147	6,938	1,591	3,284	......	......
27	960	968	1,293	5,711	7,072	7,546	2,944	6,004	1,726	3,097	......	......
28	960	968	1,284	5,726	6,634	7,867	2,796	6,129	1,695	2,878	......	......
29	960	......	1,362	5,412	6,070	7,998	2,642	5,163	1,700	2,849	......	......
30	960	......	1,355	5,400	5,737	8,470	2,558	5,034	1,699	2,826	......	......
31	960	......	1,304	......	5,895	......	2,509	4,942	......	2,717	......	......
1884.												
1	......	......	......	......	......	......	1,625	1,000	1,875	1,625	2,500	......
2	......	......	......	......	......	......	1,600	1,100	1,875	1,875	2,375	......
3	......	......	......	......	......	......	1,550	1,200	2,000	2,125	2,375	......
4	......	......	......	......	......	......	1,500	1,300	1,875	2,250	2,250	......
5	......	......	......	......	......	......	2,000	1,300	1,750	2,750	2,250	......
6	......	......	......	......	......	......	1,750	1,200	1,750	3,125	2,125	......
7	......	......	......	......	......	......	1,750	1,100	1,750	3,500	2,000	......
8	......	......	......	......	......	......	1,875	1,000	1,750	3,625	2,000	......
9	......	......	......	......	......	......	1,875	1,100	1,750	3,625	1,875	......
10	......	......	......	......	......	......	1,750	1,000	1,875	3,750	1,875	......
11	......	......	......	......	......	......	1,750	1,000	1,875	3,750	1,875	......
12	......	......	......	......	......	......	1,625	950	1,875	3,625	1,750	......
13	......	......	......	......	......	......	1,500	950	1,875	3,500	1,750	......
14	......	......	......	......	......	......	1,400	950	1,750	3,375	1,625	......
15	......	......	......	......	......	......	1,300	900	1,750	3,250	1,625	......
16	......	......	......	......	......	......	1,300	950	1,875	3,125	1,625	......
17	......	......	......	......	......	......	1,300	1,000	1,875	3,000	1,500	......
18	......	......	......	......	......	......	1,200	1,200	1,875	2,875	1,400	......
19	......	......	......	......	......	......	1,200	1,300	1,875	2,750	1,300	......
20	......	......	......	......	......	......	1,200	1,500	1,875	2,625	1,100	......
21	......	......	......	......	......	......	1,100	1,750	1,750	2,500	1,000	......
22	......	......	......	......	......	......	1,000	1,750	1,750	2,375	......	......
23	......	......	......	......	......	......	1,100	1,625	1,625	2,375	......	......
24	......	......	......	......	......	......	1,300	1,750	1,625	2,250	......	......
25	......	......	......	......	......	......	1,300	1,875	1,500	2,250	......	......
26	......	......	......	......	......	1,700	1,300	2,000	1,500	2,250	......	......
27	......	......	......	......	......	1,720	1,300	2,000	1,400	2,250	......	......
28	......	......	......	......	......	1,750	1,200	2,000	1,400	2,250	......	......
29	......	......	......	......	......	1,625	1,200	2,125	1,500	2,375	......	......
30	......	......	......	......	......	1,625	1,100	2,125	1,500	2,375	......	......
31	......	......	......	......	......	......	1,000	2,000	......	2,500	......	......
1896.												
1	......	......	......	......	......	......	......	......	......	750	1,186	715
2	......	......	......	......	......	......	......	......	......	735	1,158	709
3	......	......	......	......	......	......	......	......	......	721	1,215	718
4	......	......	......	......	......	......	......	......	......	731	1,210	726
5	......	......	......	......	......	......	......	......	......	742	1,186	734
6	......	......	......	......	......	......	......	......	......	764	1,158	742
7	......	......	......	......	......	......	......	......	......	698	1,137	750
8	......	......	......	......	......	......	......	......	......	721	1,151	758
9	......	......	......	......	......	......	......	......	......	745	1,067	766
10	......	......	......	......	......	......	......	......	......	825	1,032	774
11	......	......	......	......	......	......	......	......	......	873	871	782
12	......	......	......	......	......	......	......	......	......	964	......	790
13	......	......	......	......	......	......	......	......	......	996	......	798
14	......	......	......	......	......	......	......	......	......	955	......	806
15	......	......	......	......	......	......	......	......	......	955	......	837

Daily discharge, in second-feet, of Crow Wing River near mouth—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
16										931		868
17										897		854
18										899		833
19										901		833
20										879		834
21										813		834
22										782		835
23										833		835
24										833		805
25										865		802
26										897		800
27										913		791
28										929		782
29										927		781
30										999		780
31										1,099		772
1897.												
1	830	675	644	1,375	2,468	1,424	2,725	2,253				
2	885	678	656	10,200	2,300	1,600	3,761	2,178				
3	854	681	668	10,200	2,132	1,775	4,798	2,103				
4	823	684	677	10,202	1,962	1,865	4,785	2,029				
5	792	704	672	10,202	1,792	1,955	4,772	1,912				
6	788	724	667	9,407	1,730	1,955	4,759	1,855				
7	784	732	670	8,471	1,676	1,900	4,746	1,797				
8	786	739	673	8,290	1,625	1,875	4,604	1,710				
9	768	721	658	7,888	1,574	1,875	4,496	1,623				
10	766	703	643	7,423	1,524	1,900	4,388	1,618				
11	764	680	650	6,798	1,477	1,900	4,242	1,613				
12	762	663	658	6,174	1,431	1,940	4,096	1,609				
13	760	650	666	5,759	1,458	1,904	4,093	1,584				
14	758	637	674	5,365	1,579	1,868	4,089	1,559				
15	780	625	682	5,092	1,702	1,838	3,903	1,543				
16	803	604	691	4,804	1,723	1,809	3,658	1,528				
17	788	584	701	4,516	1,744	2,612	3,414	1,486				
18	772	603	706	4,031	1,768	3,086	3,272	1,444				
19	777	618	849	3,547	1,792	3,560	3,130	1,454				
20	782	632	870	3,494	1,721	3,234	3,047	1,430				
21	768	643	891	3,442	1,674	2,908	2,944	1,407				
22	760	654	937	3,338	1,627	2,692	3,124	1,391				
23	751	665	984	2,979	1,580	2,677	3,224	1,375				
24	738	676	1,055	2,621	1,534	2,057	3,324	1,359				
25	725	666	1,075	2,580	1,502	1,967	3,022	1,255				
26	712	655	1,095	2,539	1,470	1,877	2,721	1,248				
27	699	644	1,115	2,535	1,349	1,930	2,636	1,172				
28	703	630	1,175	2,531	1,291	1,983	2,551	1,096				
29	696		1,225	2,542	1,233	2,228	2,478	1,105				
30	689		1,275	2,505	1,240	2,473	2,403	1,115				
31	671		1,325		1,248		2,328	1,086				

Monthly discharge of Crow Wing River near mouth.

[Drainage area, 3,580 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1881.					
November (3-30)	2,965	1,451	2,079	0.581	0.60
December	1,599	987	1,289	.360	.42
1882.					
January	1,030	936	963	.269	.31
February	1,008	890	960	.268	.28
March	1,366	1,047	1,216	.340	.39
April	10,000	1,294	6,521	1.82	2.03
May	10,160	4,332	6,770	1.89	2.18
June	8,470	2,453	5,141	1.44	1.61
July	7,922	2,509	4,449	1.24	1.43
August	8,209	1,417	3,108	.868	1.00
September	4,582	1,544	2,229	.623	.70
October	5,317	1,666	3,678	1.03	1.19
1884.					
June (26-30)	1,750	1,625	1,680	.469	.09
July	2,000	1,000	1,420	.397	.46
August	2,125	900	1,390	.388	.45
September	2,000	1,400	1,740	.486	.54
October	3,750	1,625	2,770	.774	.89
November (1-21)	2,500	1,000	1,820	.508	.40
1896.					
October	1,099	698	857	.239	.28
November (1-11)	1,215	871	1,124	.314	.13
December	868	709	788	.220	.25
1897.					
January	885	671	766	.214	.25
February	739	584	663	.185	.19
March	1,325	643	836	.233	.27
April	10,202	1 375	5,362	1.50	1.67
May	2,468	1,233	1,642	.459	.53
June	3,560	1,424	2,155	.602	.67
July	4,798	2,328	3,598	1.01	1.16
August	2,253	1,086	1,546	.432	.50

LONG PRAIRIE RIVER NEAR MOTLEY.

Location.—100 yards above the highway bridge, 1 mile south of Motley, in Sec. 19, T. 133 N., R. 31 W., and 2 miles above the mouth of the river.

Records available.—June 10, 1909, to November 30, 1912.

Drainage area.—973 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Permanent.

Discharge measurements.—During all stages except low, discharge measurements are made from the bridge, but low-water measurements are made by wading at a section a short distance upstream.

Winter flow.—From November to March the river is frozen over at the gage and observations are discontinued.

Accuracy.—Conditions at this station are favorable and therefore the records should be reliable. There are no dams on the river to affect its flow at the gaging station. Backwater caused by ice gorges in Crow Wing River may possibly affect gage heights for a few days in the spring.

Daily discharge, in second-feet, of Long Prairie River near Motley.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							258	143	135	151	132	
2							250	135	132	145	132	
3							242	132	132	140	132	
4							231	127	132	135	127	
5							220	122	132	135	125	
6							220	122	122	127	122	
7							212	125	125	132	125	
8							212	163	122	135	122	
9							198	195	122	143	122	
10						572	192	192	122	163	127	
11						534	185	292	120	175	125	
12						463	181	395	117	178	122	
13						410	178	426	110	172	122	
14						385	172	395	113	163	163	
15						347	163	347	117	160	160	
16						347	163	301	122	148	205	
17						385	163	275	120	143	175	
18						385	154	242	117	140	181	
19						395	154	227	122	135	185	
20						436	172	209	125	154	235	
21						463	212	195	163	148	181	
22						479	275	185	205	148	163	
23						490	267	178	212	145	148	
24						416	216	185	212	143	140	
25						361	198	178	220	145	145	
26						332	181	175	212	143	154	
27						310	175	163	216	127	205	
28						296	160	154	195	127	216	
29						288	154	148	175	127	205	
30						271	148	145	163	132	178	
31							148	135		135		
1910.												
1				361	267	163	64	59	80	95	80	
2				347	231	154	64	61	84	97	80	
3				337	246	154	61	63	90	95	80	
4				332	242	163	64	59	95	89	77	
5				337	231	175	64	61	90	88	80	
6				337	231	198	72	61	88	84	80	
7				337	220	209	70	63	88	84	74	
8				314	212	192	74	61	84	82	72	
9				296	205	185	72	58	80	82	84	
10				292	195	178	80	58	80	84	84	
11				271	181	172	84	58	77	80	80	
12				258	178	166	90	59	74	80	113	
13				250	178	154	90	64	72	80	78	
14				246	178	148	88	67	72	78	77	
15				310	175	143	84	77	72	80	77	
16				410	205	127	80	78	77	80	78	
17			1,060	490	227	120	78	72	77	84		
18			1,330	640	246	108	74	74	78	84		
19			1,140	589	235	99	67	74	80	84		
20			770	628	220	99	67	72	74	89		
21			782	628	209	91	74	67	74	89		
22			770	622	195	90	72	67	80	91		
23			699	600	192	84	72	72	80	97		
24			589	572	185	91	67	72	80	95		
25			534	534	178	90	64	72	80	88		
26			485	431	181	82	64	72	99	88		
27			463	395	178	82	64	72	104	84		
28			431	342	172	80	64	70	110	80		
29			410	310	163	74	63	67	104	77		
30			390	292	160	72	61	80	99	84		
31			385		163		60	78		80		
1911.												
1				125	120	135	67	72	70	301	163	
2				120	120	138	59	67	70	301	145	
3				117	113	148	56	84	67	361	301	
4				113	104	175	56	88	70	301	205	
5				93	108	178	66	84	67	220	205	

Daily discharge, in second-feet, of Long Prairie River near Motley—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6				113	108	160	77	88	72	132	220	
7				95	104	138	74	82	80	132	127	
8				117	104	125	70	78	82	135	135	
9				120	104	110	63	80	84	132	127	
10				125	104	108	59	82	84	127	99	
11				127	99	101	56	78	80	125		
12				135	97	95	54	78	80	125		
13				163	101	98	51	77	77	125		
14				172	110	90	50	78	104	138		
15				160	108	84	49	74	135	148		
16				160	172	80	47	74	160	154		
17				151	185	78	47	70	166	178		
18				145	166	78	49	72	160	192		
19				143	175	72	47	70	151	195		
20				135	163	70	49	70	154	185		
21				135	143	64	51	70	166	192		
22				135	127	59	52	66	172	198		
25				132	122	58	61	64	166	192		
24				125	122	54	58	64	145	181		
25				122	117	54	56	66	132	172		
26			148	122	117	54	54	64	122	172		
27			143	120	113	54	54	64	117	163		
28			127	122	110	54	58	63	120	148		
29			138	117	110	61	56	64	113	138		
30			132	117	125	61	52	67	117	135		
31			122		132		66	70		301		
1912.												
1				480	270	612	135	185	270	185	145	
2				505	216	640	135	195	270	185	127	
3				530	290	640	143	195	270	181	135	
4				455	920	640	138	192	250	178	135	
5				805	2,100	640	148	192	250	166	127	
6				405	2,960	585	172	198	242	175	143	
7				430	2,400	480	175	195	231	163	143	
8				430	2,100	380	160	220	220	163	138	
9				333	1,840	333	178	282	212	160	138	
10				270	1,520	290	192	333	212	163	138	
11				231	1,220	290	195	380	198	166	135	
12				212	1,040	250	181	405	192	175	138	
13				195	860	250	175	380	198	175	125	
14				205	750	250	178	356	195	175	117	
15				216	668	290	160	356	195	172	125	
16				270	558	333	151	333	198	163	132	
17				250	480	380	148	333	205	163	148	
18				231	430	356	148	312	198	166	132	
19				212	405	333	138	312	195	154	132	
20				195	380	290	135	290	195	154	127	
21				185	380	270	138	270	192	154	127	
22				181	380	250	145	270	185	151	135	
23				178	405	216	151	250	185	148	125	
24				172	405	205	178	235	185	148		
25				172	380	192	220	231	195	148		
26				192	380	175	250	220	195	145		
27				242	455	163	250	205	205	145		
28				250	480	160	227	198	198	151		
29				270	505	151	195	185	195	154		
30				270	530	148	181	246	195	148		
31					585		181	254		148		

NOTE.—Daily discharge computed from a well-defined rating curve.

Monthly discharge of Long Prairie River near Motley.

[Drainage area, 973 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (10-30)	572	271	398	0.409	0.32	B.
July	275	148	195	.200	.23	B.
August	426	122	207	.213	.25	B.
September	220	110	148	.152	.17	A.
October	178	127	145	.149	.17	A.
November	235	122	156	.160	.18	B.
1910.						
March (17-31)	1,330	385	682	.701	.39	A.
April	640	246	404	.415	.46	A.
May	267	160	203	.209	.24	A.
June	209	72	131	.135	.15	A.
July	90	60	71.4	.073	.08	A.
August	80	58	67.4	.069	.08	A.
September	110	72	84.1	.086	.10	A.
October	97	77	85.5	.088	.10	A.
November (1-16)	113	72	80.9	.083	.05	A.
1911.						
March (26-31)	148	122	135	.139	.03	B.
April	172	93	129	.133	.15	A.
May	185	97	123	.126	.15	A.
June	178	54	94.2	.097	.11	A.
July	77	47	56.9	.058	.07	B.
August	88	63	73.2	.075	.09	A.
September	172	67	113	.116	.13	A.
October	361	125	184	.189	.22	A.
November (1-11)	301	99	173	.178	.07	B.
1912.						
January	......	......	[a]105	.108	.12	......
February	......	......	[a]100	.103	.11	......
March	......	......	[a]120	.123	.14	......
April	805	172	299	.307	.34	B.
May	2,960	216	848	.870	1.00	A.
June	640	148	340	.349	.39	A.
July	250	135	171	.175	.20	A.
August	405	185	265	.272	.31	A.
September	270	185	211	.216	.24	A.
October	185	145	162	.166	.19	A.
November	148	......	130	.133	.15	B.

[a] Estimated from climatological records and open water relation between flow at Pillager and Motley.

DEVELOPED WATER POWER.

There is only one power development on Crow Wing River, but there are six small plants on tributaries.

As no records of runoff are available for the tributaries, no estimate of the available power on these streams can be given.

Crow Wing River 4 miles above the mouth:—The Cuyuna Range Power Co. has in the course of construction a 20-foot dam on the Crow Wing River just below the mouth of Gull River and about 4 miles above the confluence of the Crow Wing with the Mississippi. This dam will back water to a distance of about 7 miles, forming a narrow reservoir, flooding about 800 acres. Flowage rights have been secured, so that in cases of necessity 2-foot flashboards may be used which will overflow about 900 acres. A short open flume takes the water to the power house in which are located 2 S. Morgan Smith 48-inch wheels with a rated capacity of about 900 horsepower each. A Woodard oil pressure automatic governor is used to regulate the speed of the wheels. Connected to one turbine is an Allis Chalmers, 500 KW, 3-phase, 60 cycle, alternating generator of 2300 volts.

A transmission line is to be built to the Cuyuna Range towns including Deerwood, Crosby, Ironton, and Cuyuna, a distance of about 28 miles. The current to be transmitted at 35,000 volts. Thirty-five foot Cedar poles are to be used in the construction of the transmision line. It is expected that the plant will be run continuously. There is an auxiliary steam plant of about 300 horsepower at Deerwood, Minn., which can be used in case the flow of the river is not at all times sufficient to generate the needed power.

From the records of flow of Crow Wing River it is seen that the flow at the dam for the lowest month on record, the lowest month of an average low year, and the lowest flow for the six high months of an average low year, are 315, 501 and 716 second-feet respectively corresponding to 573, 913 and 1300 horsepower at 80 per cent efficiency.

Straight River at Osage.—A flour mill at Osage develops about 50 horsepower used chiefly in operating the mill.

Fish Hook River at outlet of Fish Hook Lake near Park Rapids.—The dam at the outlet of Fish Hook Lake creates a head of 12 feet which is utilized by a power plant having an installed capacity of 330 horsepower and an average development of 75 horsepower used in running the flour and feed mill and in furnishing Park Rapids with light and power.

Long Lake Outlet at Hubbard.—At the outlet of Long Lake a dam creates a head used in developing about 75 horsepower utilized in operating a flour mill at that point.

Two Inlets River.—A dam creates a head of 17½ feet which is utilized by means of a single turbine in developing an average of 40 horsepower. This is used in operating a flour mill.

Belle River at Spruce Hill.—A water power of approximately 50 horsepower is developed at this point for use in operating a flour mill.

Wing River at Verndale.—A dam creates a head of 9 feet which is utilized by means of a 54-inch wheel of 60 horsepower capacity in operating a feed mill.

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of Crow Wing River from the mouth to the outlet of the Crow Wing lakes was made in 1909. The results of this survey are given on plates 20 to 28 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Crow Wing River from mouth to Crow Wing Dam.

Stations.	Distance.		Elevation above sea level	Ascent between points.	
	From mouth	Point to point		Total	Per mile
Mouth of River	0.0		1147.5		
Gull River	4.2	4.2	1156	8.5	2.0
	7.0	2.8	1166.5	10.5	3.8
	9.0	2.0	1171	4.5	2.2
Pillager Bridge	11.2	2.2	1176.5	5.5	2.5
Seven-mile Creek	13	1.8	1180.5	4.0	2.2
	16	3.0	1191	10.5	3.5
Long Prairie River	19.8	3.8	1205	14	3.7
Motley Bridge	21.9	2.1	1211.5	6.5	3.1
	24	2.1	1215.5	4.0	1.9
	27	3.0	1220.5	5.0	1.7
Iron Creek	29.6	2.6	1224	3.5	1.3
Swan Creek	32.2	2.6	1230	6.0	2.3
Gallapau's Ford	34.5	2.3	1233	3.0	1.3
Partridge River	38.9	4.4	1240	7.0	1.6
Thomastown Bridge	40.8	1.9	1242.5	2.5	1.3
	45	4.2	1248.5	6.0	1.4
	49	4.0	1253.5	5.0	1.2
	52	3.0	1258	4.5	1.5
Township line 135-136	53.7	1.7	1261	3.0	1.8
	56	2.3	1271	10.0	4.3
	58	2.0	1283	12.0	6.0
Section line 10-15	59	1.0	1288	5.0	5.0
Beaver Creek	61.2	2.2	1300	12.0	5.5
	63.3	2.1	1313.5	13.5	6.4
Foot of Wester's Rapids	66.1	2.8	1320	6.5	2.3
Head of Wester's Rapids	67.1	1.0	1330	10.0	10.0
	69.5	2.4	1338	8.0	3.3
Carter's Ford	71.8	2.3	1346	8.0	3.5
	75	3.2	1349.5	3.5	1.1
	80	5.0	1353.5	4.0	8.0
Huntersville Bridge	82.4	2.4	1356	2.5	1.0
Shell River	87.9	5.5	1361	5.0	0.9
Crow Wing Dam, foot	89.2	1.3	1362	1.0	0.8

For 19 miles below the Crow Wing lakes, the slope of Crow Wing River is too slight for power development. Below that section the fall of the river becomes greater, but the banks are not adapted for power sites above a point 2 miles below Oyelen.

In Sec. 26, T. 136 N., R. 33 W.—A 28-foot dam located 2 miles miles below Oyelen, at mile 54.8 would back the water 5 miles up the river, overflowing 210 acres of brush land. The length of the dam would be 200 feet at the water surface, and 600 feet at the top.

Below this point the slope of the river is slight and the banks are low being bordered by swamp in many places. This condition holds nearly to the bridge south of Pillager where the banks are of sufficient height and close enough together to offer a dam site.

In Sec. 20, T. 133 N., R. 30 W.—At a point ½ mile above the Pillager bridge, at mile 11.8 a 15 foot dam would back the water 6½ miles up the river overflowing 200 acres of wooded and pasture land. The length of the dam would be 300 feet at the water surface, and 400 feet at the top. The fall between the dam site and the mouth will be utilized by a power plant now being built.

AVAILABLE HORSEPOWER.

Records of flow from November 1881 to October 1882; June to November 1884; October 1896 to August 1897, and from June 1909 to date, are available for Crow Wing River. An unusually severe drought during 1910 so depleted the ground water that the minimum flow during 1910, 1911 and 1912 was in all probability less than the flow for an ordinary low year. The winter flow of 1897 was that of an ordinary low year, but that for 1882 was not. For this reason the latter year was disregarded in determining the flow for an ordinary low year.

The following table shows the estimated horsepower based on the available records of flow:

Undeveloped horsepower on Crow Wing River.

Site	Head in feet.	Minimum Run-off.			Horsepower (80% Efficiency).		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Sec. 26, T 136 N, R 33 W....	28	128	244	302	326	621	769
Sec. 20, T 133 N, R 30 W....	15	283	452	646	386	616	881

LONG PRAIRIE RIVER.

Although no topographic survey has been made of Long Prairie river, a tributary of the Crow Wing, there is available the following table of approximate elevations and distances compiled from various sources:

Elevations and distances along Long Prairie River from mouth to Alexandria.

Point.	Distance in miles		Elevation in feet above sea level	Ascent in feet between points	
	Above mouth	Point to point		Total	Per mile
Crow Wing River........	0	....	1,205	....	....
Sec. 28, T 131 N, R 33 W........	26	26	1,250	45	1 7
Long Prairie........	38	12	1,286	36	3.0
Range line 35-36........	60	22	1,300	14	.6
Great Northern Ry. Crossing near Alexandria........	84	24	1,347	47	2.0

From the records of flow of Long Prairie River the following table has been compiled to show the undeveloped horsepower between different points.

Undeveloped horsepower on Long Prairie River.

Section of River.	Total fall in feet.	Minimum Run-off.[a]			Horsepower (80% Efficiency).		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Between Crow Wing River and Sec. 28, T. 131 N., R. 33 W.	45	44	60	160	180	245	655
Between Sec. 28, T. 131 N., R. 33 W. and Long Prairie....	36	31	42	113	101	137	370
Between Long Prairie and Range Line 35-36........	14	25	34	90	32	43	115
Between Range Line 35-36 and G. N. Ry. Crossing near Alexandria................	47	20	28	80	85	120	342

[a] Based on the mean drainage area for the section.

SANITARY STATISTICS.

To show the sanitary quality of the water in the Crow Wing River, and the extent to which this water is used for municipal supplies, data showing the source of municipal supply, and disposal of sewage have been compiled for all towns located on the Crow Wing or its tributaries. These data are given in the following table in order of location, beginning near the source of the river:

Municipal water supply and sewage disposal of towns located on the Crow Wing and tributaries.

Town.	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems		Rural population per sq. mile.
			Source of Supply	Filtered	Amount gallons 24 hrs.	Outlet	Treated	
			Crow Wing River					14.1
Mouth Shell River....	88							
Mouth Leaf River....	40							11.2
Motley..............	22	428	No water works system....	....	....	none	....	....
Mouth Long Prairie...	20	....	....	....	....	....	....	....
Park Rapids.......	35	1,719	Shell River Fish Hook River....	no	140,000	none	....	....
			Leaf River					12.8
Henning..............	68	603	none	....	....	none	....	....
Wadena..............	40	1,829	wells	no	70,000	none	....	....
			Long Prairie River					19.4
Alexandria..........	84	3,001	wells	no	120,000	Lake Agnes	Septic tank	....
Long Prairie........	38	250	wells	no	30,000	river	Septic tank	
Browerville..........	25	633	wells	no	30,000	(a) river	no	....

(a) Storm sewer only.

From the preceding table it appears that the main river receives no urban sewage. The rural population for the entire drainage basin is 14.1 per square mile. Above the mouth of Long Prairie River none of the tributaries carry urban sewage, and as the rural population is small it is probable that the water contains comparatively few sewage bacteria. The Long Prairie brings in the drainage from 975 square miles, having a rural population of 19.4 per square mile. This stream carries the sewage from an urban population of 3,250, but this sewage is treated before it enters the river.

SAUK RIVER.

SOURCE AND COURSE.

Sauk River drains an area comprising 821 square miles lying south of the basin of Crow Wing River and north of that of the Crow. The Sauk rises in Osakis Lake, in the southwestern part of Todd County, and flows southeastward to its junction with the Mississippi about 2 miles above St. Cloud. Its tributaries are not important.

In its upper course Sauk River flows through a number of small lakes, such as Gurney, Roberts, Little Sauk, Saul and Horseshoe. In all, there are about 75 lakes in the basin comprising 1 per cent of the drainage area. Many of these lakes are small and have no visible outlet.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The surface of the basin is rolling and is in general 40 to 80 feet above the level of the Sauk. Altitude range from 1,050 to 1,400 feet above set level. The entire area is covered with blue till —a mixture of sand, gravel and clay, laid down during the glacial epoch—underlain by cretaceous sandstones and shales or Archean granite and syenites. Rocks outcrop at a few places in the basin, notably near St. Cloud, where granite is quarried. The sand and gravels of the drift yield water to the springs that emerge along the stream and also to shallow wells.

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

RAINFALL AND RUNOFF.

Rainfall records maintained at various points in the basin and extending over 10 years indicate that the mean annual precipitation in the upper part of the area is 26 inches; the lower part lies in a small zone where the rainfall as determined at three points is about 23 inches. During the winter months the average precipitation (equal to 2½ inches of rainfall) is in the form of snow which remains. The wettest year was 1905 when the rainfall averaged 34 inches and the driest 1910, when the precipitation was about 13 inches.

Runoff records of Sauk River have been maintained since 1909. During that period the annual runoff has varied from 1.30 to 1.96 inches or from 5 to 15 per cent of the rainfall.

DRAINAGE AREAS.

The following drainage areas have been measured in this basin:

Drainage areas in Sauk River basin.

River.	Drainage area above.	Square miles.
Sauk.	Sauk Center.	278
Do.	Cold Springs.	725
Do.	Gaging Station near St. Cloud.	816
Do.	Mouth.	821

GAGING STATION RECORD.

SAUK RIVER NEAR ST. CLOUD.

Location.—At highway bridge 3 miles west of St. Cloud in Sec. 9, T. 124 N., R. 28 W., 10 miles below the nearest tributary which enters at Rockville.

Records available.—July 8, 1909, to December 31, 1912.

Drainage area.—816 square miles.

Gage.—Chain, attached to bridge; datum unchanged since established. The gage is read twice a day and the mean of the readings is recorded as the mean for the day.

Channel.—Permanent, except after periods of high water when changes are apt to occur.

Discharge measurements.—Made from the bridge.

Regulation.—At the mouth of the river is a dam 9 feet high. Not only is the station above the influence of the dam, but the dam itself prevents backwater from the Mississippi River reaching the station. The first dam above the station is at Cold Springs, 15 miles distant. The opening and shutting of the turbine gates at this dam affect the flow at the gaging station during the low water season.

Winter flow.—From December to March the river is frozen completely over in the vicinity of the gaging station and measurements are made through the ice to determine the winter discharge.

Accuracy.—The mean daily gage height during the low water season is subject to some error resulting from daily fluctuations in the stage of the river caused by control of flow by dams above the station, and therefore the records for that period can not be considered better than fair.

Daily discharge, in second-feet, of Sauk River near St. Cloud.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1909.												
1								154	109	101	71	
2								166	99	93	85	
3								166	99	85	95	
4								250	95	71	98	
5								161	95	71	93	
6								78	51	78	103	
7								110	70	85	99	
8							268	142	105	85	93	
9							400	220	77	85	161	
10							425	212	91	85	112	
11							400	226	63	88	118	
12							670	226	42	93	98	
13							400	206	42	101	101	
14							425	206	63	93	88	
15							555	135	63	95	85	
16							400	67	77	91	93	
17							400	78	91	66	120	
18							266	67	99	70	131	
19							317	74	109	63	179	
20							317	74	152	74	206	
21							500	74	77	85	220	
22							500	74	63	85	220	
23							378	70	77	82	214	
24							378	74	77	85	220	
25							317	176	91	85	192	
26							250	152	84	78	206	
27							250	63	79	82	220	
28							250	51	84	58	220	
29							220	51	84	78	220	
30							166	26	84	78	220	
31							154	63		58		
1910.												
1			90	762	110	64	64	30	47	120	30	
2			100	762	110	58	52	52	47	131	30	
3			115	730	120	47	58	30	58	120	30	
4			130	610	131	47	47	38	30	101	30	
5			150	582	131	47	52	38	27	71	30	
6	108		190	450	131	64	42	38	27	71	30	
7			210	300	154	154	30	34	27	71	34	
8			250	336	142	166	38	30	24	47	30	
9			350	250	142	142	42	30	93	38	30	
10			450	235	142	154	78	34	101	38	47	
11			550	192	131	166	34	38	27	85	30	
12			600	206	131	131	24	64	30	85	30	
13			600	220	120	52	24	71	38	88	47	
14			650	250	120	38	24	71	38	85	47	
15			700	300	101	38	27	71	47	88	42	
16			700	300	101	38	24	78	47	71	27	
17			800	282	85	38	24	131	47	47	34	
18			850	282	52	38	24	71	58	38	38	
19			950	266	42	42	24	52	71	30	47	
20			990	250	42	38	36	30	64	30	30	
21			828	266	52	42	47	30	71	30	27	13
22			730	266	42	47	24	34	52	30	30	
23			266	282	42	58	24	30	71	30	30	
24			220	317	52	58	24	42	71	30	30	
25			378	300	52	58	27	34	42	47	30	
26			300	266	64	64	30	30	78	45	30	
27			425	235	58	64	71	71	78	30	30	
28		61	450	204	71	64	85	47	71	42	30	
29			500	172	64	71	71	30	71	47	30	
30			610	141	58	71	78	38	120	34	30	
31			582		64		71	47		38		
1911.												
1				300	56	30	82	90	76	116	37	
2				300	62	42	75	76	96	85	42	
3				266	62	56	56	82	124	120	62	
4				75	62	56	46	82	112	99	75	
5				68	62	36	82	96	103	90	34	

Daily discharge, in second-feet, of Sauk River near St. Cloud—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6				56	62	42	62	120	120	99	68	
7				56	62	51	52	142	131	76	82	
8				82	51	56	71	120	142	101	90	
9				37	34	56	75	101	44	142	110	
10				62	51	56	68	84	56	129	192	
11				34	62	45	48	105	110	110	131	
12				62	90	54	62	82	82	116		
13				42	62	62	68	131	110	112		
14				62	131	46	82	110	131	116		
15				34	68	46	68	84	96	103		
16				56	68	61	110	116	116	85		
17				34	46	56	57	147	62	75		
18				37	46	90	58	116	68	99		
19			300	56	56	68	42	56	90	68		
20			317	62	62	54	67	62	110	131		
21			220	56	62	58	89	37	90	120		
22			206	51	51	44	90	51	110	82		
23			282	56	82	28	96	62	131	79		
24			300	34	62	46	110	56	140	99		
25			378	30	56	56	66	42	131	82		
26			62	27	62	46	90	110	103	75		
27			62	62	68	75	79	68	110	62		
28			62	62	51	68	116	51	79	56		
29			82	56	62	110	110	62	116	68		
30			90	68	68	90	90	56	131	56		
31			356		131		75	120		34		
1912.												
1					610	565	24	98	54	231		
2					730	565	68	149	42	215		
3					730	510	92	106	18	231		
4					730	455	41	224	18	215		
5					730	381	45	144	5	215		
6				166	730	358	73	224	16	248		
7				226	730	455	92	277	24	231	120	
8				206	730	277	56	241	29	199	132	
9				356	730	215	102	224	75	183	109	
10				356	860	208	82	183	75	142	88	
11				317	1,620	215	106	171	104	155	20	
12				266	1,320	183	120	171	152	169	144	
13				336	1,400	277	98	155	126	14	88	
14				336	1,250	215	82	205	139	19	61	
15				317	1,320	215	37	183	152		69	
16				282	1,400	208	28	252	312		98	
17				266	1,180	144	82	104	312		53	
18				400	1,180	124	86	120	312		32	
19				378	1,250	120	92	142	312		69	
20				282	1,250	136	102	333	312		98	
21				266	1,250	124	120	289	255			
22				220	1,250	129	37	289	189			
23				266	1,250	124	124	234	255			
24				336	1,250	64	136	192	221			
25				300	1,250	102	155	157	174			
26				300	1,250	117	149	120	134			
27				356	1,320	106	124	120	174			
28				317	1,400	96	149	136	174			
29				336	1,250	92	124	171	221			
30				356	955	86	92	218	255			
31					625		113	98				

NOTE.—Daily discharge computed from a well-defined rating curve. Discharge March 1-21 and November 22-30, 1910, and March 1-18, 1911, estimated because of ice. A new rating curve was used after May 11, 1912, which was applied indirectly from August 16 to October 14.

Monthly discharge of Sauk River near St. Cloud.

[Drainage area, 816 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July (8-31)	670	154	358	0.439	0.39	B.
August	250	26	126	.154	.18	B.
September	152	42	83.1	.102	.11	B.
October	101	58	81.5	.100	.12	B.
November	220	71	146	.179	.20	C.
December			[a]100	.123	.14	C.
1910.						
January			[a]100	.123	.14	C.
February			[a]80.0	.098	.10	D.
March	990	90	475	.582	.67	C.
April	762	141	334	.409	.46	B.
May	154	42	92.2	.113	.13	B.
June	166	38	72.0	.088	.10	B.
July	85	24	42.6	.052	.06	B.
August	131	30	47.2	.058	.07	B.
September	120	24	55.8	.068	.08	B.
October	131	30	59.9	.073	.08	B.
November	47	30	33.0	.040	.04	B.
December			[a]20.0	.025	.03	C.
The year	990		118	.144	1.96	
1911.						
January			[a]12.0	.015	.02	C.
February			[a]10.0	.012	.01	D.
March	378		117	.143	.16	B.
April	300	27	76.1	.093	.10	A.
May	131	34	64.8	.079	.09	A.
June	110	28	56.1	.069	.08	A.
July	116	42	75.5	.093	.11	A.
August	147	37	87.6	.107	.12	A.
September	142	44	104	.127	.14	A.
October	142	34	[b]93.1	.114	.13	A.
November			107	.131	.15	C.
December			135	.164	.19	C.
The year	378		78.6	.096	1.30	
1912.						
January			[a]60	.074	.09	C.
February			[a]30	.037	.04	D.
March			[a]80	.098	.11	C.
April	400		[a]268	.328	.37	B.
May	1,620	610	1,080	1.32	1.52	C.
June	565	64	229	.281	.31	B.
July	155	24	91.3	.112	.13	B.
August	333	98	185	.227	.26	B.
September	312	5	155	.190	.21	C.
October	248	14	162	.199	.23	C.
November			89.4	.110	.12	C.

[a] Estimated from a few discharge measurements each winter, semi-weekly gage heights, and climatological records.
[b] Discharge estimated October 15 to November 6.

DEVELOPED WATER POWER.

Power is developed at 4 points on Sauk River as follows:

Sauk Center.—The Sauk Center Milling Co. has a 10-foot dam which, with the use of 1-foot flashboards, gives a head of 11 feet. In the mill located nearby is one 56-inch Leffel turbine of 92 horsepower capacity; one 56-inch S. Morgan Smith turbine of 100 horsepower capacity; one 60-inch turbine of the same make of 130 horsepower capacity, and one 42-inch American turbine of 70 horsepower capacity. The electrical equipment consists of a 150-KW General Electric alternating current generator of 1,040 volts. There is an auxiliary steam plant of 200 horsepower capacity, as the water supply is not sufficient at all times.

Melrose.—The Melrose Milling Co. has a 14-foot masonry dam at Melrose. At the right end of the dam is the mill which contains the turbines. These are set in open forebay and consist of two 42-inch American Special turbines of 135 horsepower capacity each. (There is also an old turbine of which no details are available.) The turbines are set on vertical shafts bevel geared to a horizontal shaft which is connected to the mill machinery by belting. As the plant lights one city block besides the mill itself, there is a 100-KW Western Electric direct current generator of 250 volts belt connected to the horizontal shaft. There is very little pondage as no flashboards are used. During the autumn months the plant is operated 24 hours per day, but during the remainder of the year it is operated only 12 hours. There is an auxiliary steam plant of 125 horsepower capacity, as the water supply is not sufficient at all times.

Cold Springs.—The Farmers Milling Co. has a masonry dam at Cold Springs which affords a head of 8 feet. This head is utilized by one 72-inch and two 52-inch turbines set in open forebay. These are old wheels and nothing is known regarding their size and capacity further than that they generate an average of 100 horsepower. These turbines which are controlled by hand governors are set on vertical shafts. Two of these shafts are bevel geared to a horizontal shaft to which the mill machinery is geared, and the third is connected to a small generator used in lighting the mill. During the fall of the year the plant operates continously but during the remainder of the year it operates from 10 to 12 hours, six days per week. There is no auxiliary steam plant as the water supply is sufficient.

Near the mouth of Sauk River.—The Le Sauk Roller Mill has a timber dam of the A type, 275 feet long, located one-half mile above the mouth of Sauk River. From the south end of the dam a canal 800 feet long supplies water to an old turbine which develops about 100 horsepower under an operating head of 8 feet, the tailwater being discharged through a short raceway into the river. The turbine is connected by belting to the mill machinery. The banks above the dam are so low that it is not possible to raise the water level for storage, and no flashboards are used. The plant operates intermittently about 10 hours per day. There is an auxiliary steam plant of 100 horsepower for use during the winter months, when ice gorging in the tail race cuts down the head.

From the records of flow of Sauk River the following estimates of available power at the points of development have been made:

Available horsepower at developed power sites.

Developed Site.	Head in feet.	Minimum Runoff.		Horsepower (80% Efficiency.)	
		Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Sauk Center	11	4	28	4	28
Melrose	14	5	36	6	46
Cold Springs	8	9	72	6	52
Near the Mouth	8	11	82	8	60

UNDEVELOPED WATER POWER.

Although no survey of Sauk River has been made, there are available approximate elevations at different points on the river from which the following table of elevations and distances has been compiled:

Elevations and distances along Sauk River from mouth to Osakis Lake.

Station.	Distance.		Elevation above sea level.	Fall between points.		
	From mouth.	Point to point.		Total.	Developed fall.	Undeveloped fall.
Mississippi River	0	....	992	....	....	....
G. N. Ry. Crossing	5	5	1,035	43	8	35
Sec. 6, T. 123 N., R. 31 W.	37	32	1,100	65	8	57
G. N. Ry. Crossing	62	25	1,172	72	0	72
Melrose (G. N. Ry.)	68	6	1,201	29	14	15
Sauk Center (G. N. Ry.)	76	8	1,212	11	11	0
Sauk Lake Outlet	79	3	1,220	8	0	8
Little Sauk Lake Outlet	90	11	1,240	20	0	20
Osakis Lake Outlet	104	14	1,310	70	0	70

As no topographic map of the Sauk River is available it will not be possible to show the various power sites but only the total power in the various sections of the river:

Undeveloped water power on Sauk River.

Section of River.	Distance in miles.	Total fall in feet.	Undeveloped fall.	Minimum Runoff.[a]		Horsepower (80% Efficiency.)	
				Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Mouth to G. N. Ry. Crossing	5	43	35	11	82	35	261
G. N. Ry. Crossing to Sec. 6-123-31	32	65	57	10	71	52	368
Sec. 6-123-31 to G. N. Ry.	25	72	72	8	50	52	327
G. N. Ry. to Melrose	6	29	15	6	38	8	52
Melrose to Sauk Center	8	11	0	5	32	0	0
Sauk Center to Sauk Lake Outlet	3	8	8	4	27	3	20
Sauk Lake Outlet to Little Sauk Lake Outlet	11	20	20	3	20	5	36
Little Sauk Lake to Osakis Lake Outlet	14	70	70	2	9	13	57

[a] Based on the mean drainage area of the section.

SANITARY STATISTICS.

To show the sanitary condition of the water in Sauk River and the extent to which it is used for municipal supplies, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more, located on the river. These data are given in the following table, in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns located on Sauk River.

Town.	Distance above mouth	Population 1910.	Water Works System.			Sewerage System.		Rural population of basin per square mile.
			Source of supply.	Filtered.	Amount gallons 24 hours.	Outlet	Treated.	
Osakis	104	1,013	Lake Osakis	(a)	50,000	none	....	....
Sauk Center	76	2,463	Sauk Lake	no	350,000	river	no	....
Melrose	68	2,151	river	(a)	300,000	river	no	....
Richmond	31	563	....	....	4,000	river	septic tank	....
Cold Spring	22	517	spring	no	25,000	river	septic tank	24.4

(a) Not used for drinking.

From the preceding table it appears that no urban sewage enters Sauk River about Sauk Center, nor is the water used for municipal purposes.

Between Sauk Center and Melrose, a distance of 8 miles, the river has an average fall of 1.4 feet per mile, which is too great to allow sedimentation and time for decomposition of the sewage from Sauk Center before it reaches Melrose. At the latter place, however, the water is not used for drinking.

From Melrose to the mouth the river receives untreated urban sewage from Melrose alone. The sewage from Richmond and Cold Spring is treated before entering the river. The average fall of the river between these points is 3.1 feet per mile. This slope of the river is evidence that sewage pollution is found throughout this section. The rural population of the entire basin is 24.4 per square mile.

ELK RIVER.

SOURCE, COURSE, AND TRIBUTARIES.

The drainage basin of Elk River is located chiefly in Benton and Sherburne counties. Elk River rises in T. 38 N., R. 29 W., at an elevation of approximately 1,150 feet above sea level, and flows south and southeast into the Mississippi near Elk River Postoffice at an elevation of 858 feet. Its chief tributaries are Snake and St. Francis rivers, Rice and Mayhew creeks, and Tibbetts Brook.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The entire area is covered with glacial drift which takes the form of till in Benton County, and of washed sand and gravel in Sherburne County. Beneath the drift are granites. The range of altitude is from 860 to 1,150 feet.

The basin contains about 20 small lakes, chiefly in the lower portion, and these comprise less than 1 per cent of the area.

The greater part of the drainage basin was originally covered with timber, but most of this has been cut off as the land is nearly all under cultivation.

RAINFALL.

The mean annual rainfall for the Elk River basin is about 28 inches, as shown by records just outside the basin—there being none within the basin itself. Of this amount 3 inches fall as snow. Th nearest record is that at St. Cloud, which is continuous since 1893. In that period the wettest year was 1897 when the rainfall was 41.9 inches. The driest year was 1910, when the precipitation was 14.6 inches.

DRAINAGE AREAS.

The following drainage areas have been measured in this basin:

Drainage areas in Elk River basin.

River.	Drainage area above.	Square miles.
Elk	Mouth Price Creek	204
Do	Mouth St. Francis River	384
Do	Gaging station in Sec. 23, T. 33 N., R. 27 W	615
Do	Mouth	670
Price Creek	Mouth	48
St. Francis	Mouth	199

GAGING STATION RECORDS.

ELK RIVER NEAR BIG LAKE.

Location.—At the highway bridge 4 miles east of Big Lake and one-half mile east of Bailey station on the Northern Pacific Railway; in Sec. 23, T. 33 N., R. 27 W., one-half mile above Tibbetts Brook, and 4 miles below mouth of St. Francis River.

Records available.—April 15, 1911, to December 31, 1912.

Drainage area.—615 square miles.

Gage.—Vertical staff.

Channel.—Probably permanent, as small rapids a short distance below are the control point.

Discharge measurements.—Made from the highway bridge at all stages except low, when wading measurements are made nearby.

Regulation.—The flow of the river above the station is entirely uncontrolled as the only dam on the river is located near the mouth about 8 miles below.

Winter flow.—From December to March the relation between gage heights and discharge is affected by ice, and during that period measurements are made to determine the winter discharge.

Daily discharge, in second-feet, of Elk River near Big Lake.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1					96	102	80	100	76	102	146	
2					90	102	72	90	70	92	135	
3					90	110	69	82	69	121	132	
4					88	135	63	92	78	130	139	
5					80	123	90	88	84	123	139	
6					76	119	84	84	88	178	154	
7					76	132	76	96	90	184	142	
8					76	163	69	98	90	166	135	
9					76	156	65	90	88	163	130	
10					76	135	63	88	82	158	123	
11					69	126	59	82	100	156	113	
12					65	123	54	80	100	149	110	
13					70	117	52	78	92	149		
14				144	80	108	50	78	96	189		
15				132	142	98	47	76	92	191		
16				130	158	110	47	76	88	205		
17				123	149	121	47	76	84	228		
18				119	144	104	50	69	88	236		
19				126	208	98	57	65	84	236		
20				132	222	88	57	63	82	236		
21				121	216	78	54	63	84	233		
22				117	250	76	50	69	82	219		
23				110	253	72	52	70	80	216		
24				104	225	69	52	65	80	211		
25				104	194	69	52	63	76	205		
26				98	173	108	50	63	76	191		
27				96	154	90	47	78	80	184		
28				96	142	80	59	72	82	178		
29				96	130	96	57	70	113	171		
30				96	117	98	54	76	104	166		
31					110		57	76		158		
1912.												
1				500	426	805	124	184	260	161	129	
2				700	410	735	134	171	230	153	129	
3				850	491	630	134	169	260	153	129	
4			60	885	595	560	138	169	276	151	129	
5				885	845	491	151	164	276	148	126	
6				885	1,860	423	138	161	260	146	124	
7				885	4,970	356	126	158	230	143	124	
8				845	4,620	324	122	153	245	146	124	
9				770	3,600	292	124	153	230	148	124	
10				700	2,570	260	129	153	215	146	124	
11				630	2,150	230	122	153	215	143	124	
12				595	1,740	215	134	151	200	161	124	
13				560	1,380	215	146	143	190	174	124	
14			73	595	1,180	230	143	138	187	164	124	
15				491	1,000	230	136	134	187	161	124	
16				474	845	215	136	134	187	151	124	
17				458	735	200	134	200	184	148	124	
18				458	665	197	126	230	179	148	124	
19				458	595	200	122	195	177	148	124	
20				426	560	195	119	179	190	143	124	
21				426	560	187	119	174	190	143	124	
22				410	595	179	119	164	184	143	124	
23				395	735	179	171	158	177	138	124	
24				380	805	177	187	146	174	136	98	
25				365	805	171	169	138	184	136	78	
26				395	845	158	151	134	184	136	102	
27	39			380	1,050	146	164	126	177	136	100	
28				365	1,230	138	215	158	171	134	98	
29				410	1,180	134	260	151	169	129	96	
30				426	1,050	126	230	292	164	129	94	
31					925		200	276		129		

NOTE.—Daily discharge computed from a rating table well defined between discharges 100 and 1,300 second-feet and fairly well defined between 1,300 and 4,000 second-feet.

Monthly discharge of Elk River near Big Lake.

[Drainage area, 615 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
April (14-30)	144	96	114	0.185	0.12	A
May	253	65	132	.215	.25	A
June	163	69	107	.174	.19	A
July	90	47	59.2	.096	.11	B
August	100	63	77.9	.127	.15	B
September	113	69	85.9	.140	.16	B
October	236	92	178	.289	.33	A
November	154		[a]113	.184	.21	C
December			[a]110	.179	.21	C
1912.						
January			[a]60	.098	.11	C
February			[a]50	.081	.09	C
March			[a]90	.146	.17	C
April	885	365	567	.922	1.03	A
May	4,970	410	1,320	2.15	2.48	A
June	805	126	287	.467	.52	A
July	260	119	149	.242	.28	A
August	292	126	168	.273	.31	A
September	276	164	205	.333	.37	A
October	174	129	146	.237	.27	A
November	129	78	118	.192	.21	B

[a] Estimated from three measurements made during the winter months, semi-weekly gage heights and climatological data.

ELK RIVER NEAR ELK RIVER.

Location.—At the Hastings foot bridge in Sec. 31, T. 33 N., R. 26 W., 3 miles above the mouth of the river. The nearest tributary is Tibbetts Brook which enters 3 miles above. This station was maintained by the U. S. Engineer Corps.

Records available.—October 15, 1896, to September 14, 1897. These records have been compiled from unpublished data in the U. S. Engineer Office at St. Paul. As the drainage area at this point is only 9 per cent larger than that of the station near Big Lake, the records are very nearly comparable.

Drainage area.—670 square miles.

Gage.—No data. This was not of great importance as very frequent discharge measurements were made, on which the estimates were largely based.

Winter flow.—The river was frozen over during the winter months, but frequent measurements were made to determine the flow.

Daily discharge, in second-feet, of Elk River near Elk River.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
1												
2												126
3												
4											158	
5												
6											160	
7												97
8												
9											148	
10												91
11												
12												
13											119	
14												
15										117		
16												
17											154	
18												111
19											96	
20												
21												
22												99
23										100	98	
24												
25												
26										99		
27												
28										98		
29												
30										169		
31												
1897.												
1					413	142	470	965	278			
2			94		405	200	487	895	278			
3		71			368	210	585	880	278			
4					341	215	736	880	298			
5					323	221	784	834	437			
6					298	292	1,110	820	504			
7	120				280	297	2,230	915	462			
8					260	285	3,350	915	427			
9					250	302	3,860	880	376			
10					239	321	4,030	834	355			
11	109	91			239	310	3,960	789	342			
12				1,940	221	295	3,740	744	335			
13			89	1,820	210	280	3,320	686	462			
14	106			1,710	200	277	2,930	658	496			
15				1,590	200	272	2,870	618				
16				1,470	186	292	2,540	566				
17				1,350	174	297	1,860	526				
18				1,230	166	306	1,640	502				
19			180	1,100	206	315	1,480	467				
20		102		990	200	335	1,380	507				
21				866	190	358	1,350	454				
22				820	186	413	1,240	421				
23				796	184	462	1,160	406				
24				732	180	445	1,080	385				
25		100		690	178	413	1,060	368				
26				645	166	384	1,010	342				
27				592	168	423	970	335				
28	68			545	162	480	940	318				
29			845	512	157	480	925	304				
30				476	152	473	930	294				
31					146		955	286				

Monthly discharge of Elk River near Elk River.

[Drainage area, 670 square miles.]

Month.	Discharge in second-feet.				Run-off.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.
1896.					
October			[a]115	0.172	0.20
November			[a]135	.202	.23
December			[a]105	.157	.18
1897.					
January			100	.149	.17
February			90.0	.134	.14
March			270	.403	.46
April (12-30)			1,050	1.57	1.11
May	413	146	228	.340	.39
June	480	142	326	.487	.54
July	4,030	470	1,770	2.64	3.04
August	965	286	606	.904	1.04
September (1-14)	504	278	381	.569	.30

[a] Estimated.

DEVELOPED WATER POWER.

The only power developed on Elk River is that of the Elk River Milling Co. whose dam at Elk River gives an 11-foot head used in generating 150 horsepower by means of two turbines, one of 125 horsepower capacity and the other of 25 horsepower. The power is used in operating the flour mill.

SANITARY CONDITION.

No settlement of any considerable size is situated on Elk River or its tributaries, and therefore no urban sewage enters the river. The rural population is 21.6 per square mile.

CROW RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The area drained by Crow River lies in Stevens, Kandiyohi, Meeker, Renville, McLeod, Wright and Hennepin counties between the basins of the Sauk and the Minnesota. Crow River proper is a short stream, being formed by the junction of the North and South forks 2 or 3 miles above Rockford. Throughout its course it forms the boundary between Hennepin and Wright counties, and it discharges into the Mississippi at Dayton. The North Fork, which is the longer of the two, rises in McLeod and Grove lakes, in the eastern part of Pope County. These lakes together are about 4 miles long and average one-third mile wide. From the outlet of the lakes the general course of the North Fork is southeastward through Rice and Cedar lakes, both of which are of considerable size. At Manannah it receives the Middle Fork, which rises in Crow Lake, in the southwestern part of Stevens County, and flows southward through Green Lake (area several square miles) and then eastward to its junction with the North Fork. Below the Middle Fork it receives one or two small tributaries which also head in the lakes. The South Fork heads in a number of lakes in the southeastern part of Kandiyohi County, from which it takes a general easterly course, flowing through Otter Lake.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The valley of the North Fork lies 40 to 50 feet below the general surface level—that of the South Fork is from 30 to 40 feet below the surface and one-fourth to one-half mile wide. The basin of the North Fork contains about 70 lakes, comprising approximately 3 per cent of its drainage area—that of the South Fork contains 120 lakes, comprising 2 per cent of the total area drained. Many of these lakes are small and have no apparent outlet. Altitudes range from 900 to 1,300 feet above sea level.

The entire basin is covered by blue till, of glacial origin, and scattered through it, especially in the western portion, are deposits of modified drift composed of sand and gravel. These deposits being porous form ground water reservoirs which give rise to springs, though such springs are not of great importance in the Crow River Basin. In the western part of the area the drift rests on cretaceous rocks—in the eastern part it is underlain by Archean granites and Upper Cambrian sandstones. Rock outcrops are found nowhere in the basin.

The lower part of the area, east of the west line of Wright County, lies in the district that was originally forested—the upper part is in the prairie region. Very little of the area is forested at the present time. The land is nearly all under cultivation.

RAINFALL AND RUNOFF.

The upper portion of the basin lies in a small area of low rainfall as shown by the records at 3 stations. The mean rainfall for this area is 23 inches. The remainder of the basin has an annual precipitation of 27.5 inches which is the normal amount for the center of the State. In the upper portion of the basin, the wettest year since 1895 was 1896, when the rainfall was 33 inches. The driest year was 1910, when it was 14 inches. For the lower portion of the basin continuous records are available since 1866. In that period the wettest year was 1868, when the rainfall was 41.6 inches. The driest year was 1910, when the precipitation was 11.6 inches.

Runoff records of Crow River have been maintained since 1909. Since that time the runoff has varied from 0.83 to 1.51 inches or from 2.7 to 11.5 per cent of the rainfall.

DRAINAGE WORK.

Much of the basin is so flat that ditching is necessary to secure the proper drainage. The following table compiled from the report of the State Drainage Commission shows the amount of drainage work done in the basin:

Drainage in Crow River basin.

County.	Original swamp area, acres.	Benefited by drainage, acres.
Kandiyohi	40,000	20,000
Meeker	27,000	12,000
McLeod	9,000	7,000
Wright	3,000	5,000

DRAINAGE AREAS.

The following drainage areas have been measured in the basin of Crow River:

Drainage areas in Crow River basin.

River.	Above.	Drainage area square miles.
North Fork	Cedar Lake	303
Do	Mouth Middle Fork	317
Do	Kingston	873
Do	Junction with South Fork	1,310
Middle Fork	Mouth	297
South Fork	Konisha	467
Do	Gaging Station	1,160
Do	Junction with North Fork	1,170
Buffalo Creek	Mouth	276
Crow	Rockford	2,520
Do	Mouth	2,590

GAGING STATION RECORDS.

NORTH FORK CROW RIVER NEAR ROCKFORD.

Location.—At highway bridge in Sec. 1, T. 118 N., R. 25 W., 3 miles west of Rockford, and 1½ miles above the junction of the South Fork. There are no tributaries within several miles of the station.

Records available.—June 15, 1909, to June 30, 1910. Owing to unsatisfactory conditions no estimates of daily discharge were made and only the base data are available.

Drainage area.—1,310 square miles.

Gage.—Vertical staff which remained permanent.

Channel.—The station was within the influence of the dam at Rockford and conditions remained constant as long as the dam was not opened nor the water level below the crest. From July 27 to August 10, 1909, the dam was open for repairs.

Discharge measurements.—Made from the bridge.

Winter flow.—Observations were discontinued during the winter months because of ice.

Discharge measurements of North Fork of Crow River near Rockford.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	Sq. ft.	Feet.	Sec.-ft.
1909.					
June 15	G. A. Gray	148	817	6.88	1,200
July 22	Robert Follansbee	135	521	4.72	438
July 31	do	119	286	[a]2.89	303
Aug. 11	G. A. Gray	134	483	[b]4.41	329
Sept. 23	do	134	500	4.53	262
1910.					
Mar. 17	C. J. Emerson	148	808	6.88	1,210
June 4	G. A. Gray	124	438	3.90	108

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

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

(Observer, Miss Grace Wandersee.)

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							5.70	2.97	3.99	4.28	4.35	4.63
2							5.58	2.91	3.99	4.25	4.38	4.69
3							5.48	2.83	3.98	4.27	4.35	4.73
4							5.39	2.91	4.04	4.25	4.33	4.83
5							5.30	2.81	4.13	4.35	4.38	4.58
6							5.22	2.75	4.04	4.35	4.35	4.41
7							5.12	2.73	4.01	4.38	4.33	4.39
8							5.00	2.78	3.89	4.35	4.33	4.38
9							a	2.97	3.93	4.41	4.35	4.38
10							a	3.85	3.93	4.43	4.35	4.43
11							a	4.38	3.91	4.43	4.32	4.35
12							5.08	4.48	4.11	4.43	4.32	4.25
13							5.35	4.47	4.63	4.43	4.39	4.23
14							5.54	4.43	4.55	4.43	4.48	4.23
15						6.92	5.45	4.41	4.53	4.43	4.48	4.25
16						7.10	5.38	4.34	4.45	4.43	4.48	4.23
17						7.20	5.15	4.34	4.35	4.43		4.31
18						7.20	5.05	4.42	4.35	4.41		4.28
19						7.14	4.90	4.35	4.33	4.41		4.28
20						7.15	4.70	4.33	4.23	4.43		4.28
21						6.88	4.60	4.29	4.41	4.39		4.33
22						6.65	4.71	4.24	4.48	4.41		4.31
23						6.52	4.71	4.28	4.59	4.39	4.58	4.28
24						6.48	4.63	4.21	4.53	4.43	4.51	
25						6.36	4.61	4.15	4.47	4.38	4.53	
26						6.25	4.52	4.14	4.43	4.38	4.61	
27						6.12	3.43	4.13	4.38	4.34	4.68	
28						6.00	2.98	4.08	4.33	4.33	4.73	
29						5.95	2.94	4.03	4.31	4.28	4.61	
30						5.82	2.85	4.02	4.28	4.31	4.68	
31							2.91	4.01		4.33		
1910.												
1				5.05	4.15	3.85						
2				4.95	4.15	3.89						
3				4.82	4.12	3.90						
4				4.70	4.10	3.86						
5				4.60	4.10	3.85						
6				4.60	4.10	3.85						
7				4.58	4.10	3.85						
8				4.50	4.10	3.82						
9				4.42	4.08	3.80						
10			5.20	4.40	4.05	3.80						
11			5.42	4.40	4.02	3.80						
12			5.72	4.40	4.00	3.80						
13			6.20	4.36	4.00	3.80						
14			6.62	4.35	4.00	3.80						
15			7.30	4.22	4.00	3.80						

a—Below 5.00 feet.

Daily gage height, in feet, of North Fork of Crow River near Rockford—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
16			7.05	4.18	4.00	3.80						
17			6.85	4.30	4.02	3.78						
18			6.72	4.42	4.05	3.70						
19			6.58	4.45	4.05	3.70						
20			6.45	4.40	4.10	3.62						
21			6.25	4.40	4.10	3.55						
22			6.08	4.35	4.10	3.52						
23			5.95	4.30	4.08	3.60						
24			5.75	4.35	4.04	3.55						
25			5.62	4.30	4.04	3.52						
26			5.52	4.30	4.00	3.65						
27			5.40	4.30	4.00	3.80						
28			5.30	4.25	3.99	3.78						
29			5.24	4.22	3.90	3.75						
30			5.15	4.20	3.90	3.60						
31			5.05		3.86							

SOUTH FORK CROW RIVER NEAR ROCKFORD.

Location.—At highway bridge 3½ miles southwest of Rockford in Sec. 1, T. 118 N., R. 25 W.; no tributaries within several miles.

Records available.—June 15, 1909, to March 31, 1912.

Drainage area.—1,160 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Slightly shifting.

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

Regulation.—The nearest dam is that at Delano which is merely used as a diversion dam by the Great Northern Railway Co. The control for the station is determined by the dam at Rockford. From July 27 to August 10, 1909, and from June 1, 1911 to March 31, 1912, the dam at Rockford was open and the control was temporarily changed.

Winter flow.—During the winter periods of 1911 and 1912 the flow was based on discharge measurements; prior to that time the station was discontinued during the frozen periods.

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

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							614	130	45	118	113	
2							502	128	46	116	111	
3							575	115	48	108	108	
4							533	114	63	115	110	
5							510	111	73	125	115	
6							468	105	66	125	110	
7							421	100	70	125	108	
8							378	100	39	125	108	
9							345	100	44	125	108	
10							306	130	45	139	105	
11							308	123	45	141	100	
12							450	141	116	139	106	
13							674	136	402	139	115	
14							686	123	299	134	139	
15						2,090	590	118	257	132	160	
16						2,200	500	110	214	129	162	
17						2,220	407	110	172	132	129	
18						2,150	348	111	143	116	151	
19						1,990	371	110	139	115	152	
20						1,820	257	105	129	118	166	
21						1,610	237	94	147	123	170	
22						1,350	226	92	192	122	172	
23						1,160	216	89	205	125	162	
24						1,030	195	79	195	122	154	
25						890	172	76	178	115	154	
26						787	162	76	158	111	174	
27						728	176	76	143	110	214	
28						728	148	70	123	108	257	
29						707	140	60	125	111	233	
30						665	135	54	125	108	222	
31							131	48		108		
1910.												
1				315	136	100	79	8	6.8	3.2	34	
2				295	139	100	83	4.6	6.8	3.2	33	
3				270	131	102	83	6	6	4.6	34	
4				260	125	101	79	6	5.6	6	33	
5				245	127	101	79	5.6	5.6	7.6	31	
6			190	239	128	102	77	6	4.2	9.6	36	
7			243	227	128	102	66	5.6	3.9	8.4	37	
8			331	212	128	95	56	5.6	4.2	9.6	41	
9			525	208	125	91	54	5.6	2.5	12	45	
10			626	197	118	97	68	6	2.5	14	42	
11			801	190	116	100	66	5.3	2.5	14	33	
12			1,040	182	115	97	62	5.3	2.5	14	31	
13			1,390	182	112	92	58	16	2.5	14	35	
14			1,800	170	110	96	51	17	2.5	14	40	
15			2,650	167	108	91	44	24	2.5	14	40	
16			2,020	159	110	86	44	18	2.5	19	38	
17			1,700	170	118	83	44	19	2.5	20	40	
18			1,500	176	118	81	44	20	2.5	23	38	
19			1,310	175	120	86	41	17	2.5	33	34	
20			1,130	176	129	83	37	20	2.5	33	35	
21			978	180	135	80	37	25	2.5	34	37	
22			829	183	131	79	28	23	2.5	39	35	
23			738	183	128	77	28	16	2.5	48	42	
24			644	180	127	75	40	11	2.5	45		
25			575	170	120	75	38	8.4	2.5	42		
26			525	163	114	96	34	8	5.3	44		
27			458	157	114	103	26	6.8	5.3	42		
28			412	156	112	95	25	6	4.6	39		
29			395	156	108	89	24	6.4	3.2	34		
30			348	145	105	80	16	7.6	3.2	42		
31			331		101		8.4	6		41		
1911.												
1			20	78	81	80	29	12	6	10	89	
2			20	79	81	65	24	21	5.3	10	68	
3			20	79	80	60	24	16	5.3	19	64	
4			25	78	77	55	23	10	10	33	77	
5			28	78	74	50	23	8	14	38	72	

Daily discharge, in second-feet, of South Fork of Crow River near Rockford —Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6			32	80	69	45	23	8	14	272	74	
7			38	78	69	40	23	8	14	557	69	
8			49	81	74	35	23	8	12	450	62	
9			64	81	70	30	24	8	12	341	59	
10			72	81	67	25	23	8	10	264	64	
11			78	86	58	20	22	8	19	212	56	
12			78	89	54	15	19	8	63	180		
13			80	90	45	13	18	8	60	160		
14			91	90	54	12	16	20	39	160		
15			77	91	74	13	16	34	24	173		
16			83	95	90	12	16	51	20	218		
17			81	95	90	12	17	36	17	378		
18			79	92	114	13	15	27	14	378		
19			81	96	131	12	14	20	13	329		
20			80	91	142	8	12	15	12	272		
21			88	91	145	9	10	14	12	239		
22			91	86	150	8	10	13	12	218		36
23			88	84	157	8	10	12	10	194		
24			80	80	156	8	10	8	10	175		
25			80	81	144	22	10	6	8	136		
26			84	80	123	48	10	6	8	129		
27			80	79	110	33	10	6	8	125		
28			83	81	103	42	6	6	10	115		
29			81	81	97	39	4	6	10	108		
30			80	83	91	31	5	6	10	103		
31			79		89		6	6		100		

Daily discharges based on a well defined rating curve except July 27 to August 10, 1909, when the control was temporarily changed. This curve was applied indirectly during the latter part of 1911.

Monthly discharge of South Fork of Crow River near Rockford.
[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (15-30)	2,220	665	1,380	1.19	0.71	B
July	686	131	361	.311	.36	B
August	141	48	101	.087	.10	C
September	402	39	135	.116	.13	C
October	141	108	122	.105	.12	B
November	257	100	146	.126	.14	C
1910.						
March (6-31)	2,650	190	903	.778	.75	B
April	315	145	196	.169	.19	B
May	139	101	121	.104	.12	B
June	103	75	91.2	.079	.09	B
July	83	8.4	49.0	.042	.05	B
August	25	4.6	11.1	.0096	.01	A
September	6.8	2.5	3.57	.0031	.003	A
October	48	3.2	23.4	.020	.02	B
November	45		37.0	.032	.04	C
1911.						
March	91	20	67.4	.057	.07	B
April	96	78	84.5	.072	.08	B
May	157	45	95.5	.082	.09	B
June	80	8	28.8	.024	.03	C
July	29	4	16.0	.014	.02	C
August	51	6	13.6	.012	.01	B
September	63	5.3	16.1	.014	.02	B
October	557	10	197	.168	.19	B
November	89		41.0	.035	.04	C
December			35.0	.030	.03	D
1912.						
January			[a] 20	.017	.02	C
February			[a] 10	.0086	.009	C
March			[a] 110	.095	.11	C

[a] Estimated.

CROW RIVER AT ROCKFORD.

Location.—At the highway bridge at Rockford, a little more than a mile below the junction of the North and South forks. Between the junction and the station are the outlets of Rebecca Lake and Lake Sarah, both of which are very small streams.

Records available.—June 4, 1909, to December 31, 1912.

Drainage area.—2,520 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Permanent.

Discharge measurements.—During high and medium stages discharge measurements are made from the bridge, but during low stages measurements are made from a boat and cable several hundred yards downstream.

Regulation.—A short distance above the station is the 7-foot dam of a flour mill which operates intermittently. As the turbine uses but a small portion of the flow, the effect of shutting it down is inappreciable at the gage except during extreme low water. At that time four readings per day are taken to determine the mean flow. This dam was partly destroyed May 31, 1911, and has not yet been rebuilt. Since that date the dam has no effect upon the flow at this station.

Winter flow.—Gage heights are affected by ice during extremely cold periods but for the remainder of the winter are unaffected.

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

Stations were originally established on both forks above their junction to be used as a check on the Rockford records, but the conditions on the North Fork were so unsatisfactory that its station was discontinued June 30, 1910.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							1,700	415	209	278	217	472
2							1,540	375	198	278	217	478
3							1,490	355	187	274	209	522
4						1,190	1,400	345	209	291	217	610
5						1,160	1,300	322	225	314	217	425
6						1,680	1,220	309	225	266	217	332
7						1,750	1,100	300	209	257	213	300
8						1,830	965	336	194	257	209	287
9						1,870	875	355	179	257	209	309
10						1,810	815	322	187	266	202	291
11						1,680	815	370	172	283	206	296
12						1,630	1,020	467	266	278	209	278
13						2,110	1,440	445	610	266	209	296
14						3,130	1,540	430	533	266	278	291
15						3,380	1,460	420	489	257	283	300
16						3,650	1,320	370	440	257	274	309
17						3,750	1,130	365	355	249	217	296
18						3,720	978	385	314	237	257	283
19						3,580	875	380	300	233	291	291
20						3,400	755	365	270	233	336	296
21						3,130	725	309	327	257	345	291
22						2,880	701	300	450	245	345	287
23						2,640	677	283	478	237	229	283
24						2,530	610	283	472	233	304	283
25						2,530	566	274	494	233	322	300

Daily discharge, in second-feet, of Crow River at Rockford—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
26						2,390	522	261	390	229	385	296
27						2,110	815	257	336	225	467	296
28						1,970	489	245	300	233	522	300
29						1,930	445	233	296	233	472	291
30						1,830	400	221	291	217	478	291
31							390	217		213		291
1910.												
1	291	233	206	833	309	172	107	64	67	54	85	93
2	291	233	202	797	304	172	93	64	67	49	85	90
3	291	225	202	737	283	165	88	58	69	62	85	96
4	287	225	194	713	266	158	88	60	67	62	85	76
5	291	225	217	665	266	158	80	58	69	58	90	90
6	291	221	249	643	266	172	78	58	69	60	76	85
7	287	217	332	610	270	158	83	60	64	62	85	85
8	283	217	395	599	287	151	78	58	64	64	73	85
9	283	217	755	560	291	144	83	52	64	45	85	80
10	291	217	1,040	538	261	118	80	54	60	62	83	83
11	291	217	1,370	511	249	144	76	52	60	64	80	73
12	291	209	1,790	484	253	141	76	51	58	62	76	80
13	283	209	2,270	456	241	125	74	58	56	60	76	78
14	278	217	2,860	425	241	131	71	67	58	58	85	78
15	278	209	3,760	445	241	131	71	69	58	60	85	80
16	283	209	3,530	430	257	125	71	74	58	51	80	76
17	283	206	3,080	425	300	118	71	74	60	58	80	78
18	287	209	2,860	462	274	112	76	71	56	62	85	73
19	287	217	2,640	467	283	104	71	71	58	58	90	80
20	287	209	2,510	478	300	96	71	69	54	67	85	76
21	274	209	2,220	472	318	88	74	67	54	71	90	76
22	274	202	1,980	467	300	90	71	67	52	74	96	71
23	266	202	1,810	467	291	85	71	67	52	74	96	71
24	257	209	1,630	450	274	83	64	67	49	76	85	67
25	249	202	1,460	420	257	90	64	64	45	80	96	54
26	245	202	1,330	395	233	115	67	64	56	83	96	54
27	241	209	1,190	385	221	151	69	64	56	85	88	67
28	241	209	1,100	385	202	144	67	64	52	88	96	67
29	241		1,020	355	190	134	69	64	52	88	96	67
30	241		953	332	179	115	64	69	52	74	96	67
31	233		881		172		64	69		85		67
1911.												
1	67	40	51	151	128	225	179	85	85	104	209	144
2	62	40	51	131	131	194	151	90	80	101	138	144
3	56	40	49	148	125	202	134	98	80	131	165	144
4	54	43	51	151	118	202	115	93	85	162	187	144
5	58	34	38	151	118	500	112	90	90	405	194	141
6	58	40	52	151	109	415	125	90	90	665	198	144
7	51	38	54	151	107	405	122	90	90	881	198	138
8	52	40	58	154	112	395	118	96	90	905	194	144
9	51	38	67	148	107	336	125	107	90	695	209	144
10	51	40	71	154	101	266	131	98	85	472	179	158
11	51	40	88	190	107	249	128	88	118	395	125	151
12	51	38	104	202	107	213	125	80	131	385	112	151
13	51	40	118	217	101	225	118	96	162	365	165	158
14	49	40	128	202	98	158	112	98	158	365	158	158
15	43	41	131	209	131	154	101	98	144	365	165	165
16	47	43	151	209	154	194	96	128	125	385	162	179
17	47	43	158	206	187	194	96	112	104	643	176	179
18	47	43	158	202	327	158	98	88	96	701	162	165
19	47	38	144	202	400	144	101	90	96	643	158	158
20	47	43	162	198	445	134	101	90	93	610	151	151
21	47	47	165	194	478	131	101	85	90	599	144	144
22	40	49	162	194	522	125	96	85	90	511	144	138
23	47	51	158	187	560	115	98	85	88	462	138	138
24	47	51	158	151	544	115	101	83	88	425	144	141
25	43	51	158	125	489	187	96	83	90	405	144	138
26	43	38	144	118	355	213	88	85	90	365	144	144
27	43	47	158	118	300	187	85	88	90	336	144	144
28	43	51	158	125	261	151	85	85	90	304	141	138
29	34		154	125	209	172	80	80	101	283	134	154
30	40		151	118	183	183	80	78	101	253	131	179
31	41		151		194		80	85		233		209

Daily discharge, in second-feet, of Crow River at Rockford—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
1				3,500	665	1.570	233	445	965	395	209	
2				2,270	638	1.500	213	420	965	370	202	
3				1,710	755	1.360	202	395	965	345	194	
4				1,570	1,220	1.220	217	355	905	340	183	
5				1,500	1,950	965	233	355	905	322	179	
6				1,290	2,510	785	274	365	845	304	172	
7				1,100	2,950	725	249	395	785	283	172	
8				905	3,310	665	233	472	725	266	172	
9				815	3,580	610	261	610	695	266	172	
10				725	3,850	528	283	665	665	257	172	
11				665	3,670	445	300	785	610	322	187	
12				610	3,580	395	327	965	555	345	187	
13				555	3,400	420	555	1,160	500	340	187	
14				665	3,040	472	528	1,100	500	322	172	
15				755	2,770	528	500	1,100	500	304	158	
16				725	2,430	528	445	1,030	500	300	151	
17				665	2,270	472	395	1,160	500	283	151	
18				610	2,030	445	336	1,290	500	274	151	
19				555	1,790	445	309	1,360	472	266	158	
20				500	1,640	420	345	1,430	472	257	165	
21				500	1,500	420	345	1,360	445	257	172	
22				555	1,500	395	370	1,360	445	249	172	
23				528	1,360	395	582	1,290	445	241	176	
24				528	1,290	370	755	1,220	445	233	165	
25				500	1,290	345	755	1,160	445	229	158	
26				555	1,360	610	725	1,100	420	225	151	
27				665	1,430	555	665	1,030	420	225	151	
28				755	1,500	420	610	965	395	225	144	
29				755	1,500	327	610	965	395	229	138	
30				725	1,570	257	555	1,030	395	225	141	
31					1,570		528	1,030		217		

NOTE.—Daily discharges determined from a well-defined rating curve.

Monthly discharge of Crow River at Rockford.

[Drainage area, 2,520 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (4-30)	3,750	1,160	2,420	0.960	0.96	A
July	1,700	390	970	.385	.44	A
August	467	217	333	.132	.15	A
September	494	172	320	.127	.14	A
October	314	213	253	.100	.12	A
November	522	202	285	.113	.13	A
December	610	278	328	.130	.15	A
1910.						
January	291	233	274	.109	.13	B
February	233	202	214	.085	.09	B
March	3,760	194	1,490	.591	.68	A
April	833	332	514	.204	.23	A
May	318	172	261	.104	.12	A
June	172	83	130	.052	.06	A
July	107	64	75.2	.030	.03	A
August	74	51	63.5	.025	.03	B
September	69	45	58.5	.023	.03	B
October	88	45	66.3	.026	.03	B
November	96	73	86.3	.034	.04	B
December	96	54	76.2	.030	.04	B
The year	3,760	45	276	.109	1.51	

Monthly discharge of Crow River at Rockford—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
January	67	34	48.6	0.019	0.02	B
February	51	34	42.4	.017	.02	B
March	165	38	116	.046	.05	A
April	217	118	166	.066	.07	A
May	560	98	229	.091	.10	A
June	500	115	218	.087	.10	A
July	179	80	109	.043	.05	A
August	128	78	91.2	.036	.04	A
September	162	80	100	.040	.04	A
October	905	101	437	.173	.20	A
November	209	112	160	.064	.07	A
December	209	138	152	.060	.07	B
The year	905	34	157	.062	.83	
1912.						
January			60	.024	.03	C
February			70	.028	.03	C
March			380	.151	.17	C
April	[a]3,500	500	925	.367	.41	B
May	3,850	638	2,060	.817	.94	A
June	1,570	257	620	.246	.27	A
July	755	202	417	.165	.19	A
August	1,430	355	915	.363	.42	A
September	965	395	593	.235	.26	A
October	395	217	281	.112	.13	A
November	209	138	169	.067	.07	A

NOTE.—Practically open-water conditions during the winter except during 1912, when the winter estimates were based on discharge measurements and climatological data.

[a] Estimated.

CROW RIVER NEAR DAYTON.

Location.—One mile above the mouth of the river near Dayton. There is no tributary of importance below the junction of the North and South Forks. This station was maintained by the United States Engineer Corps.

Records available.—October 14, 1896, to September 13, 1897. These records have been compiled from unpublished data in the United States Engineer Office at St. Paul. As the drainage area at this point is only 3% larger than that at Rockford with no intervening tributaries, the records at the two points are directly comparable.

Drainage area.—2,590 square miles.

Gage.—No data. This was relatively unimportant as very frequent discharge measurements were made, and the estimates based almost directly on these.

Winter flow.—The river was frozen over during the winter months, but measurements were made to determine the discharge.

Daily discharge, in second-feet, of Crow River near Dayton.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
1												
2												
3												
4											227	128
5												
6											227	
7												103
8												
9												
10												
11											299	92
12												
13											164	
14										175		
15												
16												
17											52	
18												100
19												
20												
21										155	136	
22												127
23										131		
24												
25												
26										118		
27												
28										101		
29												
30										223		
31												
1897.												
1					1,730	462	1,010	1,740	706			
2					1,630	365	1,090	1,670	792			
3		88			1,540	408	1,170	1,580	933			
4	138				1,440	773		1,520	927			
5			118		1,310	480		1,440	991			
6					1,280	456		1,370	1,030			
7					1,190	787		1,320	1,060			
8					1,120	745		1,300	1,040			
9				9,180	1,050	689		1,230	1,020			
10			106	8,440	985	675	2,030	1,180	997			
11	185			7,690	962	717	2,500	1,120	997			
12				6,940	948	689	3,100	1,120	1,050			
13				6,190	932	689	3,050	1,010	1,060			
14	135			5,440	872	716	3,100	1,000				
15				5,040	815	717	3,150	997				
16			87	4,650	794	696	3,250	968				
17		105		4,360	780	815	3,320	939				
18				4,080	745	880	3,080	916				
19				3,790	731	932	2,840	910				
20				3,510	731	948	2,610	870				
21				3,230	647	984	2,700	854				
22				3,110	627	1,020	2,610	826				
23				2,920	536	1,000	2,400	814				
24		83		2,800	536	962	2,350	803				
25				2,610	530	888	2,380	760				
26		86	1,480	2,410	530	815	2,390	743				
27				2,220	530	731	2,170	722				
28				2,090	530	948	2,100	706				
29				1,920	530	948	1,990	663				
30	100			1,840	498	955	1,950	648				
31					486		1,830	674				

Monthly discharge of Crow River near Dayton.

[Drainage area, 2,590 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1896.					
October			[a] 150	0.058	0.07
November			[a] 185	.071	.08
December			[a] 110	.042	.05
1897.					
January			[a] 135	.052	.06
February			[a] 90	.035	.04
March			[a] 500	.193	.22
April (9-30)	9,180	1,840	4,290	1.66	1.36
May	1,730	486	889	.343	.40
June	1,020	365	763	.295	.33
July (25 days)	3,320	1,010	2,410	.931	.87
August	1,740	648	1,050	.405	.47
September (1-13)	1,060	706	969	.374	.18

[a] Estimated.

DEVELOPED WATER POWER.

Although the low-water discharge of Crow River is very small there are three power plants on the main river and seven on the various forks. These developments are as follows:

NORTH FORK.

There are four points on the North Fork at which water power is developed, Manannah, Forest City, Kingston and French Lake. These plants are all small, and it is probable they do not develop more than 50 horsepower each.

MIDDLE FORK.

Green Lake.—At this point there is a developed water power utilizing a head of 7 feet and generating an average of 75 horsepower by means of 2 turbines.

New London.—The New London Milling Co. utilizes a head ranging from 8 to 16 feet (averaging 12 feet) in operating a flour and feed mill. There is a 36-inch American turbine of 160 horsepower capacity which develops an average of 100 horsepower.

SOUTH FORK.

Near Hutchinson.—A flour mill develops an average of 60 horsepower under an 8-foot head by means of one turbine.

CROW RIVER.

Rockford.—There is a timber dam at this point which creates a head of 7 feet. At the right end of the dam is located the feed mill which contains a 52-inch Houston turbine of 35 horsepower capacity. The average power utilized is about 20 horsepower. No flashboards are used on the dam as the water supply is sufficient. The water is backed upstream for about 3 miles. The plant is operated intermittently.

Hanover.—The Hanover Roller Mills have a dam which creates a head of 7 feet and which backs the water nearly 3 miles upstream. At the left end of the dam is located the power plant. There are one 61-inch Leffel turbine of 43 horsepower capacity, one 52-inch Leffel turbine of 28 horsepower capacity, and one 44-inch Leffel turbine of 32 horsepower capacity. These wheels are on vertical shafts set in open forebay. The shafts of the two larger turbines are bevel geared to a horizontal shaft which is connected with the mill machinery by belting. These wheels are controlled by two hand governors. The third wheel which has an automatic governor is belt-connected to a 24 KW Peerless direct current generator of 220 volts, used in lighting Hanover. The mill operates intermittently during the day, and the lighting plant is run at night. There is an auxiliary steam plant of 75 horsepower. About 35 horsepower are required to run the mill.

A wooden flume 400 feet long supplies water from the pond above the Hanover Roller Mills to the power plant of Saenger's Saw Mill. This consists of a 56-inch Leffel turbine of 53 horsepower capacity and a 30-inch Victor turbine of 34 horsepower capacity. These are set on vertical shafts bevel geared to a horizontal shaft, belt connected to the Saw Mill machinery. The plant is operated intermittently and requires about 25 horsepower. There is an auxiliary steam plant of 30 horsepower for use chiefly during the winter months, as the water right is second to that of the roller mills.

Bernings Mill 2 miles east of St. Michael.—A dam at this point creates a head of 5½ feet which is utilized by one 48-inch Leffel turbine of 20 horsepower capacity, one 40-inch Leffel turbine of 13 horsepower capacity and one 40-inch New American turbine of 25 horsepower capacity. These turbines are used in operating a roller mill and saw mill. The average development is about 40 horsepower.

With the exception of the rather fragmentary records at Dayton, the period covered by the continuous records includes the extremely low flow of the winters of 1910, 1911 and 1912, so that the low flow for an ordinary year is somewhat uncertain. The following table has been compiled from the existing records, and shows the available continuous horsepower at the developed sites on the main river. The records on the forks are too fragmentary on which to base estimates:

Available horsepower at developed power sites.

Developed Site.	Head in feet.	Minimum Run-off.		Horsepower (80% Efficiency).	
		Lowest month.	Lowest month, average low year.	Lowest month.	Lowest month average low year.
Rockford	7	40	100	25	64
Hanover	7	40	100	25	64
Bernings Mill	5.5	40	100	20	50

SANITARY STATISTICS.

To show the sanitary quality of the water in Crow River and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more, located on the river or its tributaries. These data are given in the following table in order of location beginning near the source.

Municipal water supply and sewage disposal of towns on Crow River and tributaries.

Town.	Distance above mouth	Population 1910.	Water Works System.			Sewerage System.		Rural population of basin per square mile.
			Source of supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
			North Fork Crow River					26.3
Paynesville	190	901	wells	no	20,000	none	...	...
Buffalo	80	1,229	none	...	...	none	...	...
			South Fork Crow River					30.2
Hutchinson	150	2,368	deep well	no	55,000	river	no	...
Mouth Buffalo Creek	75	...	...	...	...	...	...	...
Delano	50	1,031	wells	no	60,000	S. Fk. Crow	no	...
			Buffalo Creek					
Brownton	38	509	well	no	...	none	...	...
Glencoe	20	1,788	deep well	no	60,000	none	...	...

From the preceding table it is seen that the North Fork receives no urban sewage nor is the water used for municipal purposes. The rural population in this basin is 26.3 per square mile.

The South Fork receives untreated sewage from Hutchinson and Delano, representing a population of 3,400. As the river below Delano has considerable fall, although ponded by dams at Rockford, Hanover and Bernings Mill, it is probable that sewage pollution will be found at the mouth of Crow River. The rural population in the basin of the South Fork is 30.2 per square mile.

No water from the Crow or its tributaries is used for municipal purposes.

RUM RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The area drained by Rum River lies east of the central part of Minnesota, chiefly in Mille Lacs, Isanti and Anoka counties. Rum River rises in Lake Mille Lacs (207 square miles in area), and for 16 miles flows through three lakes bordered by flat, marshy shores; the entire fall in this distance being not more than 2 feet. Below the lakes the river winds southward as far as Princeton, where it is joined by the West Branch. Below Princeton it flows eastward in a still more winding course until it reaches Cambridge, where it turns to the south and enters the Mississippi at Anoka.

For a distance of 50 miles below the lakes the fall of the river is heavy, but from Bogus Brook to the St. Francis dam the fall is slight. From St. Francis to Cedar Creek, a distance of 10 miles, there is considerable fall, but below this point the slope is very flat, as the influence of the Anoka dam reaches nearly to this point. Along the upper stretch of the river the banks are low, but their height gradually increases and at Page they are 20 to 30 feet above the water surface. They continue high to Princeton—are low between that point and Cambridge, and below Cambridge rise again to a general height of 20 feet or more.

The principal tributaries are West Branch, Tibbetts, Bogus and Spencer brooks, and Upper and Lower Stanchfield and Cedar creeks. With the exception of the West Branch the streams are small.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The general surface of the basin is level or gently undulating. There are but few lakes except Mille Lacs and 20 small lakes in the immediate vicinity, which have a combined water surface of 240 square miles. Altitudes range from 850 to 1,300 feet above sea level. The area is covered by a thick glacial deposit of red till, beneath which are Archean granites and gneisses or Upper Cambrian sandstones and limestones. Along the Rum River Valley are deposits of modified drift composed of sand and gravel. Rock is exposed only at a few places along upper Rum River and the West Branch.

Below Princeton the greater part of the area is under cultivation, but between Princeton and Milaca the proportion of cleared and cultivated land becomes smaller, and above Milaca, except for isolated clearings and farms along the river, the area is covered with brush. Practically the entire area has been cut over and logging has ceased in the basin.

RAINFALL AND RUNOFF.

The mean annual rainfall is about 28.5 inches of which 3 inches are precipitated in the form of snow. The nearest long time record is at Minneapolis and is continuous from 1866. The wettest year was 1868 when the rainfall was 41.6 inches, and the driest 1910, when the precipitation was 11.6 inches.

Runoff records of Rum River have been maintained continuously since 1909. These show a runoff ranging from 1.87 to 2.41 inches or from 6.7 to 16.9 per cent of the rainfall.

REGULATION OF FLOW.

Lake Mille Lacs forms a natural reservoir for Rum River, tending to equalize its flow. In years of very low flow, however, this regulation is detrimental to the river, as of the area at the outlet more than half is comprised within the lake surface itself, where evaporation exceeds precipitation by 6 inches or more. This loss must be made up from the small tributary runoff. The effect of this is seen in the period of low rainfall from the spring of 1910 to the summer of 1911. The runoff at Onamia, which included not only Lake Mille Lacs but the three small lakes below its outlet, was very small and ceased entirely during the winter. During the greater portion of this period there was said to be no flow from Mille Lacs, the flow past Onamia representing the area below the lake.

DRAINAGE WORK

Owing to the general flatness of portions of the basin, drainage is defective. The following table compiled from the Report of the State Drainage Commission shows the need for improved drainage and the work already accomplished:

Drainage in Rum River basin.

County.	Original swamp area, acres.	Benefited by drainage, acres.
Mille Lacs	34,000	6,600
Isanti	20,000	7,400
Anoka	50,000	54,000

DRAINAGE AREAS.

The following drainage areas have been measured in the basin of Rum River:

Drainage area in square miles in Rum River basin.

River.	Above.	Square miles.
Rum River	Mille Lacs Lake Outlet	378
Do	Onamia	414
Do	Sec. 10, T 39 N, R 27 W	544
Do	Sec. 27, T 39 N, R 27 W	601
Do	Sec. 34, T 37 N, R 26 W	721
Do	Cambridge	1,160
Do	Cedar Creek	1,360
Do	Gaging Station near Anoka	1,430
Do	Mouth	1,550
West Branch	Mouth	167

GAGING STATION RECORDS.

RUM RIVER AT ONAMIA.

Location.—At the steel highway bridge at Onamia, 200 yards below the outlet of Lake Onamia and 5 miles above the mouth of Bradbury Brook.

Records available.—September 24, 1909, to December 31, 1912.

Drainage area.—414 square miles, of which 207 square miles are taken up by the water surface of Mille Lacs Lake.

Gage.—Vertical staff. The gage was located originally at the wooden highway bridge just below the Soo Railway bridge, but May 4, 1910, this bridge was destroyed and the gage moved 200 yards downstream to the steel highway bridge. The new gage was set to read the same as the old one.

Channel.—Shifting, affected by grass and high water.

Discharge measurements.—Made from the steel highway bridge.

Regulation.—Two miles below Onamia is an abandoned logging dam which raises the water level about 3 feet but does not control the flow. As there is a good fall to the river, the influence of this dam does not reach the gaging station. Owing to the natural storage afforded by the lakes, the range of stage at Onamia is slight.

Winter flow.—At the original location gage heights were practically unaffected by ice. At the present location, however, the river freezes over.

Accuracy.—The extremely low water of 1911 was favorable to the growth of grass in the river channel. This growth created an appreciable backwater at the gage and therefore the records for that period are not as reliable as during the remainder of the period.

Daily discharge, in second-feet, of Rum River at Onamia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1										94	94	154
2										94	94	154
3										94	94	180
4										94	94	180
5										94	94	167
6										94	94	154
7										94	94	141
8										94	94	128
9										94	94	108
10										94	106	88
11										106	106	68
12										106	106	68
13										128	106	68
14										180	119	68
15										239	138	57
16										180	154	57
17										170	154	57
18										154	154	57
19										154	154	55
20										138	138	54
21										138	138	52
22										128	138	50
23										119	138	50
24									94	106	138	50
25									94	94	128	50
26									94	94	128	50
27									94	94	128	48
28									94	94	128	47
29									94	94	138	45
30									94	94	138	45
31										94		45
1910.												
1	45	78	78	387	272	227	68	25	9.6	7.0	7.8	3.5
2	45	78	78	372	272	227	57	25	9.6	7.0	7.9	3.5
3	45	78	78	359	272	210	50	25	8.5	7.0	7.0	3.5
4	45	78	78	359	272	210	50	25	7.9	6.1	7.0	3.5
5	45	78	78	372	252	192	45	23	7.9	6.1	6.1	3.0
6	47	78	78	372	252	180	38	23	7.0	6.1	5.5	3.0
7	48	78	78	372	252	180	30	23	7.0	5.5	5.5	3.0
8	50	78	85	359	252	170	25	23	7.0	5.5	5.5	3.0
9	50	78	85	338	239	170	25	23	6.1	5.0	5.5	3.0
10	50	78	85	338	239	154	25	20	6.1	5.0	5.0	3.0
11	50	78	85	338	227	154	25	20	6.1	5.0	5.0	3.0
12	50	78	85	338	210	138	25	23	6.1	5.5	5.0	3.0
13	56	68	94	338	210	138	23	23	5.5	5.5	4.2	3.0
14	62	68	106	338	192	128	23	23	5.5	5.5	4.2	3.0
15	68	68	119	359	192	128	25	20	5.5	5.5	4.2	3.0
16	68	68	128	372	192	119	25	16	5.5	5.5	4.2	3.0
17	68	68	154	372	210	106	25	16	5.5	5.5	4.2	3.0
18	68	68	170	359	210	94	25	16	5.5	5.5	4.2	3.0
19	78	68	180	359	210	85	25	16	5.5	6.1	4.2	3.0
20	85	68	210	338	210	78	25	14	5.0	6.1	4.2	3.0
21	85	68	239	338	210	78	25	14	5.0	6.1	4.2	3.0
22	78	68	272	338	192	57	25	14	4.2	6.1	4.2	3.0
23	78	68	292	318	192	45	25	14	4.2	7.0	4.2	3.0
24	78	78	305	305	192	45	25	13	3.5	7.0	4.2	3.0
25	78	78	338	305	210	38	25	13	3.5	7.9	4.2	3.0
26	78	78	372	305	210	45	25	13	3.5	7.9	4.2	2.5
27	78	78	372	292	227	50	25	13	4.2	8.5	3.5	2.5
28	78	78	387	292	227	57	25	13	5.0	8.5	3.5	2.5
29	78		387	292	239	68	25	11	5.5	8.5	3.5	2.5
30	78		387	292	239	78	25	11	6.7	8.5	3.5	2.5
31	78		387		239		25	11		8.5		2.5
1911.												
1				3.4	4.8	2.9	7.4	1.2	0.6	6.0	14.5	8.5
2				3.4	4.3	3.2	7.4	1.2	.7	6.0	14.5	8.5
3				3.4	3.8	3.8	6.1	1.4	.7	7.0	14.5	8.5
4				3.8	3.4	4.1	6.1	1.4	.7	7.0	14.5	8.5
5				3.8	3.2	4.3	6.1	1.4	.7	7.0	14.5	8.5

Daily discharge, in second-feet, of Rum River at Onamia—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6	......	......	......	3.8	2.9	4.8	5.2	1.4	.8	8.5	14.5	8.5
7	......	......	......	4.3	2.6	5.2	4.8	1.2	.8	10.0	14.5	7.0
8	......	......	......	4.3	2.9	6.1	4.8	1.2	.8	11.0	12.4	7.0
9	......	......	......	4.8	2.9	7.4	4.3	1.2	.8	11.0	12.4	7.0
10	......	......	......	4.8	2.9	8.6	3.8	.9	1.0	12.4	12.4	6.0
11	......	......	......	5.2	2.6	8.6	3.4	.9	1.1	12.4	12.4	6.0
12	......	......	......	5.2	2.6	8.6	3.2	.9	1.2	14.5	11.0	6.0
13	......	......	......	6.1	2.4	8.6	2.9	.9	1.5	16.6	11.0	6.0
14	......	......	......	7.4	2.6	9.5	2.6	.9	2.4	16.6	11.0	6.0
15	......	......	......	8.6	2.6	9.5	1.5	1.2	3.0	18.0	11.0	6.0
16	......	......	......	9.5	2.9	9.5	1.5	1.2	3.6	18.0	11.0	......
17	......	......	......	9.5	2.9	9.5	1.5	1.2	4.5	18.0	11.0	......
18	......	......	......	9.5	3.2	8.6	1.5	1.2	4.5	18.0	11.0	......
19	......	......	......	9.5	3.2	8.6	1.5	1.2	5.4	16.6	11.0	......
20	......	......	......	9.5	3.4	7.4	1.5	1.2	5.4	16.6	10.0	......
21	......	......	1	9.5	3.4	7.4	1.4	1.2	5.4	18.0	10.0	......
22	......	......	2	8.6	3.2	8.6	1.4	.9	5.4	18.0	10.0	......
23	......	......	3	8.6	3.2	8.6	1.4	.9	5.4	18.0	10.0	......
24	......	......	3	8.6	2.9	7.4	1.2	.9	5.4	16.6	10.0	......
25	......	......	3	7.4	2.6	7.4	1.2	.9	6.0	16.6	10.0	......
26	......	......	3	7.4	2.6	7.4	1.2	.9	6.0	16.6	10.0	......
27	......	......	3	6.1	2.4	7.4	.9	.8	6.0	16.6	8.5	......
28	......	......	3	6.1	2.4	7.4	.9	.8	6.0	14.5	8.5	......
29	......	......	3	6.1	2.4	7.4	.9	.7	6.0	14.5	8.5	......
30	......	......	3	5.2	2.4	6.9	.9	.6	6.0	14.5	8.5	......
31	......	......	3	......	2.6	......	1.2	.6	......	14.5	......	......
1912.												
1	......	......	......	2	24	62	29	14	15	10	7.5	......
2	......	......	......	4.6	27	62	29	13	15	10	7.5	......
3	......	......	......	5.5	38	62	27	12	15	10	7.5	......
4	......	......	......	7.8	56	56	27	12	15	10	7.5	......
5	......	......	......	9	78	51	24	11	15	10	7.5	......
6	......	......	......	11	140	51	24	12	14	9	7.5	......
7	......	......	......	12	170	47	22	13	14	9	6.6	......
8	......	......	......	14	210	43	20	14	14	9	6.6	......
9	......	......	......	18	190	43	19	14	14	9	6.6	......
10	......	......	......	24	170	38	19	15	14	9	6.6	......
11	......	......	......	27	170	33	18	15	14	9	6.0	......
12	......	......	......	27	155	33	16	15	13	10	6.0	......
13	......	......	......	29	140	33	15	14	13	10	6.0	......
14	......	......	......	29	140	33	15	14	13	10	6.0	......
15	......	......	......	29	127	38	15	14	12	9	6.0	......
16	......	......	......	33	114	43	15	14	12	9	6.0	......
17	......	......	......	33	114	43	15	15	12	9	6.0	......
18	......	......	......	29	102	47	15	14	11	9	6.0	......
19	......	......	......	29	89	47	14	14	11	9	5.6	......
20	......	......	......	29	84	47	14	14	10	9	5.6	......
21	......	......	......	33	71	43	14	14	10	8.4	5.6	......
22	......	......	......	33	71	43	14	14	10	8.4	5.6	......
23	......	......	......	38	78	43	15	14	10	8.4	5.0	......
24	......	......	......	43	71	38	16	14	9	8.4	5.0	......
25	......	......	......	43	66	38	15	14	9	8.4	5.0	......
26	......	......	......	47	66	38	15	14	10	7.5	4.4	......
27	......	......	......	43	66	33	15	14	10	7.5	4.4	......
28	......	......	......	38	66	33	14	14	10	7.5	4.0	......
29	......	......	......	29	66	29	14	14	10	7.5	4.0	......
30	......	......	......	27	66	29	14	15	10	7.5	3.6	......
31	......	......	......	......	66	......	14	15	......	7.5	......	......

Daily discharges for 1909 and 1910 computed from a well defined rating curve, except during December, 1910, for which period it is estimated. Daily discharge for 1911 and 1912 computed from two rating tables not well defined.

Monthly discharge of Rum River at Onamia.

[Drainage area, 414 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
Sept. (24-30)	94	94	94.0	0.227	0.06	B
October	239	94	118	.285	.33	B
November	154	94	121	.292	.33	B
December	180	45	83.7	.202	.23	B
1910.						
January	85	45	64.1	.155	.18	B
February	78	68	74.1	.179	.19	B
March	387	78	189	.457	.53	B
April	387	292	341	.824	.92	B
May	272	192	226	.546	.63	B
June	227	38	122	.295	.33	A
July	68	23	30.1	.073	.08	A
August	25	11	18.1	.044	.05	A
September	9.6	3.5	5.92	.014	.02	A
October	8.5	5.0	6.47	.016	.02	A
November	7.9	3.5	4.86	.012	.01	A
December	3.5	2.5	[1]3.00	.007	.008	D
The year	387	2.5	90.4	.218	2.97	
1911.						
January	.0	.0	.00	.000	.00	B
February	.0	.0	.00	.000	.00	B
March	3.0	.0	.97	.0023	.003	B
April	9.5	3.4	6.45	.016	.02	C
May	4.8	2.4	2.97	.0072	.008	C
June	9.5	2.9	7.16	.017	.02	C
July	7.4	.9	2.89	.0070	.008	C
August	4.4	.6	1.05	.0025	.003	C
September	6.0	.6	3.26	.0079	.009	B
October	18.0	6.0	13.9	.034	.04	B
November	14.5	8.5	11.4	.028	.03	C
December	8.5	.0	[1]5.03	.012	.01	D
The year	18.0	.0	4.60	.011	.15	
1912.						
January			[1].00	.0000	.000	
February			[1].00	.0000	.000	
March			[1]2.0	.0048	.006	
April	47	2	25.9	.063	.07	D
May	210	24	99.7	.241	.28	B
June	62	29	42.6	.103	.11	B
July	29	14	17.8	.043	.05	C
August	15	11	13.8	.033	.04	D
September	15	9	12.1	.029	.03	D
October	10	7.5	8.87	.021	.02	C
November	7.5	3.6	5.91	.014	.02	C

[1] Estimated.

RUM RIVER AT CAMBRIDGE.

Location.—At highway bridge ½ mile west of Cambridge. No tributary within several miles.

Records available.—June 12, 1909, to December 31, 1912.

Drainage area.—1,160 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Shifting.

Discharge measurements.—Made from the bridge.

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

Winter flow.—From December to March, discharge measurements are made through ice to determine the winter flow.

Accuracy.—During the summer of 1911 and 1912 grass grew in the channel to such an extent that it caused backwater in varying amount at the gage. Therefore during that period the records cannot be considered better than fair. The remainder of the records are believed to be good.

Daily discharge, in second-feet, of Rum River at Cambridge.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.[a]												
1							724	314	156	297	227	
2							667	280	156	290	240	
3							583	259	156	278	242	
4							527	252	149	273	236	
5							485	236	153	273	236	
6							458	220	158	264	236	
7							418	209	145	249	231	
8							391	227	145	242	227	
9							352	229	162	245	220	
10							327	249	156	254	227	
11							317	292	156	259	227	
12						1,040	337	302	166	283	220	
13						956	330	317	168	268	220	
14						898	314	399	179	273	302	
15						855	300	428	183	290	373	
16						826	276	394	170	290	434	
17						812	256	352	162	278	485	
18						797	242	314	164	278	472	
19						797	227	283	187	268	460	
20						754	245	252	185	256	448	
21						696	409	240	283	266	438	
22						667	469	213	535	254	429	
23						870	431	205	547	249	419	
24						1,030	472	200	544	249	410	
25						1,130	502	191	510	249	400	
26						1,160	463	187	444	242	391	
27						1,130	409	183	401	233	442	
28						1,060	365	183	365	227	455	
29						942	375	183	340	227	381	
30						840	352	176	322	231	391	
31							332	156		227		

[a] Daily discharge computed from a fairly well defined rating curve, except Mar. 1 to 11, 1910, for which period it was estimated.

Daily discharge, in second-feet, of Rum River at Cambridge—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.[a]												
1			135	742	372	211	130	78	84	99	78	100
2			135	717	354	205	121	81	85	99	81	92
3			135	692	352	199	110	81	86	94	81	89
4			140	661	344	195	107	73	89	92	81	
5			140	629	337	197	104	72	86	91	84	
6			150	602	320	213	101	71	89	81	72	
7			200	594	287	215	95	73	89	86	73	
8			250	585	299	211	94	76	84	79	72	
9			300	558	287	205	92	79	81	78	85	
10			400	530	283	197	94	71	81	78	60	
11			500	501	280	187	94	72	79	76	72	
12			634	488	269	176	95	76	81	76	61	
13			731	480	260	172	95	79	81	76	79	
14			815	465	260	165	92	84	81	76	89	
15	170		892	462	254	158	91	86	78	76	76	
16			1,040	452	246	154	85	91	78	73	73	
17			1,230	446	260	147	81	104	78	76	64	
18			1,340	454	290	138	81	107	76	77	77	
19			1,280	470	296	132	81	104	76	92	86	
20			1,260	475	311	125	78	100	76	86	89	
21			1,260	488	306	123	76	100	78	86	85	
22			1,240	488	306	115	76	98	76	85	79	
23			1,210	454	303	109	81	91	72	85	85	
24			1,140	452	299	101	98	89	72	85	89	
25			1,080	470	287	106	95	89	76	85	86	
26			1,010	472	274	107	91	91	95	85	85	
27			970	444	274	110	86	85	107	85	84	
28			915	419	265	121	89	81	106	84	98	44
29			869	396	246	130	86	79	107	81	76	
30			823	386	231	132	84	84	98	78	89	
31			779		223		84	84		81		
1911.[b]												
1			63	79	87	158	319	190	70	98	168	
2			63	79	89	147	301	215	72	97	140	
3			65	75	84	153	275	240	68	116	146	
4			70	72	80	176	262	242	76	150	157	
5			75	80	82	209	294	251	80	150	118	
6			80	81	80	220	302	247	90	195	155	
7			100	78	77	569	287	232	88	254	139	
8			125	82	69	619	275	233	89	216	135	
9			150	84	69	547	265	233	96	370	130	
10			183	87	71	474	246	225	115	455	130	
11			166	91	77	428	220	196	145	450		
12			196	118	69	418	200	195	165	395		
13			166	174	68	407	182	194	152	345		
14			153	189	69	381	172	205	141	285		
15			233	185	149	362	169	205	139	251		
16			174	179	266	355	156	190	145	240		
17			153	162	290	342	151	172	131	305		
18			149	135	332	337	157	161	158	380		
19			121	162	362	321	160	160	198	425		
20			111	183	381	322	161	158	194	455		
21			114	174	485	314	155	135	183	450		
22			89	162	622	307	151	113	176	400		
23			87	149	580	300	150	104	146	360		
24			92	129	482	288	150	91	120	325		
25			86	125	415	278	155	84	107	295		
26			94	116	404	280	148	72	97	271		
27			95	80	342	280	145	68	87	260		
28			107	106	273	278	164	64	98	245		
29			94	100	227	297	165	60	107	225		
30			86	109	198	322	180	62	105	202		
31			84		174		180	64		183		

[a] Daily discharge computed from a fairly well defined rating curve, except Mar. 1 to 11, 1910, for which period it was estimated.

[b] Daily discharge computed from a rating curve not very well defined which was applied indirectly during 1911 and 1912 owing to shifting conditions.

Daily discharge, in second-feet, of Rum River at Cambridge—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.[b]												
1				500	1,220	1,600	120	178	215	150	110	
2				900	1,100	1,320	110	140	320	150	110	
3				1,520	1,010	1,000	110	118	500	140	110	
4				1,740	1,100	870	120	108	620	140	110	
5				1,520	1,460	780	140	98	650	130	110	
6				1,380	2,020	710	130	118	590	130	110	
7				1,320	3,320	620	120	118	470	120	110	
8				1,250	4,550	560	110	118	380	120	110	
9				1,190	4,900	500	100	118	290	130	110	
10				1,100	4,650	440	100	129	240	120	110	
11				1,010	4,000	390	90	118	190	130	110	
12				890	3,480	360	110	118	165	140	110	
13			74	803	2,920	320	100	108	150	160	110	
14				774	2,400	320	90	108	140	150	110	
15				774	1,880	320	90	98	120	150	110	
16				803	1,520	320	90	98	130	160	110	
17				890	1,280	290	90	152	130	140	110	
18				980	1,160	290	80	190	120	140	110	
19				980	1,020	320	70	178	130	130	110	
20				950	910	320	80	178	130	130	115	
21				832	840	290	70	165	130	120	115	
22				774	1,020	260	60	140	140	120	115	
23				717	1,280	240	120	140	140	120	115	
24				717	1,490	210	160	118	130	120	115	
25				745	1,660	210	160	118	150	110	115	
26				717	1,770	190	210	98	160	110	115	
27				717	1,920	170	320	88	150	110	115	
28				890	1,920	160	380	88	150	100	110	
29				1,130	1,840	160	350	78	140	110	110	
30				1,220	1,840	140	290	129	140	120	110	
31					1,770		210	190		110		

[b] Daily discharge computed from a rating curve not very well defined which was applied indirectly during 1911 and 1912 owing to shifting conditions.

Monthly discharge of Rum River at Cambridge.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (12-30)	1,160	667	908	0.783	0.55	A
July	724	227	399	.344	.40	A
August	428	156	256	.221	.25	A
September	547	145	252	.217	.24	A
October	297	227	260	.224	.26	A
November	485	220	337	.291	.32	B
December			[a]210	.181	.21	C
1910.						
January			[a]155	.134	.15	C
February			[a]145	.125	.13	C
March	1,340	135	742	.640	.74	B
April	742	386	516	.445	.50	B
May	372	223	290	.250	.29	B
June	215	101	159	.137	.15	A
July	130	76	92.5	.080	.09	A
August	107	71	84.8	.073	.08	A
September	107	72	84.2	.073	.08	A
October	99	73	83.3	.072	.08	A
November	98	60	79.6	.067	.07	A
December			[a]55.0	.047	.05	D
The year	1,340		207	.178	2.41	

Monthly discharge of Rum River at Cambridge—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum	Minimum	Mean	Per square mile.		
1911.						
January			[a]45	0.039	0.04	C
February			[a]55	.047	.05	D
March	233	[b]63	117	.101	.12	C
April	189	72	121	.104	.12	B
May	622	68	228	.197	.23	B
June	619	147	330	.284	.32	B
July	319	145	203	.175	.20	D
August	251	60	163	.141	.16	C
September	198	68	121	.104	.12	C
October	455	97	285	.246	.28	C
November	168	[b]110	125	.108	.12	C
December			[a]114	.098	.11	C
The year	622		160	.138	1.87	
1912.						
January			[a]80	.069	.08	C
February			[a]70	.060	.06	C
March			[a]100	.086	.10	C
April	1,740	500	991	.854	.95	B
May	4,900	840	2,040	1.76	2.03	B
June	1,600	140	456	.393	.44	C
July	380	60	141	.122	.14	C
August	190	78	127	.109	.13	C
September	650	120	237	.204	.23	C
October	160	100	129	.111	.13	B
November	115	110	111	.096	.11	C

[a] Estimated from ice measurements and semi-weekly gage heights.
[b] Estimated.

RUM RIVER NEAR ANOKA.

Location.—At highway bridge on line between ranges 24 and 25 west, and 5 miles north of Anoka. The nearest tributary of importance is Cedar Creek which enters 2½ miles above.

Records available.—May 8, 1905, to July 21, 1906; June 22, 1909, to November 23, 1909.

Drainage area.—1,430 square miles.

Gage.—Chain gage which remained permanent.

Channel.—Slightly within the influence of the dam at Anoka, and therefore slightly shifting.

Discharge measurements.—Made from bridge.

Winter flow.—Ice caused backwater during the winter months and the observations were discontinued.

Regulation.—The dam at St. Francis, twelve miles above holds back the night flow during the low water period, sufficiently to show a difference between night and morning readings of a tenth of a foot.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1						770	1,840	704	720	892	1,340	
2						704	1,770	720	704	950	1,200	
3						704	1,800	736	874	910	1,100	
4						736	1,880	704	950	838	1,040	
5						804	1,980	736	874	821	1,100	
6						770	2,260	704	950	804	1,200	
7						1,700	2,630	720	910	770	1,230	
8					2,060	2,300	2,900	720	910	753	1,310	
9					2,220	2,630	3,280	720	874	736	1,310	
10					2,630	3,080	3,760	704	804	838	1,370	
11					2,860	3,370	4,370	704	770	990	1,340	
12					2,810	3,470	4,790	672	787	910	1,280	
13					2,810	3,370	4,790	657	804	892	1,340	
14					2,860	3,180	4,370	657	838	874	1,180	
15					3,080	2,810	3,280	672	804	910	1,130	
16					3,960	2,810	2,720	672	950	1,060	1,100	
17					4,580	2,720	1,940	804	910	1,100	1,080	
18					4,680	2,720	1,570	1,180	1,180	1,260	1,060	
19					4,480	2,760	1,340	1,230	1,390	1,450	1,040	
20					4,160	2,760	1,180	1,260	1,570	1,600	990	
21					3,860	2,810	1,080	1,340	1,770	1,700	990	
22					3,660	2,860	1,040	1,420	1,800	1,800	970	
23					3,180	2,900	950	1,280	1,910	1,700	990	
24					2,810	2,860	804	1,200	1,670	1,670	1,080	
25					2,380	2,860	720	1,130	1,510	1,770	1,130	
26					2,220	2,720	770	1,040	1,360	1,800	1,180	
27					1,800	2,540	804	950	1,180	1,740	1,340	
28					1,510	1,980	787	838	1,040	1,570	1,450	
29					1,230	1,840	558	804	950	1,480	1,640	
30					990	1,840	672	753	910	1,390	1,980	
31					838		787	736		1,370		
1906.												
1				2,550	1,570	3,300	1,630					
2				2,620	1,450	3,500	1,690					
3				2,700	1,330	3,380	1,630					
4				2,850	1,480	3,110	1,570					
5				3,080	1,570	3,080	1,480					
6				3,620	1,570	2,850	1,390					
7				4,380	1,510	2,920	1,120					
8				4,750	1,600	3,260	1,120					
9				5,130	1,540	3,900	1,070					
10				5,220	1,510	5,580	1,030					
11				4,920	1,360	6,830	1,010					
12				4,660	1,330	7,560	1,010					
13				4,340	1,510	7,430	990					
14				4,420	1,690	6,580	990					
15				4,420	1,630	5,600	970					
16				4,340	1,510	4,960	950					
17				4,260	1,480	3,820	970					
18				4,220	1,450	3,340	950					
19				4,300	1,360	2,780	910					
20				4,260	1,330	2,110	890					
21				4,020	1,390	1,600	870					
22				3,780	1,570	1,510						
23				3,300	1,570	1,570						
24				2,780	1,570	1,540						
25				2,480	1,690	1,570						
26				2,040	1,830	1,660						
27				1,970	2,400	1,900						
28				1,800	2,740	2,040						
29				1,660	2,700	1,940						
30				1,630	2,850	1,600						
31					3,150							
1909.												
1							913	474	322	404	333	
2							772	458	309	395	333	
3							606	474	296	336	344	
4							613	458	286	291	336	
5							641	442	286	214	301	

Daily discharge, in second-feet, of Rum River near Anoka—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
6							606	522	296	333	333	
7							589	386	368	317	333	
8							546	416	322	301	312	
9							506	413	312	284	291	
10							480	423	301	312	306	
11							539	436	309	350	312	
12							522	468	291	350	312	
13							539	461	325	347	336	
14							474	480	344	350	416	
15							442	556	319	356	500	
16							395	586	312	362	458	
17							380	559	182	365	490	
18							380	522	199	350	791	
19							350	477	209	333	659	
20							336	426	268	336	670	
21							442	436	350	339	696	
22						723	696	404	589	344	670	
23						648	685	416	685	336	624	
24						867	624	398	648	328		
25						985	641	404	627	336		
26						1,080	659	374	556	322		
27						1,170	624	350	513	312		
28						1,140	589	333	477	306		
29						1,050	606	336	442	296		
30						985	572	333	426	284		
31							474	319		282		

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

Monthly discharge of Rum River near Anoka.

[Drainage area, 1,430 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1905.						
May (8-31)	4,680	838	2,820	1.97	1.76	A
June	3,460	704	2,310	1.62	1.81	A
July	4,790	558	2,040	1.43	1.65	A
August	1,420	657	876	.613	.71	A
September	1,910	704	1,090	.762	.85	A
October	1,800	736	1,200	.839	.97	A
November	1,980	970	1,220	.853	.95	B
1906.						
January			672	.470	.54	D
February			612	.428	.45	D
March			786	.550	.63	D
April	5,210	1,630	3,550	2.48	2.77	A
May	3,150	1,330	1,720	1.20	1.38	A
June	7,550	1,510	3,430	2.40	2.68	A
July (1-21)	1,690	870	1,150	.804	.63	A
1909.						
June (22-30)	1,170	648	950	.664	.22	C
July	913	336	556	.389	.45	C
August	586	319	437	.306	.35	C
September	685	182	372	.260	.29	C
October	401	282	328	.229	.26	C
November (1-23)	696	291	442	.309	.26	C

DEVELOPED WATER POWER.

There are two developments on Rum River and one on Spencer Brook a tributary, described as follows:

RUM RIVER.

St. Francis.—The St. Francis Milling Co. has a 9-foot dam at this point which creates a head of 10 feet. The pond extends upstream 2 miles. Near the right end of the dam is located the power house in which are installed two turbines one of 75 horsepower and the other of 50 horsepower capacity. The turbines have an automatic governor. The water is conducted to the turbines by means of a flume. The plant is operated 10 hours per day and uses about 75 horsepower. There is no auxiliary steam plant.

Anoka.—The Pillsbury Milling Co. of Minneapolis, operates the Lincoln Mill at Anoka by water power. A 12-foot timber dam ponds the water for a distance of nearly six miles, creating a head of 13 feet. At the left end of the dam is located the mill which contains four 72-inch turbines of the Jonval type and one 60-inch turbine. The combined capacity of these wheels is 450 horsepower. Water is supplied to the wheels by means of a short flume. The plant runs continuously though with a varying number of turbines, depending upon the water supply. There is an auxiliary steam plant.

SPENCER BROOK.

Spencer Brook.—A flour and feed mill at this point is operated by means of a turbine developing about 20 horsepower under an 8½-foot head.

From the records of flow the following table has been compiled showing the available continuous horsepower at the developed sites on Rum River. As there are no records of Spencer Brook, no estimate for the plant on that stream can be given:

Available horsepower at developed power sites.

Developed Site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
St. Francis	10	50	75	125	45	68	114
Anoka	13	62	93	155	73	110	183

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

To determine the water power possibilities of Rum River a survey of the river from the mouth to Onamia was made during 1909. The results of this survey are given on plates 68 to 73 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Rum River from mouth to Onamia.

Station.	Distance.		Elevation above sea level.	Ascent between points.	
	From mouth.	Point to point.		Total.	Per mile.
Mississippi River	0.0	....	832	....	....
Anoka dam, foot	0.8	0.8	833	1.0	1.2
Anoka dam, crest	0.8	0.0	845.5	12.5	....
Upper end pond Anoka dam	6.5	5.7	846	0.5	0.0
Range line 24-25	10.1	3.6	848	2.0	0.6
Cedar Brook	12.7	2.6	850	2.0	0.8
Gillespie Bridge	15.7	3.0	865	15.0	5.0
Seely Brook	19.3	3.6	873.5	8.5	2.4
St. Francis dam, foot	22.3	3.0	884	10.5	3.5
St. Francis dam, crest	22.3	0.0	893.5	9.5	....
Upper end pond St. Francis dam	24.0	1.7	893.5	0.0	0.0
Bridge west of Isanti	34.2	10.2	896	2.5	0.2
Bridge west of Cambridge	41.6	7.4	899	3.0	0.4
Lower Stanchfield Creek	48.7	7.1	903	4.0	0.6
Range line 23-24	53.2	4.5	906.5	3.5	0.8
Findell Bridge	59.0	5.8	912	5.5	0.9
Range line 24-25	64.9	5.9	919.5	7.5	1.3
Spencer Brook	72.2	7.3	930	10.5	1.4
Isanti-Sherburne County line	78.2	6.0	938.5	8.5	1.4
Sherburne-Mille Lacs County line	83.9	5.7	947	8.5	1.5
Princeton Bridge	87.2	3.3	951.5	4.5	1.4
Section line 9-16	93.5	6.3	959.5	8.0	1.3
	98.0	4.5	967	7.5	1.7
Vandell Brook	105.1	7.1	995	28.0	3.9
Township line 37-38	109.9	4.8	1,027.5	32.5	6.8
Milaca dam, foot	111.6	1.7	1,040	12.5	7.4
Milaca dam, crest	111.6	0.0	1,045	5.0	....
Upper end pond, Milaca dam	112.0	0.4	1,045	0.0	0.0
Abandoned logging dam, foot	112.9	0.9	1,047.5	2.5	2.8
Abandoned logging dam, vrest	112.9	0.0	1,052	4.5	....
Mike Dreur Brook	117.0	4.1	1,084	32.0	7.8
Tibbetts Brook	121.5	4.5	1,121	37.0	8.2
Page Bridge	125.7	4.2	1,152	31.0	7.4
Stony Brook	130.1	4.4	1,182	30.0	6.8
Abandoned logging dam, foot	134.9	4.8	1,207.5	25.5	5.3
Abandoned logging dam, crest	134.9	0.0	1,211.5	4.0	....
Abandoned logging dam, foot	136.1	1.2	1,220.5	9.0	7.5
Abandoned logging dam, crest	136.1	0.0	1,225.5	5.0	....
Abandoned logging dam, foot	139.5	3.4	1,244.5	19.0	5.6
Abandoned logging dam, crest	139.5	0.0	1,247	2.5	....
Onamia Bridge	141.5	2.0	1,249	2.0	1.0

A study of the foregoing table and the topography as shown on the atlas sheets shows the following possible developments:

In sec. 10, T. 39 N., R. 27 W.—A 25-foot dam at mile 124.2, 1½ miles below Page postoffice would have a crest length of 400 feet. It would back the water about 4 miles upstream and would overflow 200 acres, covered chiefly with brush.

In sec. 27, T. 39 N., 27 W.—A 20-foot dam at mile 121-4, just below Tibbetts and Whitney brooks, would have a crest length of 500 feet. It would back the water 2½ miles upstream, or within a mile of the dam site in section 10. The area of overflowed land would be 140 acres covered chiefly with brush.

In sec. 2, T. 38 N., R. 27 W.—A 20-foot dam at mile 117.7, ½ mile above Mike Dreur Brook would have a crest length of 500 feet. It would back the water 3 miles upstream and overflow 170 acres of brush and swamp land.

In sec. 34, T. 37 N., R. 26 W.—A 20-foot dam at mile 97.8, 2½ miles below Bogus Brook would have a crest length of 600 feet. It would back the water about 4 miles upstream, and would overflow 600 acres of meadow and wooded land.

Below this point the slope of the river and the topography of the banks are unsuited for power development (except at St. Francis) until a point is reached a mile above Cedar Creek.

In sec. 31, T. 33 N., R. 24 W.—A 28-foot dam at mile 13.7, 1 mile above Cedar Creek would have a crest length of 300 feet. It would back the water 8 miles upstream, or within ½ mile of the St. Francis Dam, and would overflow 250 acres, some of which is under cultivation.

The last dam site is just above the influence of the dam at Anoka and therefore, there is no undeveloped power below this point.

AVAILABLE HORSEPOWER.

The important part that Mille Lacs Lake plays in the flow of Rum River during low water is seen by the records of flow since 1909 which are all that are available. During the extremely dry year of 1910, the lake fell so low that the flow of the upper river for the succeeding year was practically nothing. So low was the ground water level at the end of the year that the flow of the upper river ceased entirely during January, February and March of 1911, and was extremely low during the remainder of 1911 as the lake and ground water had not yet returned to normal level. For this reason it cannot be stated accurately what the low flow would be during an ordinary low year, nor can a fair estimate be made of the dependable flow for the six high months of an ordinary low year. For the lower river however, the influence of Mille Lacs Lake is very much less as shown by the records at Cambridge. On this account, estimates of flow for an ordinary low year can be made with more certainty. With this explanation, the following table has been compiled. showing the available horsepower at the sites just described

Available undeveloped horsepower.

Site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Sec. 10, T. 39 N., R. 27 W...	25	0	5	....	0	11	....
Sec. 27, T. 39 N., R. 27 W...	20	12	18	....	22	33	....
Sec. 2, T. 38 N., R. 27 W....	20	12	18	....	22	33	....
Sec. 34, T. 37 N., R. 26 W...	20	22	29	....	40	53	....
Sec. 31, T. 33 N., R. 24 W...	28	54	82	136	137	209	346

SANITARY STATISTICS.

To show the sanitary quality of the water in Rum River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply, and disposal of sewage have been compiled for all towns of 400 inhabitants or more, located on the river. These data are given in the following table, in order of location beginning near the source of the river.

Municipal water supply and sewage disposal of towns on Rum River.

Town.	Distance above mouth	Population 1910.	Water Works System			Sewerage System.		Rural population per square mile above.
			Source of supply	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
Milaca..............	112	1,102	river	no	45,000	river	no	....
Princeton..........	87	1,555	deep well	no	....	river	no	13.9
Cambridge..........	42	400	none	....	....	none	....	....
Anoka..............	1	3,092	Rum River	calcium hypochlorite	100,000	none	....	20.0

Above Onamia the population in the drainage basin is about 1600 or 4.6 per square mile. Of this area of 414 square miles, 207 square miles is comprised within the area of Mille Lacs itself. As this comprises such a large percentage of the area, and as the lake itself has an average depth of about 30 feet, sedimentation and sunlight are active agents in reducing the bacteria from such rural sewage as may reach the lake. Between Mille Lacs and Onamia, a distance of 16 miles, the channel of the river lies through a chain of three small lakes. The fall in this distance is not more than 2 feet.

From Onamia to Milaca, a distance of 29 miles, there are no settlements of any size on the river or its tributaries. The rural population is about 5 per square mile of the entire drainage area. In this portion, the average fall of the river is 7 feet per mile. At Milaca the Rum receives its first urban sewage which is untreated.

Between Milaca and Princeton, a distance of 25 miles, the river has an average fall of 3.6 feet per mile which insures the presence of pollution in the river at Princeton. The rural population is much greater in this section of the basin, being 13.9 per square mile for the entire area above Princeton.

The river receives no additional urban sewage between Princeton and Anoka at its mouth. The average fall of the river in this portion is 1.2 feet per mile. The lower 7 miles of the river has practically no fall as it is within the influence of the Anoka dam. This tends to decrease the degree of pollution by sedimentation. The entire rural population of the basin is 20 per square mile.

It should be noted that no untreated river water is used for municipal purposes.

MINNESOTA RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Minnesota River, by far the largest tributary of the Mississippi in the State of Minnesota, drains an area comprising 16,600 square miles extending nearly across the southern part of the State from west to east. The river rises on the eastern slope of the Dakota foot hills (Coteau des Prairies) in the northeastern part of Marshall County, S. Dak., about 30 miles west of Lake Traverse, at an approximate elevation of 1896 feet above sea level, and flows southeastward to the State border, where it enters Bigstone Lake, a body of water 26 miles long, 1 to 1½ miles wide, and exceeding 15 feet in depth at only a few places. In this portion of its course it is a mere mountain torrent, whose fall in 40 miles is about 900 feet and whose bed is often entirely dry; for this reason perhaps Bigstone Lake has commonly been considered its source. Emerging from Bigstone Lake at Ortonville the Minnesota flows southeastward 225 miles to Mankato, where it turns abruptly and flows northeastward to its junction with the Mississippi a few miles below the falls of St. Anthony, between the cities of Minneapolis and St. Paul.

From Bigstone Lake to the upper end of Marsh Lake, a distance of 22 miles, the river winds through a valley 1½ miles wide and 50 to 100 feet below the general level of the basin. About one-half the bottom land in this stretch is under cultivation and the remainder is marshy. At Marsh Lake, which was formed by the alluvium deposited at its lower end by Pomme de Terre River, the valley broadens to 3 miles. The lake, which is 4 miles long by 1 mile wide, is mostly filled with marsh grass, and the greater portion of the valley surface is marshy. From Marsh Lake to Lac Qui Parle, which was formed by Lac Qui Parle River as Marsh Lake was formed by the Pomme de Terre, the valley is 1 to 1½ miles wide. At Lac Qui Parle, which is about 8 miles long and ¾ mile wide, the valley is 1½ miles wide and lies 100 feet below the general surface level. From the outlet of Lac Qui Parle to the line between ranges 30 and 40, the valley is ¾ of a mile wide. Much of the area consists of marsh and ponds and not more than a third of it is under cultivation. In the next 6 miles the valley widens out to 2 miles and its character changes, as granite outcrops at many places. Little of the land is under cultivation. From the lower end of this wide section in T. 115 N., R. 39 W., to Mankato, the average width of the valley is 1 mile, its depth below the general level increases to 200 feet, and most of the land is under cultivation. Below Mankato the valley averages a mile in width and lies 100 to 150 feet below the surface level. From Chaska to the mouth little land is under cultivation, as it is marshy.

From Bigstone Lake to Granite Falls the slope of the river is 0.6 foot per mile except at the outlet of the lake, where the fall is heavy for a short distance. At Granite Falls and at Minnesota Falls, where granite outcrops, the river descends in falls and rapids 41 feet in a distance of 4 miles. In the 30 miles below Minnesota Falls, the average slope is 1.3 feet per mile, but thence to the mouth of Cottonwood River the slope becomes much less, being only 0.5 foot per mile. From Cottonwood River to Faxon the slope increases to 1 foot per mile, but below that very point the water surface is very nearly level.

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

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The soil in the Minnesota Valley is alluvial. Above Minneopa the river flows over the drift which covers the basin, but below that point it occupies a preglacial gorge whose bottom, filled with gravel and sand, lies 100 to 200 feet below the present bed of the river.

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

The country as a whole, is flat or gently undulating, but along the southern border of the basin is a table land 20 to 30 miles wide that rises several hundred feet above the valley and extends from southeast to northwest across the southwestern part of the State.

Elevations in the basin range from 1000 in the valleys to 1900 feet above sea level on the high plateau.

Except in the immediate valley of the Minnesota, the Blue Earth and one or two other tributaries, the area is covered with blue till, a confused mixture of sand, clay, and gravel of glacial origin. The table land on the southwestern border is capped with porous deposits of sand and gravel which supply water to the artesian wells and springs in the basin. In the western part of the basin the drift rests on Cretaceous sandstone and shales; farther east it overlies the crystalline schists and gneisses of Archean age. In the vicinity of New Ulm quartzite of Middle Cambrian age is found. Rock outcrops only along the river valleys.

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

RAINFALL AND RUNOFF.

Rainfall records covering periods exceeding 15 years are available for different sections of the drainage area. These records indicate that the annual rainfall ranges about 24 inches in the upper part to 28 inches in the central and lower parts. Of this amount 3 inches is precipitated in the form of snow which remains throughout the winter. Since 1886 the wettest year in the upper portion of the basin was 1905 when the rainfall was about 35 inches. The driest year was 1895 when the precipitation averaged 15 inches. In the central portion of the basin the rainfall records are continuous since 1892. During that period the wettest year was 1903 when the precipitation was about 36 inches. The driest year was 1910 when the rainfall averaged 15 inches. In the lower portion of the basin, the longest record is that at St. Paul which is continuous since 1837. During that period, the wettest year was 1849 when the rainfall was 49.7 inches. The driest year was 1910 when the precipitation was 10.2 inches.

Runoff records were maintained at the outlet of Bigstone Lake from 1900 to 1903; at Montevideo from 1910 to 1912, and at Mankato from 1904 to 1912. The annual variation in the rainfall and runoff for those stations is shown in the following table:

Relation between rainfall and runoff.

Station.	Year.	Rainfall in inches.	Runoff in inches.	Percentage of rainfall.
Minnesota above Whetstone River	1900	22.51	0.21	0.9
	1901	23.94	.18	0.8
	1902	19.76	.24	1.2
	1903	29.34	.29	1.0
Minnesota above Montevideo	1910	16.48	.94	5.6
	1911	28.06	28	1.0
Minnesota above Mankato	1904	24.16	1.45	6.1
	1905	31.69	2.58	8.2
	1906	31.15	4.09	13.1
	1907	21.13	4.14	19.5
	1908	31.78	5.25	16.5
	1909	26.32	4.73	18.0
	1910	16.39	1.28	7.8
	1911	28.82	.55	1.9
Whetstone above Mouth	1900	23.79	.60	2.5
	1901	24.60	.54	2.2
	1902	18.62	.11	0.6
	1903	27.62	1.34	4.8

The effect of evaporation from Bigstone Lake is seen by comparing the percentage of runoff of the Minnesota above the Whetstone, and Whetstone River above its mouth. It is seen that the rainfall on the two adjacent areas from 1900 to 1903 was very nearly the same. With the exception of 1902 the percentage of runoff of the Minnesota was from 2½ to 5 times smaller than that of the Whetstone.

FLOODS.

The large area drained by the Minnesota, the comparatively steep slopes of the tributaries, the slight slope of the river itself, and the small channel capacity, combine to cause severe floods in the Minnesota Valley. So severe have been these floods that a considerable portion of the fertile bottom lands are not under cultivation. Records of runoff have been maintained at Mankato, since 1903 and these show the flood of June 1908 to have been the most severe. At that time the river rose 10 feet in four days, falling much more slowly. This rise was due to a rain which, while extending over the entire basin, was especially heavy in the vicinity of Mankato. In the upper portion of the basin the rainfall which began the 22d and lasted two days, varied from 1.5 to 2 inches during that time. Near Mankato the precipitation only lasted one day and amounted to 4.25 inches at St. Peter, and 3.23 inches at Lake Crystal. As there had been a heavy rain a few days previous, the soil was well saturated and could take up little or none of the rain from the second storm. The maximum stage of this flood was 43,800 second feet at Mankato, which represented a runoff of 3.0 second feet per square mile for the entire drainage basin above that point.

REGULATION OF FLOW.

The flow of the Minnesota is not regulated to any extent naturally, as there are few lakes in the basin except on the extreme headwaters. Bigstone Lake by far the largest lake in the basin has too small a tributary runoff to be of any considerable value in regulating the flow. The same may be said of both Marsh Lake and Lac Qui Parle, although to a less degree. The absence of regulation of flow is seen in the severe floods to which the valley is subject.

NAVIGATION.

Although called a navigable stream there is practically no navigation with the possible exception of a few miles just above the mouth, where a few pleasure craft are found. The United States Engineer Corps made a survey of the upper river in 1909 and 1910 for the purpose of finding a suitable reservoir site. The proposed plan is to increase the low water flow during the summer months in the interest of navigation. Aside from this and the removal of snags at various times, little or no work has been done by the Federal government.

DRAINAGE WORK.

Although there is little swamp land in the upland area of the basin, much of the land is so flat that drainage is necessary. The following table taken from the Report of the State Drainage Commission shows the miles of ditches and acreage benefited in each county comprising the area drained by the Minnesota and its tributaries. The counties are arranged in descending order, beginning at the upper end of the basin:

Drainage in the Minnesota basin.

County.	Miles of ditch.	Acreage benefited.
Bigstone	55	12,000
Grant	25	27,000
Stevens	45	8,000
Lac qui Parle	232	20,800
Lincoln	62	7,000
Lyon	40	7,300
Yellow Medicine		
Chippewa	220	22,000
Swift	39	14,000
Pope	109	46,000
Douglas	150	15,000
Kandiyohi	90	18,000
Renville	290	45,000
Redwood	300	95,000
Martin	118	24,000
Watonwan	40	6,000
Brown	227	19,000
Nicollet	135	23,000
Sibley	150	17,000
Carver	12	2,400
Scott		
Le Sueur	100	10,000
Blue Earth	52	11,000
Faribault	60	10,000
Waseca	72	12,000
Dakota	3	500
Total	2,626	472,000

DRAINAGE AREAS.

The following drainage areas have been measured on the Minnesota and its tributaries:

Drainage areas in Minnesota River basin.

River.	Drainage area above.	Square miles.
Minnesota	Bigstone Lake outlet	846
Do	Odessa	1,560
Do	Montevideo	6,300
Do	Sec. 30, T 114 N, R 36 W	7,800
Do	Sec. 33, T 109 N, R 28 W	11,100
Do	Mankato	14,600
Do	Mouth	16,600
Whetstone	Mouth	441
Yellow Bank	Mouth	536
Pomme de Terre	Pelican Lake Outlet	128
Do	Mud Creek	399
Do	Mouth	847
Lac qui Parle	East Branch	484
Do	Gaging station at Lac Qui Parle	[a]838
Do	Mouth	[a]900
East Branch	Mouth	286
Chippewa	East Branch	875
Do	Range line 121-122	1,360
Do	Gaging station near Watson	1,940
Do	Mouth	1,990
East Branch of Chippewa	do	476
Shakopee Creek	do	304
Stony River	do	176
Yellow Medicine	South Branch	266
Do	Mouth	550
South Branch of Yellow Medicine	do	104
Hawk Creek	North Branch	188
Do	Mouth	437
North Branch Hawk	do	182
Redwood	Three Mile Creek	286
Do	Gaging station near Redwood Falls	403
Do	Mouth	748
Three Mile Creek	do	156
Beaver Creek	do	242
Cottonwood	Plum Creek	289
Do	Sleepy Eye Creek	864
Do	Gaging station near New Ulm	1,190
Do	Mouth	1,200
Plum Creek	do	98
Highwater Creek	do	192
Sleepy Eye Creek	do	261
Little Cottonwood	do	180
Blue Earth	East Fork	714
Do	Watonwan	1,480
Do	Gaging station near Rapidan	2,260
Do	Mouth	3,430
West Branch Blue Earth	do	168
East Branch Blue Earth	do	301
Elm Creek	do	301
Watonwan	South Branch	368
Do	Mouth	775
South Branch of Watonwan	do	191
Le Sueur	Cobb River	518
Do	Mouth	1,160
Cobb	do	318
Maple	do	307
Cherry Creek	do	39
Le Sueur Creek	do	149
Rush Creek	South Branch	135
Do	Mouth	246
Sand Creek	do	278

[a] Revised since 1910 report.

GAGING STATION RECORDS.

MINNESOTA RIVER ABOVE WHETSTONE RIVER.

Location.—At the outlet of Bigstone Lake and above Whetstone River. This station was maintained by the United States Engineer Corps.

Records available.—April 17, 1899, to May 14, 1904. These records have been compiled from unpublished data in the United States Engineer Office at St. Paul.

Drainage area.—846 square miles.

Gage.—No data. This was relatively unimportant as almost daily measurements were made, and the estimates of flow based directly on these.

Winter flow.—The river was frozen over during the winter months, but measurements were made to determine the discharge.

Regulation.—The flow is regulated by Bigstone Lake which is a natural reservoir of 29 square miles area. This is shown by the comparatively uniform flow.

Daily discharge, in second-feet, of Minnesota River above Whetstone River.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899												
1					66	66	45	7	7	7	30	16
2					62	59	46	5	9	34	20	16
3					66	60	47	5	7	32	10	16
4					66	64	47	5	6	30	7	15
5					66	61	50	5	5	33	6	14
6					65	52	60	4	5	31	7	14
7					64	[a]	53	4	5	36	6	14
8					64	[a]	47	4	5	33	7	14
9					65	47	39	5	5	34	7	14
10					66	47	30	5	5	34	7	5
11					62	47	29	4	5	31	7	14
12					72	47	25	4	5	36	7	14
13					63	56	24	4	5	34	17	14
14					62	59	14	4	6	33	16	12
15					58	56	17	4	6	9	17	14
16					57	57	14	3	23	28	16	14
17				47	61	58	13	4	7	29	16	8
18				47	58	59	11	4	7	28	13	14
19				49	57	61	10	4	8	29	7	14
20				54	58	54	10	6	8	30	13	14
21				52	61	61	9	5	8	35	17	14
22				52	60	57	8	5	8	6	16	14
23				53	59	58	7	6	7	27	16	14
24				54	61	59	6	6	7	26	16	8
25				59	61	58	9	6	7	28	16	14
26				55	62	56	7	6	7	27	7	14
27				60	60	54	7	7	28	9	7	14
28				61	61	54	9	7	6	28	16	14
29				59	62	42	8	8	32	10	14	14
30				59	66	41	8	7	6	32	14	14
31					69	......	6	8	......	31		8
1900												
1	14	11	10	10	30	22	3	9	4	19	14	17
2	15	12	12	6	40	21	3	10	4	16	14	16
3	28	12	11	3	5	4	3	11	4	17	15	16
4	30	14	10	0	5	4	3	12	5	14	14	18
5	34	17	11	0	5	4	3	14	5	19	14	16

[a] No current. Backwater from Whetstone.

Daily discharge, in second-feet, of Minnesota River above Whetstone River—Cont.

Day.	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
6	24	18	11	0	6	4	3	20	5	16	15	16
7	8	18	11	0	7	4	3	19	5	14	14	16
8	8	20	12	2	6	3	3	19	4	19	15	16
9	28	20	12	4	25	3	4	15	5	19	18	12
10	28	10	12	5	34	3	6	[c]0	24	22	17	18
11	30	11	70	5	33	3	5	[c]0	24	16	15	16
12	18	10	65	6	32	4	4	21	23	15	15	16
13	28	21	60	5	6	4	4	21	22	14	15	17
....	8	18	17	2	6	4	4	[c]3	20	14	17	15
15	26	18	17	2	6	3	5	26	20	15	14	17
16	26	21	12	3	6	3	5	29	17	14	15	14
17	26	23	12	3	7	3	4	33	15	15	16	18
18	30	24	12	3	6	3	4	37	17	16	17	18
19	30	21	12	2	7	3	5.	39	6	16	14	13
20	30	18	12	2	7	3	4	40	5	16	19	19
21	14	21	11	2	6	3	3	38	5	15	19	16
22	26	10	11	2	7	3	3	38	5	16	20	15
23	26	11	10	2	6	3	3	38	5	17	19	15
24	28	10	10	3	18	3	2	39	5	16	19	17
25	26	11	10	[b]20	23	3	2	40	5	15	19	18
26	24	11	10	[b]25	8	3	2	39	5	15	19	20
27	25	11	10	[b]26	18	3	2	39	5	16	19	18
28	10	11	10	4	19	4	3	40	16	15	18	16
29	8	......	10	4	18	4	[b]8	[c]4	19	17	18	16
30	10	......	10	[b]30	19	3	[b]8	[c]4	6	15	18	16
31	10	......	10	......	21	......	[b]6	[c]4	......	15	......	18
1901.												
1	19	22	21	15	4	6	6	1	6	4	11	5
2	19	21	23	2	15	6	6	1	7	5	9	8
3	20	21	26	0	4	6	6	1	7	6	9	16
4	21	22	26	2	5	6	7	.9	7	7	9	14
5	21	21	25	7	5	6	6	.8	7	8	13	9
6	21	21	24	8	36	12	5	.6	6	9	17	7
7	19	21	23	5	35	12	4	.5	5	9	9	5
8	19	21	23	2	28	5	4	.4	4	10	12	6
9	19	21	24	0	26	5	4	.4	4	10	11	12
10	19	19	24	0	32	5	4	.5	4	11	9	11
11	20	20	23	3	34	12	4	.5	3	10	8	8
12	20	20	24	5	6	6	3	.5	5	10	7	7
13	21	22	27	5	17	6	3	6	8	11	12	9
14	20	22	28	5	5	7	3	1	8	12	10	14
15	20	22	27	6	5	7	3	8	5	11	8	14
16	22	22	27	4	4	7	3	8	5	12	4	16
17	22	22	28	0	4	6	3	7	5	12	3	19
18	22	22	28	0	4	6	3	4	5	11	9	20
19	21	21	28	2	5	6	3	7	5	11	6	21
20	20	21	29	3	5	6	3	2	5	11	3	26
21	21	21	25	2	5	6	3	5	5	11	6	31
22	21	20	22	2	5	6	3	6	5	11	10	17
23	21	20	23	2	27	5	3	6	5	11	9	27
24	22	20	28	1	5	5	3	6	4	10	5	29
25	20	20	27	1	10	5	3	5	4	10	6	28
26	21	20	20	5	5	5	3	5	4	10	17	29
27	20	20	22	[b]20	5	5	2	4	4	10	15	31
28	21	20	29	8	5	5	2	5	2	9	17	30
29	21	......	31	[b]23	6	6	1	6	3	11	14	15
30	21	......	28	4	10	6	.8	7	4	12	16	24
31	20	......	27	......	6	......	.8	7	......	12	......	20
1902.												
1	19	16	20	21	20	14	5	19	6	4	21	29
2	21	16	16	21	14	14	6	14	6	4	25	29
3	17	18	21	21	20	14	5	14	7	4	26	29
4	19	18	20	21	13	14	5	13	6	4	26	29
5	15	18	20	20	18	14	5	12	5	4	26	29

[b] Mill running.
[c] Mill gates closed.

Daily discharge, in second-feet, of Minnesota River above Whetstone River—Cont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
6	25	19	20	25	14	16	5	14	5	4	26	29
7	28	20	20	25	16	14	5	9	5	4	24	27
8	20	19	20	26	24	16	5	8	5	4	25	29
9	25	16	16	26	24	16	4	6	5	4	25	29
10	28	22	16	26	25	14	5	1	4	4	25	29
11	27	21	15	26	18	14	7	1	4	4	25	29
12	17	16	16	27	23	12	6	1	4	3	25	29
13	21	19	15	7	24	12	6	3	4	4	26	29
14	27	19	18	16	23	12	6	3	4	4	26	29
15	20	20	19	17	25	11	7	4	3	4	26	28
16	29	22	16	20	23	11	8	4	4	4	26	28
17	22	19	17	20	20	9	7	4	4	4	26	28
18	28	19	18	23	20	9	6	4	4	4	27	28
19	28	20	18	21	22	8	6	4	4	4	27	29
20	28	18	18	8	21	6	6	4	4	4	27	29
21	28	18	17	17	22	5	6	4	4	4	27	29
22	26	18	18	18	20	5	6	6	4	5	27	29
23	26	16	17	20	18	5	4	4	4	5	29	29
24	26	20	19	15	15	5	4	4	4	5	28	29
25	28	21	18	19	17	4	4	4	4	5	28	29
26	16	20	19	20	18	4	4	4	4	6	28	29
27	18	21	19	9	19	5	4	4	4	7	29	29
28	18	21	19	17	19	4	4	4	4	10	30	29
29	20	......	19	18	18	4	4	4	4	14	30	29
30	19	......	18	18	13	5	4	4	4	14	29	28
31	21	......	17	......	14	......	7	6	......	16	......	28
1903.												
1	28	29	29	91	35	2	14	13	2	10	10	10
2	28	29	29	79	35	2	13	15	2	12	10	10
3	28	29	29	15	28	2	65	5	4	16	10	10
4	28	29	29	52	11	2	68	5	2	16	10	10
5	28	29	29	63	16	4	20	5	2	20	10	10
6	28	29	29	20	10	2	20	5	2	14	10	20
7	28	29	29	20	2	2	17	5	2	14	10	4
8	28	29	16	26	2	2	28	5	2	14	10	16
9	28	29	16	21	2	2	14	23	2	13	10	20
10	28	29	20	15	2	4	14	26	2	50	10	20
11	28	29	20	50	2	4	7	26	2	50	10	16
12	28	29	20	60	2	18	7	24	2	50	10	16
13	28	29	20	64	2	4	10	2	20	41	10	10
14	28	28	20	71	2	4	10	3	20	45	10	13
15	29	28	20	73	2	4	10	2	20	48	10	16
16	29	28	20	80	2	4	11	2	20	21	10	16
17	29	28	20	86	2	4	10	2	10	5	10	13
18	29	28	20	88	2	3	5	2	10	5	10	16
19	29	28	20	78	2	3	5	3	10	31	10	13
20	29	29	20	76	2	3	5	2	10	38	10	10
21	29	29	20	74	2	6	5	2	10	34	10	5
22	29	28	20	61	2	6	5	2	10	23	10	5
23	29	28	20	39	2	7	9	2	10	26	10	5
24	29	28	20	27	2	12	5	2	10	5	10	5
25	29	28	20	22	2	19	5	2	10	5	10	5
26	29	28	24	21	2	17	5	2	10	5	10	5
27	29	29	44	22	2	18	32	2	10	5	10	5
28	29	29	72	22	2	14	5	2	10	5	10	5
29	29	......	83	25	2	12	5	2	10	5	10	5
30	29	......	96	30	2	11	5	2	10	5	10	5
31	29	......	89	......	2	......	13	2	......	5	......	5
1904.												
1	5	6	6	10	10	......	......	......	......	......	......	......
2	5	6	6	10	10	......	......	......	......	......	......	......
3	5	6	6	10	10	......	......	......	......	......	......	......
4	5	6	6	10	10	......	......	......	......	......	......	......
5	5	6	6	10	10	......	......	......	......	......	......	......
6	5	6	6	10	10	......	......	......	......	......	......	......
7	5	6	6	20	10	......	......	......	......	......	......	......
8	5	6	6	20	10	......	......	......	......	......	......	......
9	5	6	6	20	10	......	......	......	......	......	......	......
10	5	6	6	20	10	......	......	......	......	......	......	......

Daily discharge, in second-feet, of Minnesota River above Whetstone River—Cont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
11	5	6	6	20	10							
12	5	6	6	20	10							
13	5	6	6	20	10							
14	5	6	6	20	10							
15	5	6	6	20								
16	5	6	6	20								
17	5	6	6	20								
18	5	6	6	20								
29	5	6	6	20								
20	5	6	6	20								
21	5	6	10	20								
22	5	6	10	20								
23	5	6	20	20								
24	5	6	20	20								
25	5	6	10	20								
26	5	6	10	20								
27	5	6	6	20								
28	5	6	6	10								
29	5	6	6	10								
30	5		6	10								
31	5		6									

During first part of April, 1901, Whetstone backwater retarded the flow, and during the latter part the mill gates were closed.

The increased flow during the latter part of the year 1901 was due to the disappearance of weeds, which had clogged the channel, and also to the operation of the mill.

Monthly discharge of Minnesota River above Whetstone River.

[Drainage area, 846 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1899.					
April (17-30)	61	47	54.4	0.064	0.03
May	72	59	62.6	.074	.09
June	66	0	51.7	.061	.07
July	53	6	23.1	.027	.03
August	8	3	5.2	.0061	.007
September	32	5	8.5	.010	.01
October	36	6	27.4	.032	.04
November	30	6	12.5	.015	.02
December	16	5	13.3	.016	.02
1900.					
January	30	8	21.8	.026	.03
February	24	10	15.5	.018	.02
March	70	10	16.5	.020	.02
April	30	0	6.0	.0071	.008
May	40	5	14.3	.017	.02
June	22	3	4.6	.0054	.006
July	8	2	3.9	.0046	.005
August	40	3	22.6	.027	.03
September	24	4	10.3	.012	.01
October	22	14	16.1	.019	.02
November	20	14	16.5	.020	.02
December	20	12	16.4	.019	.02
The year	70	0	13.7	.016	.21

Monthly discharge of Minnesota River above Whetstone River—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1901.					
January	22	19	20.5	0.024	0.03
February	22	19	20.9	.025	.03
March	31	20	25.5	.030	.03
April	23	0	4.7	.0056	.006
May	36	4	11.9	.014	.02
June	12	5	6.4	.0076	.008
July	7	0.8	3.5	.0041	.005
August	8	0.4	3.6	.0043	.005
September	8	2	5.0	.0059	.007
October	12	4	9.9	.012	.01
November	17	3	9.8	.012	.01
December	31	5	17.0	.020	.02
The year	36	0	11.6	.014	.18
1902.					
January	29	16	22.9	.027	.03
February	22	16	18.9	.022	.02
March	20	15	18.0	.021	.02
April	27	7	19.6	.023	.03
May	25	13	19.4	.023	.03
June	16	4	9.9	.012	.01
July	8	4	5.4	.0064	.007
August	19	1	6.1	.0072	.008
Spetember	7	3	4.4	.0052	.006
October	16	3	5.5	.0064	.007
November	30	21	26.5	.031	.03
December	29	27	28.7	.034	.04
The year	30	1	15.4	.018	.24
1903.					
January	29	28	28.5	.034	.04
February	29	28	28.6	.034	.04
March	96	16	31.1	.037	.04
April	91	21	49.0	.058	.06
May	35	2	6.0	.0071	.008
June	19	2	6.6	.0078	.009
July	68	5	14.4	.017	.02
August	26	2	6.4	.0076	.009
September	20	2	8.2	.0097	.01
October	50	5	20.5	.024	.03
November	10	10	10.0	.012	.01
December	20	5	10.5	.012	.01
The year	96	2	18.3	.022	.29
1904.					
January	5	5	5.0	.0059	.007
February	6	6	6.0	.0071	.008
March	20	6	7.4	.0088	.01
April	20	10	17.0	.020	.02
May (1-14)	10	10	10.0	.012	.006

MINNESOTA RIVER NEAR ODESSA.

Location.—At highway bridge 1 mile southwest of Odessa in Sec. 32, T. 121 N., R. 45 W., half a mile below the mouth of Stony Run, a very small stream entering from the north.

Records available.—July 4, 1909, to November 19, 1912.

Drainage area.—1,560 square miles.

Gage.—Chain, attached to bridge, datum unchanged since established.

Channel.—Somewhat shifting.

Discharge measurements.—Made from the bridge except during low stages when they are made at a wading section.

Winter flow.—The river is frozen over and observations are discontinued from December to March. The flow during that period may possibly be estimated by using the runoff per square mile of drainage area above Montevideo. (See pp. 217 and 218.)

Regulation.—The flow at Odessa is entirely uncontrolled, as the nearest dam is at Granite Falls.

This station was established in order to determine the runoff from Bigstone Lake available for storage and the amount of flood water contributed by the upper valley. As Whetstone River enters Minnesota River above Odessa a station was established on that stream also for the purpose of determining the amount of water passing Odessa from that source.

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

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

Daily discharge, in second-feet, of Minnesota River near Odessa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	......	......	......	......	......	......	......	28	31	53	65	......
2	......	......	......	......	......	......	......	24	31	60	65	......
3	......	......	......	......	......	......	......	30	34	60	63	......
4	......	......	......	......	......	......	54	31	37	58	62	......
5	......	......	......	......	......	......	49	26	36	59	64	......
6	......	......	......	......	......	......	49	23	36	55	58	......
7	......	......	......	......	......	......	46	42	36	57	64	......
8	......	......	......	......	......	......	49	58	36	59	59	......
9	......	......	......	......	......	......	53	56	36	77	52	......
10	......	......	......	......	......	......	52	49	40	87	57	......
11	......	......	......	......	......	......	48	44	36	98	58	......
12	......	......	......	......	......	......	64	40	31	115	59	......
13	......	......	......	......	......	......	57	41	32	88	64	......
14	......	......	......	......	......	......	53	43	37	74	75	......
15	......	......	......	......	......	......	51	45	47	65	156	......
16	......	......	......	......	......	......	46	39	53	63	122	......
17	......	......	......	......	......	......	42	41	47	66	106	......
18	......	......	......	......	......	......	39	42	47	61	102	......
19	......	......	......	......	......	......	33	40	52	56	92	......
20	......	......	......	......	......	......	32	37	43	64	92	......
21	......	......	......	......	......	......	34	39	53	65	92	......
22	......	......	......	......	......	......	41	37	63	60	92	......
23	......	......	......	......	......	......	37	37	59	66	91	......
24	......	......	......	......	......	......	31	32	59	58	97	......
25	......	......	......	......	......	......	27	33	57	65	98	......
26	......	......	......	......	......	......	28	29	53	65	97	......
27	......	......	......	......	......	......	28	34	50	63	97	......
28	......	......	......	......	......	......	24	32	58	59	97	......
29	......	......	......	......	......	......	28	32	59	51	96	......
30	......	......	......	......	......	......	25	29	59	56	95	......
31	......	......	......	......	......	......	28	30	......	66	......	......
1910.												
1	......	......	......	241	407	114	22	16	33	46	41	......
2	......	......	......	224	360	108	24	16	24	40	39	......
3	......	......	......	210	336	101	22	16	33	42	37	......
4	......	......	......	233	314	102	20	16	32	46	51	......
5	......	......	......	252	278	101	18	16	50	38	57	......
6	......	......	......	220	265	104	21	16	34	35	57	......
7	......	......	......	213	259	92	20	16	24	35	43	......
8	......	......	......	205	255	85	19	17	44	34	37	......
9	......	......	850	202	246	94	19	16	42	34	34	......
10	......	......	726	195	240	105	17	16	40	32	34	......
11	......	......	652	188	234	99	18	16	38	34	31	......
12	......	......	621	179	221	97	17	16	36	32	33	......
13	......	......	582	166	210	97	16	17	33	32	36	......
14	......	......	535	184	196	85	16	20	36	34	41	......
15	......	......	518	212	188	77	15	22	36	35	37	......

Daily discharge, in second-feet, of Minnesota River near Odessa—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
16	......	......	496	239	197	68	15	23	32	32	41	......
17	......	......	475	258	210	62	14	22	31	35	43	......
18	......	......	465	236	217	64	14	21	42	34	48	......
19	......	......	432	202	192	56	13	20	40	43	52	......
20	......	......	407	205	179	50	13	20	35	79	......	......
21	......	......	381	269	173	44	12	22	32	65	......	......
22	......	......	362	368	161	39	12	23	32	43	......	......
23	......	......	351	409	156	41	14	23	44	41	......	......
24	......	......	341	498	173	37	15	24	38	43	......	......
25	......	......	319	532	164	41	16	28	44	43	......	......
26	......	......	295	500	435	43	16	28	56	49	......	......
27	......	......	276	488	127	40	15	27	62	63	......	......
28	......	......	278	462	127	35	15	22	44	61	......	......
29	......	......	255	430	149	30	14	22	38	57	......	......
30	......	......	271	407	125	25	14	24	42	45	......	......
31	......	......	249	......	118	......	14	32	......	46	......	......
1911.												
1	......	......	......	49	25	13	9	6	5	17	24	......
2	......	......	......	58	25	14	8	5	5	19	24	......
3	......	......	......	41	25	14	8	6	5	22	24	......
4	......	......	......	40	25	43	9	9	6	44	27	......
5	......	......	......	45	24	35	9	7	6	28	23	......
6	......	......	......	43	21	30	10	7	6	30	22	......
7	......	......	......	47	21	27	8	8	9	28	22	......
8	......	......	......	46	22	19	7	7	11	22	21	......
9	......	......	......	40	24	16	7	6	9	20	22	......
10	......	......	......	36	20	15	6	7	11	20	22	......
11	......	......	......	24	22	14	6	6	8	22	......	......
12	......	......	......	59	21	17	6	6	8	20	......	......
13	......	......	......	94	16	15	6	6	7	22	......	......
14	......	......	......	77	14	14	5	6	7	21	......	......
15	......	......	......	62	19	12	5	6	6	22	......	......
16	......	......	......	54	21	12	5	6	6	29	......	......
17	......	......	......	48	15	12	5	6	6	34	......	......
18	......	......	......	35	16	11	5	6	9	26	......	......
19	......	......	180	34	21	10	6	6	7	25	......	......
20	......	......	172	34	22	10	6	6	6	26	......	......
21	......	......	162	34	25	9	6	6	6	26	......	......
22	......	......	157	34	15	10	6	6	8	21	......	......
23	......	......	130	34	18	10	6	6	9	20	......	......
24	......	......	95	26	14	10	6	6	7	21	......	......
25	......	......	76	26	13	8.4	6	6	7	20	......	......
26	......	......	159	25	16	8.4	5	6	6	22	......	......
27	......	......	183	25	14	9.2	5	6	8	22	......	......
28	......	......	37	25	14	11	5	6	11	20	......	......
29	......	......	26	30	15	14	5	6	15	21	......	......
30	......	......	26	25	14	13	5	6	16	26	......	......
31	......	......	26	......	14	......	5	6	......	25	......	......
1912.												
1	......	......	......	355	70	28	14	88	34	36	44	......
2	......	......	......	288	58	25	14	84	33	32	41	......
3	......	......	......	270	52	22	15	77	32	34	41	......
4	......	......	......	225	137	19	20	70	30	34	38	......
5	......	......	......	153	185	17	44	64	30	35	38	......
6	......	......	......	94	252	16	52	58	30	41	38	......
7	......	......	......	94	315	16	46	55	30	39	36	......
8	......	......	......	74	270	14	36	52	31	38	36	......
9	......	......	......	67	217	14	36	49	32	36	36	......
10	......	......	......	61	121	14	41	44	31	36	35	......
11	......	......	......	55	94	22	49	41	30	36	35	......
12	......	......	......	52	80	20	64	41	31	34	34	......
13	......	......	......	55	70	23	64	41	30	32	34	......
14	......	......	......	74	61	28	77	41	25	32	33	......
15	......	......	......	137	55	24	91	31	22	32	33	......
16	......	......	......	252	46	32	84	31	20	34	32	......
17	......	......	......	325	41	41	84	34	18	34	32	......
18	......	......	......	279	38	52	70	36	15	52	31	......
19	......	......	......	193	36	52	67	36	13	70	30	......
20	......	......	......	105	34	32	70	37	12	52	32	......

Daily discharge, in second-feet, of Minnesota River near Odessa—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
21				121	32	31	58	39	15	36	32	
22				105	32	27	58	41	35	32	32	
23				98	77	24	64	36	50	34	32	
24				88	55	24	74	36	64	34	32	
25				80	41	22	74	36	58	36	32	
26				169	41	20	70	41	41	36	32	
27				145	38	17	70	39	34	35	31	
28				121	36	16	70	38	32	32	31	
29				94	32	15	77	36	35	41	30	
30				84	32	14	80	35	36	46	30	
31					30		84	35		44		

Daily discharges computed from a well defined rating curve which was applied indirectly from July 1 to Sept. 30, 1911, owing to obstructed channel conditions.

Monthly discharge of Minnesota River near Odessa.

[Drainage area, 1,560 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July (4-31)	64	24	41.0	0.026	0.03	B
August	58	24	36.9	.024	.03	B
September	63	31	44.9	.029	.03	B
October	115	51	66.1	.042	.05	B
November	156	52	83.6	.054	.06	B
1910.						
March (9-31)	850	249	441	.283	.24	B
April	532	166	288	.185	.21	A
May	407	118	213	.137	.16	A
June	114	25	71.2	.046	.05	A
July	24	12	16.5	.011	.01	A
August	32	16	20.4	.013	.02	A
September	62	24	38.2	.024	.03	A
October	79	32	42.8	.027	.03	A
November (1-19)	57	31	41.7	.027	.02	A
1911.						
March (19-31)	183	26	110	.071	.03	B
April	94	24	41.7	.027	.03	A
May	25	13	19.1	.012	.01	A
June	43	8.4	15.2	.0097	.01	A
July	10	5	6.3	.0040	.005	B
August	9	5	6.3	.0040	.005	B
September	16	5	7.9	.0051	.006	B
October	44	17	23.9	.015	.02	B
November (1-10)	27	21	23.1	.015	.006	B
1912.						
January			[a]5.0	.0032	.004	
February			[a]4.0	.0026	.003	
March			[a]20.0	.013	.01	
April	355	52	144	.092	.10	B
May	315	30	86.4	.055	.06	A
June	52	14	24.0	.015	.02	B
July	91	14	58.6	.038	.04	A
August	88	31	45.9	.029	.03	B
September	64	12	31.0	.020	.02	C
October	70	32	37.9	.024	.03	B
November	44	30	[a]34.1	.022	.02	C

[a] Estimated from climatological records and relation between open water flow at Odessa, Lac qui Parle, Watson and Montevideo.

MINNESOTA RIVER NEAR MONTEVIDEO.

Location.—At the highway bridge 1 mile south of Montevideo in Sec. 19, T. 117 N., R. 40 W., a short distance below the mouth of Chippewa River.

Records available.—July 23, 1909, to December 31, 1912.

Drainage area.—6,300 square miles.

Gage.—Chain, attached to bridge. The datum of the gage was lowered 2.00 feet September 16, 1909, and 1.00 foot additional July 29, 1910, to avoid negative readings. All gage heights have been referred to the last datum.

Channel.—Permanent.

Discharge measurements.—Made from bridge.

Regulation.—The nearest dam is at Granite Falls but its influence does not extend to the Montevideo station. There is no dam above the station. The discharge of Chippewa River is so much less than that of the Minnesota that the control of the former by a dam at Montevideo has very little effect on the Minnesota gage heights.

Winter flow.—The river is frozen over from December to March and measurements are made through the ice to determine the winter discharge.

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

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1								446	248	236	290	
2								433	248	230	299	
3								426	252	224	281	
4								420	238	217	277	
5								400	230	212	270	
6								374	230	202	270	
7								410	224	193	266	
8								467	226	187	285	
9								492	236	232	261	
10								523	221	259	232	
11								523	197	296	240	
12								534	207	336	263	
13								559	217	296	274	
14								587	217	268	305	
15								562	207	292	270	
16								548	204	274	288	
17								523	208	283	382	
18								506	187	288	389	
19								467	183	296	374	
20								441	197	281	321	
21								413	272	292	500	
22							805	400	314	303	467	
23							761	374	318	305	402	
24							713	348	312	296	292	
25							668	334	316	290	332	
26							623	350	303	303	334	
27							595	325	294	305	314	
28							551	312	290	303	255	
29							534	310	252	246	382	
30							514	279	240	246	362	
31							478	268		274		

Daily discharge, in second-feet, of Minnesota River near Montevideo—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1			150	1,600	1,410	508	181	58	83	95	111	
2			150	1,530	1,410	511	184	73	58	81	10[illegible]	
3		164	160	1,420	1,360	452	173	82	75	75	100	
4			700	1,480	1,310	441	158	96	71	107	86	
5			850	1,490	1,250	410	149	78	65	85	117	
6			1,030	1,400	1,250	446	173	62	72	107	117	
7			1,310	1,380	1,140	410	160	62	68	91	114	
8			1,640	1,370	1,070	441	162	62	67	85	120	
9			1,770	1,360	1,120	405	154	65	87	85	125	
10			1,520	1,250	1,090	384	134	71	68	75	120	
11			1,990	1,290	1,030	415	154	55	50	79	117	
12			2,060	1,200	964	410	149	49	71	75	112	
13			2,250	1,1[illegible]0	954	478	130	52	68	73	111	
14			2,100	1,090	902	452	119	59	67	87	110	
15			2,010	1,100	770	410	131	61	68	68	119	
16			2,340	1,260	832	367	123	62	69	83	125	
17			2,420	1,310	889	355	114	83	59	79	128	
18			2,260	1,320	851	334	106	78	75	77	122	
19			2,210	1,310	822	288	89	75	71	90	117	
20			2,180	1,360	864	271	92	88	72	119	114	
21			2,180	1,490	832	271	100	84	73	90	125	
22			2,150	1,620	832	256	101	85	65	89	122	
23			2,100	1,780	822	250	87	94	75	90	120	
24			2,080	1,670	841	242	82	85	79	95	123	
25			2,030	1,650	792	241	109	99	77	97	126	
26			1,990	1,630	751	220	86	98	88	103	142	
27			1,820	1,600	688	206	84	96	100	119	130	
28			1,850	1,580	656	199	58	65	83	138	120	
29			1,730	1,540	599	190	67	71	78	123	130	
30			1,690	1,510	659	184	74	57	74	97	130	
31			1,680		571		78	83		116		
1911.												
1			100	242	242	166	119	33	50	101	176	
2			125	246	230	115	105	35	56	98	155	
3			150	246	227	119	139	39	50	110	214	
4			150	238	220	173	118	25	62	121	263	
5			150	242	206	282	99	40	70	125	269	
6			175	246	213	234	140	43	77	119	279	
7			200	246	156	294	90	50	66	156	269	
8			256	250	167	269	74	56	77	169	252	
9			254	246	193	271	57	55	106	161	230	
10			250	239	199	284	101	56	108	143	242	
11			244	246	193	207	95	58	119	114		
12			310	254	186	316	99	48	113	107		
13			332	273	176	236	79	41	93	142		
14			379	294	169	233	74	41	96	167		
15			400	316	176	169	67	40	114	127		
16			256	318	171	176	53	53	107	154		
17			239	305	173	224	63	58	76	173		
18			260	301	176	180	56	46	71	186		
19			254	312	169	254	53	41	82	155		
20			246	323	234	176	51	41	87	150		
21			252	327	215	151	50	46	90	166		
22			260	334	200	173	57	40	85	249		
23			262	242	176	169	48	40	85	312		
24			263	242	169	157	72	50	75	213		
25			273	238	180	154	77	38	66	220		
26			290	250	157	155	50	44	76	239		
27			310	246	191	180	34	33	87	246		
28			296	234	189	180	29	65	87	250		
29			263	215	180	107	25	60	93	294		
30			254	234	188	133	27	52	109	327		
31			250		180		30	46		288		
1912												
1				200	1,030	807	174	156	144	181	120	
2				250	1,200	745	221	144	156	168	108	
3				300	1,610	685	221	132	144	132	108	
4				410	2,120	656	236	120	138	138	132	
5				436	2,700	627	236	132	132	168	168	

Daily discharge, in second-feet, of Minnesota River near Montevideo—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6				715	3,500	599	252	150	132	132	168	
7				685	4,000	571	292	156	144	144	168	
8				715	3,700	571	336	150	132	181	126	
9	28	7		685	3,300	489	360	144	132	156	138	
10				685	2,900	436	336	132	138	120	132	
11				656	2,700	436	292	120	126	156	132	
12				627	2,300	462	236	144	120	181	168	
13				571	2,080	462	221	144	126	144	168	
14				571	1,960	436	156	144	132	144	144	
15				599	1,810	462	168	162	108	181	144	
16				599	1,730	462	188	168	132	174	156	
17				627	1,690	462	207	156	132	181	120	
18				627	1,730	571	207	138	132	168	132	
19				627	1,420	627	188	156	132	168	156	
20				656	1,350	599	181	207	120	108	156	
21				656	1,280	516	194	236	120	156	168	
22			105	627	1,200	489	200	221	108	188	156	
23				599	1,170	292	207	207	138	168	120	
24				599	1,140	271	207	181	144	102	132	
25				571	1,140	252	207	168	132	120	120	
26				656	1,140	236	194	156	144	174	156	
27				745	1,100	236	194	144	120	156	181	
28				776	934	207	194	138	156	132	181	
29				807	870	207	207	156	132	168	162	
30				1,000	870	194	174	168	138	194	168	
31					838		168	181		168		

Daily discharges computed from a well-defined rating curve, except March 1-5 and Nov. 28-30, 1910, and March 1-7, 1911, which were estimated on account of ice, and May 5-12, 1912, which were estimated from maximum stage observed and comparison of discharge at other stations on the river.

Monthly discharge of Minnesota River near Montevideo.

[Drainage area, 6,300 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July (22-31)	805	478	624	0.099	0.04	A
August	587	268	431	.068	.08	A
September	318	197	243	.039	.04	A
October	336	187	267	.042	.05	A
November	500	232	316	.050	.06	B
December			[a]230	.037	.04	C
1910.						
January			[a]200	.032	.04	C
February			[a]150	.024	.02	C
March	2,420	150	1,690	.268	.31	B
April	1,780	1,090	1,420	.225	.25	A
May	1,410	571	946	.150	.17	A
June	511	184	348	.055	.06	A
July	184	58	121	.019	.02	A
August	98	49	73.8	.012	.01	A
September	100	50	72.5	.012	.01	A
October	138	73	92.7	.015	.02	A
November	142	86	119	.019	.02	B
December			[a]65	.010	.01	D
The year	2,420		442	.070	.94	

[a] Estimated from a few ice measurements, semi-weekly gage heights and comparison with climatological data.

Monthly discharge of Minnesota River near Montevideo—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
January			[a]40	0.0063	0.007	D
February			[a]50	.0079	.008	D
March	400	100	248	.039	.04	B
April	334	215	265	.042	.05	A
May	242	156	190	.030	.03	A
June	316	107	198	.031	.03	A
July	140	25	72.0	.011	.01	A
August	65	25	45.6	.0072	.008	A
September	119	50	84.4	.013	.01	A
October	327	98	180	.029	.03	B
November	279		165	.026	.03	C
December			160	.025	.03	D
The year	400		142	.023	.28	
1912.						
January			[a]25	.0040	.005	C
February			[a]15	.0024	.003	C
March			[a]85	.014	.02	C
April	1,000	[a]200	609	.097	.11	A
May	4,000	838	1,820	.289	.33	B
June	807	194	469	.074	.08	A
July	360	156	221	.035	.04	A
August	236	120	158	.025	.03	B
September	156	108	133	.021	.02	B
October	194	102	156	.025	.03	B
November	181	108	146	.023	.03	C

[a] Estimated from a few ice measurements, semi-weekly gage heights and comparison with climatological data.

MINNESOTA RIVER NEAR MANKATO.

Location.—At Sibley Park, 2 miles above the center of Mankato, and a few hundred yards below the mouth of Blue Earth River, the nearest tributary.

Records available.—May 20, 1903, to December 31, 1912. Since 1906 the gage heights have been furnished by the United States Weather Bureau.

Drainage area.—14,600 square miles.

Gage.—Chain maintained by the United States Engineer Corps; datum unchanged since established.

Channel.—Shifting at intervals.

Discharge measurements.—Made from a boat and cable near the gage.

Regulation.—The nearest dam on the river is at Minnesota Falls, 140 miles upstream. There is no dam below the station. A dam on Blue Earth River at Rapidan, a few miles above the mouth, controls the flow of that river but its flow is such a small part of the entire discharge at the Mankato station that the effect of such control is very slight.

Winter flow.—From December to March, measurements are made through the ice to determine the winter discharge.

Maximum and minimum flow.—The highest known stage of the river occurred in 1881 and is shown by a well-marked line in Mankato. The stage was approximately 27 feet above the zero of the present gage.

This value was corroborated by Mr. M. B. Haynes, city engineer of Mankato, who states that the highwater occurred after the ice went out and was not caused by backwater. The corresponding discharge was approximately 65,000 second feet. Since the establishment of the gage the highest stage recorded was 21.2 feet on June 26, 1908. The lowest stage recorded was 0.5 in 1911 when the flow was 89 second-feet for three days.

Accuracy.—Measurements made during the earlier years indicated changing conditions of flow, and accordingly the discharge for years previous to 1907 was obtained largely by the indirect method. These results can not be considered as accurate as the later ones which were based on a well-defined rating curve showing permanent channel, except during 1912, when the channel shifted again.

Daily discharge, in second-feet, of Minnesota River near Mankato.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1						27,200	3,710	3,100	2,980	5,760	3,650	1,340
2						23,000	3,900	2,930	3,770	5,610	3,460	1,260
3						18,900	4,350	2,880	3,460	5,460	3,340	1,220
4						15,800	6,960	2,980	4,090	6,060	3,220	1,260
5						13,400	6,540	3,400	4,160	6,140	3,100	1,260
6						11,300	6,620	3,840	4,160	6,460	2,980	1,300
7						9,530	6,540	4,090	2,980	15,600	2,760	1,300
8						7,380	6,460	3,840	3,460	18,900	2,660	1,300
9						6,700	6,300	3,340	3,580	20,500	2,540	1,300
10						6,700	6,380	3,100	3,840	20,400	2,490	1,300
11						5,910	6,300	2,880	4,220	18,600	2,440	1,300
12						5,460	5,760	2,760	5,610	17,200	2,390	1,260
13						5,180	5,460	2,660	8,120	15,500	2,340	1,260
14						4,760	5,320	2,660	13,500	13,900	2,280	1,220
15						4,480	4,760	3,960	17,800	12,200	2,230	1,190
16						3,960	4,220	4,350	22,700	10,800	1,930	1,190
17						3,710	4,160	5,460	27,300	10,100	1,380	1,190
18						3,220	4,690	5,180	25,100	9,110	1,220	1,160
19						3,100	4,960	4,760	22,600	8,310	1,090	1,160
20					9,530	2,930	5,460	4,220	19,500	7,930	1,030	1,160
21					8,500	2,930	6,060	4,090	17,200	7,380	970	1,160
22					7,650	2,880	5,610	3,960	14,800	6,790	1,000	1,160
23					7,560	2,880	5,540	3,460	13,200	6,220	1,000	1,160
24					7,650	2,760	5,040	3,100	11,300	5,910	1,100	1,160
25					10,800	2,710	4,690	2,880	10,100	5,320	1,100	1,160
26					14,900	2,540	4,220	2,660	8,800	5,040	1,200	1,160
27					22,300	2,540	4,090	2,540	8,220	4,760	1,300	1,160
28					30,800	2,490	4,220	2,490	6,700	4,480	1,300	1,160
29					38,700	2,440	3,710	2,930	5,610	4,220	1,260	1,160
30					36,800	2,540	3,460	2,930	6,140	3,960	1,380	1,160
31					32,000		2,980	2,930		3,770		1,000
1904.												
1	1,160			3,220	4,760	1,420	1,940	1,120	550	470	870	600
2	1,160			3,100	4,420	1,460	1,820	1,090	750	470	840	
3	1,160			2,930	4,220	1,700	1,780	1,000	910	470	840	
4	1,030			2,880	3,960	1,930	1,730	930	750	470	840	
5	980			2,880	3,710	2,910	1,700	900	750	470	810	
6	860			2,760	3,770	3,040	1,640	840	720	470	810	
7	740			2,660	3,840	2,350	1,520	810	690	470	810	
8	680			2,540	3,710	2,350	1,490	810	690	470	780	
9	660			3,710	3,580	2,400	1,430	910	690	470	780	
10	640			5,180	3,460	2,400	1,520	940	630	530	780	
11	630			6,540	3,340	2,480	1,520	890	630	580	750	
12	630			7,740	3,100	2,430	1,400	820	630	580	750	
13	620			7,740	2,980	2,370	1,400	820	605	580	750	
14	620			7,380	2,880	2,320	1,400	760	580	580	750	
15	600			6,960	2,660	2,260	1,320	760	580	580	750	

Daily discharge, in second-feet, of Minnesota River near Mankato—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
16	590			6,540	2,540	2,070	1,240	720	580	580	750	
17	580			6,220	2,440	1,970	1,140	720	580	580	690	
18	580			5,760	2,280	1,970	1,140	700	530	665	690	
19	580			5,460	2,130	1,920	1,140	700	530	720	690	
20	580			5,180	2,080	1,920	1,060	670	530	870	690	
21	580			4,900	2,030	1,880	1,050	650	510	940	690	
22	580			5,180	1,930	1,830	980	650	510	1,010	690	
23	570			5,760	1,880	1,840	950	620	490	1,050	690	
24	570			6,220	1,840	1,790	950	600	490	1,010	690	
25	570			6,220	1,740	1,820	950	600	470	1,010	655	
26	560			6,060	1,740	2,120	1,090	540	470	975	655	
27	560			6,060	1,640	2,220	1,050	540	470	940	625	
28	560			5,760	1,600	2,170	1,020	540	470	940	625	
29	560			5,320	1,560	2,130	1,020	540	470	940	625	
30	560			5,100	1,510	2,020	1,120	540	470	940	625	**315**
31	560				1,460		1,160	540		905		
1905.												
1			2,160	3,400	1,180	4,550	4,960	3,460	1,690	1,340	1,300	
2			2,370	3,520	1,180	4,340	6,950	3,280	1,640	1,300	1,220	
3			2,640	3,340	1,220	4,150	7,460	3,160	1,610	1,260	1,260	
4			3,830	3,280	1,510	3,960	9,400	2,930	1,560	1,220	1,220	
5			4,080	3,460	2,010	3,770	10,700	2,760	1,510	1,220	1,300	
6			4,620	3,520	2,110	3,580	13,500	2,600	1,470	1,140	1,590	
7			4,340	3,520	2,050	3,400	16,400	2,540	1,400	1,140	1,680	
8			3,830	3,460	1,920	3,100	17,700	2,390	1,400	1,140	1,860	
9			3,580	3,340	1,870	2,980	18,600	2,280	1,370	1,100	1,950	
10			2,980	3,100	2,320	2,860	17,100	2,180	1,340	1,220	1,950	
11			2,320	2,800	3,400	2,750	16,600	2,100	1,340	1,140	1,950	
12			2,210	2,640	4,620	2,700	14,900	2,050	1,340	1,100	1,950	
13			2,530	2,480	5,040	2,530	16,300	1,960	1,260	1,060	1,900	
14			1,730	2,320	6,090	2,480	12,200	1,960	1,220	1,100	1,900	
15			1,920	2,210	7,730	2,320	11,100	1,960	1,300	1,260	1,860	
16			2,060	2,010	10,100	2,370	9,900	1,960	1,260	1,300	1,810	
17			2,110	2,010	11,500	2,530	9,150	1,380	1,300	1,300	1,720	
18			2,210	1,920	11,900	2,420	8,180	1,960	1,300	1,340	1,720	
19			3,700	1,820	11,700	2,530	7,820	1,900	2,930	1,260	1,680	
20			4,340	1,730	11,500	2,480	7,270	1,870	2,200	1,340	1,680	
21			4,900	1,640	11,000	2,420	6,760	1,820	1,950	1,340	1,630	
22			5,180	1,510	10,100	2,260	6,450	1,380	1,900	1,380	1,590	
23			5,620	1,460	9,290	2,210	5,960	1,680	1,810	1,420	1,540	
24			5,620	1,460	8,110	2,160	5,540	2,260	1,720	1,420	1,860	
25			5,480	1,380	7,380	3,040	5,400	2,120	1,540	1,380	1,500	
26			5,180	1,380	6,710	4,080	5,120	1,940	1,460	1,380	1,500	
27			4,760	1,300	6,710	4,760	4,720	1,890	1,460	1,340	1,500	
28			4,620	1,260	5,480	4,900	4,340	1,890	1,420	1,340	1,500	
29			4,220	1,220	5,180	4,480	4,210	1,850	1,380	1,340	1,500	**1,070**
30			3,960	1,180	4,900	4,340	3,850	1,800	1,340	1,340	1,500	
31			3,700		4,680		3,650	1,730		1,300		
1906.												
1				5,300	4,580	7,900	7,600	3,260	7,090	5,700	5,840	**3,490**
2				6,050	4,770	8,140	7,430	3,150	6,930	5,420	5,700	**2,930**
3				6,830	4,970	8,140	7,430	3,150	6,930	5,140	5,700	**2,820**
4				6,050	5,050	8,140	7,430	3,040	6,930	4,860	5,700	**3,150**
5				5,730	4,970	8,520	7,260	2,820	7,090	4,470	5,560	**3,260**
6				5,300	4,900	8,910	7,090	2,820	6,930	4,340	5,560	**3,150**
7				5,150	4,680	9,110	6,930	2,720	6,770	4,090	5,560	**2,500**
8				5,870	4,610	9,420	6,770	3,040	6,460	3,840	5,840	
9				5,300	4,510	9,730	6,460	4,340	6,140	3,600	5,840	
10				5,740	4,320	9,940	6,300	4,600	5,700	3,380	5,700	
11				6,690	4,120	9,940	6,140	5,700	5,280	3,260	5,700	
12				5,900	4,050	9,840	5,840	7,260	5,000	3,040	5,420	
13				6,450	3,910	9,620	5,560	6,770	4,730	2,930	5,280	
14				8,340	3,800	9,420	5,280	6,460	4,470	2,820	5,000	
15				8,510	3,680	9,310	5,000	6,460	4,220	2,720	4,860	
16				9,100	3,550	9,110	4,730	6,140	4,220	2,610	4,600	
17				9,290	3,550	8,910	4,470	6,000	4,220	2,400	4,730	
18				9,210	3,860	8,620	4,340	5,840	4,220	2,400	4,600	
19				8,990	3,910	8,810	4,090	5,700	4,340	2,300	4,220	
20				8,520	3,910	8,710	3,960	5,560	4,470	2,200	4,220	

Daily discharge, in second-feet, of Minnesota River near Mankato—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906.												
21				8,120	3,780	8,420	3,720	5,140	4,860	2,200	4,090	
22				7,540	4,280	8,330	3,600	4,730	5,280	2,200	4,090	
23				6,840	4,030	8,330	3,380	4,860	5,560	2,200	3,840	
24				6,080	4,220	8,140	3,260	5,140	5,840	2,400	3,840	
25				5,940	4,280	7,960	3,040	5,420	6,000	3,040	3,490	
26				5,550	4,340	7,780	3,040	6,000	6,140	3,490	3,720	
27				5,230	4,810	7,780	2,820	6,770	6,300	4,090	3,840	
28				4,860	5,340	7,780	2,930	7,260	6,140	4,860	3,720	
29				4,720	6,000	7,780	3,150	7,600	6,140	5,280	3,600	
30				4,580	6,930	7,780	3,260	7,600	6,000	5,560	3,600	
31					7,600		3,380	7,430		5,700		
1907.												
1				9,520	4,470	6,140	14,600	4,860	4,220	1,900	1,060	
2				10,200	4,470	6,000	12,900	4,340	3,840	1,900	1,380	
3				12,000	4,470	5,700	12,200	3,960	3,490	2,200	1,720	
4				12,900	4,600	5,280	11,300	3,600	3,150	2,000	1,900	
5				13,600	4,730	5,140	10,600	3,490	2,930	2,100	1,900	
6				13,400	4,600	4,860	9,940	3,260	2,500	2,300	1,900	
7				12,900	4,600	4,860	9,110	3,150	2,400	2,300	1,720	
8				12,400	4,600	4,860	8,330	2,930	2,300	2,200	1,720	
9				11,700	4,470	5,140	7,780	2,930	2,200	2,000	1,630	
10				11,000	4,340	8,910	7,090	2,930	2,000	1,900	1,540	
11				10,200	4,220	11,700	6,610	2,720	2,000	1,630	1,540	
12				9,730	3,960	14,800	5,840	2,610	1,900	1,540	1,460	
13				9,110	3,960	17,100	5,140	2,500	1,720	1,460	1,300	
14				8,520	3,840	17,800	5,000	2,300	1,630	1,460	1,140	
15				8,140	3,720	17,800	6,000	2,200	1,630	1,380	1,140	
16				7,780	3,840	17,600	6,300	2,100	1,540	1,380	1,060	
17				7,600	3,960	17,100	6,460	2,000	1,720	1,300	1,220	
18				7,260	3,960	19,400	6,770	1,900	1,900	1,300	1,300	
19				6,610	3,960	20,400	7,430	1,900	2,300	1,220	1,300	
20				6,300	3,960	21,800	7,200	2,720	2,610	1,220	1,300	
21			7,780	6,140	3,960	22,100	7,900	3,040	4,090	1,140	1,220	
22			9,730	5,700	3,840	22,100	9,110	2,930	4,600	1,140	1,220	
23			10,200	5,280	3,720	21,000	9,310	2,720	4,090	1,140	1,220	
24			9,110	5,000	3,600	20,700	9,310	2,500	3,490	1,140	1,220	
25			8,520	4,860	3,840	21,000	9,110	2,300	3,040	1,060	1,220	
26			8,910	4,730	4,600	21,300	8,520	2,100	2,720	1,060	1,220	
27			8,910	4,600	5,280	20,200	7,260	2,720	2,500	1,060	1,220	
28			8,910	4,600	6,140	18,900	7,090	3,720	2,200	1,060	1,220	
29			9,110	4,470	6,300	17,600	6,460	4,420	2,100	1,060	1,220	
30			9,110	4,470	6,460	16,100	6,000	4,340	2,000	1,060	1,220	
31			9,310		6,300		5,420	4,220		1,060		
1908.												
1				3,720	5,840	31,100	30,500	7,090	1,810	911	1,380	
2				3,600	5,560	29,300	29,000	6,610	1,630	911	1,380	
3				3,490	5,420	26,900	26,900	6,140	1,540	987	1,300	
4				3,600	5,000	23,500	24,600	5,840	1,460	987	1,300	
5				3,600	5,280	22,100	22,900	5,280	1,460	987	1,300	
6				3,490	4,470	21,000	23,200	4,730	1,380	987	1,220	
7				3,600	4,220	20,400	23,200	4,470	1,300	987	1,220	
8				3,600	4,220	19,900	22,400	4,220	1,220	987	1,140	
9				3,600	4,220	18,600	21,800	3,960	1,220	987	1,060	
10				3,490	4,220	18,100	21,300	3,960	1,140	987	987	
11				3,490	3,960	17,100	19,600	3,380	1,060	911	911	
12				3,380	3,960	16,400	18,100	3,260	1,060	911	835	
13				3,600	3,720	15,800	17,400	3,150	987	911	835	
14				3,600	3,840	14,800	16,400	2,920	987	911	835	
15				3,380	5,000	13,900	15,400	2,820	987	911	835	
16			4,340	3,380	6,140	13,100	14,400	2,820	987	911	835	
17			4,600	3,380	6,930	12,200	14,100	2,720	987	835	835	
18			4,220	3,490	7,960	12,000	14,400	2,610	987	835	835	
19			4,090	3,960	8,910	12,400	15,100	2,610	987	835	835	
20			3,840	4,200	9,520	12,400	14,800	2,500	911	835	835	
21			4,090	4,200	12,000	16,400	13,600	2,400	911	911	835	
22			3,960	4,080	16,100	16,800	12,400	2,200	911	911	835	
23			3,840	3,840	18,100	27,500	11,000	2,200	911	911	835	
24			3,960	3,720	17,600	34,900	9,520	2,100	911	987	835	
25			3,840	3,840	18,600	43,200	8,330	2,00[illegible]	911	987	835	

Daily discharge, in second-feet, of Minnesota River near Mankato—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
26			?,720	4,340	19,200	43,800	7,260	1,900	91.	1,00(	835	......
27			3,720	4,600	19,700	41,600	8,910	1,810	835	1,14(	835	......
28			3,72(	5,420	21,800	38,700	9,110	1,900	835	1,14(	835	......
29			3,720	5,840	24,600	36,500	9,520	2,100	835	1,140	835	......
30			3,600	5,840	31,100	33,000	8,910	2,100	911	1,220	855	......
31			3,490	......	32,000	......	7,600	2,000	......	1,300	......	......
1909.												
1				29,900	7,600	7,070	14,000	1,440	925	695	585	......
2				28,700	8,340	7,780	14,000	1,300	865	695	640	......
3				27,200	8,150	8,720	14,000	1,240	865	640	640	......
4				26,000	8,150	9,120	13,500	1,170	865	585	640	......
5				24,900	7,960	9,320	12,600	1,100	805	585	1,820	......
6				24,000	7,600	9,520	11,500	1,040	805	530	1,820	......
7				23,200	7,070	9,120	10,600	985	750	530	1,660	......
8				21,500	6,560	8,720	9,730	985	750	475	1,520	......
9				19,900	5,920	8,340	8,530	985	750	475	1,370	......
10				18,600	5,310	7,960	7,780	985	750	530	1,240	......
11				17,100	4,730	7,600	7,070	925	750	585	1,100	......
12				16,600	4,310	7,420	6,400	1,100	750	585	1,100	......
13				16,400	4,040	7,780	5,610	1,240	750	585	1,100	......
14				15,900	3,650	8,340	5,310	1,520	750	640	1,520	......
15				15,400	3,520	8,530	4,730	1,370	750	695	2,000	......
16			7,240	14,400	3,520	7,960	4,450	2,540	750	695	2,950	......
17			7,240	13,700	3,520	8,340	4,040	2,950	695	695	3,170	......
18			7,420	12,600	3,650	7,960	3,650	2,840	695	695	2,840	......
19			7,600	12,100	3,900	7,780	3,780	2,540	695	695	2,950	......
20			7,960	11,700	3,900	7,420	3,900	2,350	640	640	3,060	......
21			8,150	11,000	3,900	6,900	3,650	2,260	640	640	3,060	......
22			8,340	10,600	3,900	6,240	2,440	2,000	750	640	3,060	......
23			8,720	10,200	3,650	6,080	2,840	1,820	750	640	3,060	......
24			10,800	9,730	3,520	6,900	2,540	1,590	750	640	3,170	......
25			15,900	9,320	3,520	7,070	2,350	1,520	805	640	3,170	......
26			18,400	8,920	5,650	6,560	2,170	1,440	865	640	3,170	......
27			20,700	8,150	5,610	7,960	1,820	1,300	805	585	3,650	......
28			28,400	7,960	4,590	9,730	1,820	1,240	805	585	4,040	......
29			31,400	7,420	5,310	12,100	1,740	1,100	805	585	5,610	......
30			31,400	7,600	5,760	13,300	1,590	1,100	750	585	5,920	......
31			30,800	......	6,400	......	1,520	985	......	585	......	......
1910.												
1			500	3,780	2,840	1,440	805	265	215	265	265	......
2			500	3,650	2,640	1,370	750	265	215	215	265	......
3			600	3,520	2,440	1,370	750	265	215	215	265	......
4			600	3,280	2,260	1,300	695	265	265	215	265	......
5			700	3,060	2,080	1,240	095	265	265	265	315	......
6			1,500	2,840	2,000	1,240	640	215	215	215	315	......
7			4,000	2,840	2,000	1,170	640	215	215	215	315	......
8			4,500	2,840	1,910	1,170	585	215	215	215	315	......
9			5,000	2,840	1,910	1,170	585	165	215	215	315	......
10			7,000	2,740	1,910	1,100	585	165	215	215	315	......
11			10,000	2,740	1,910	1,100	530	165	165	215	315	......
12			20,000	2,740	1,910	1,040	530	165	165	215	315	......
13			18,000	2,640	1,910	1,100	530	165	165	215	315	......
14			16,000	2,440	1,910	1,040	475	165	165	215	315	......
15			15,200	2,260	1,910	985	420	165	165	215	315	......
16			14,200	2,260	1,910	985	420	165	215	215	315	......
17			15,200	2,260	1,910	925	420	265	215	215	265	......
18			11,700	2,170	1,910	1,040	365	265	215	215	265	......
19			10,600	2,170	1,820	1,040	365	265	215	215	265	......
20			9,940	2,170	1,740	925	365	420	215	215	265	......
21			9,320	2,170	1,740	925	315	475	215	215	265	......
22			8,720	2,170	1,740	925	315	365	215	215	265	......
23			8,530	2,170	1,660	925	315	265	215	215	265	......
24			7,600	2,170	1,660	865	315	265	215	265	265	......
25			7,240	2,170	1,590	865	315	265	215	265	265	......
26			6,730	2,350	1,590	805	265	265	265	265	265	......
27			6,240	2,540	1,520	805	265	265	265	265	265	175
28			5,760	2,640	1,520	805	265	265	265	265	265	......
29			5,160	2,840	1,520	805	265	265	265	265	265	......
30			4,870	3,060	1,440	805	265	215	265	265	265	......
31			4,590	......	1,440	......	265	215	......	265	......	......

Daily discharge, in second-feet, of Minnesota River near Mankato—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1			679	790	625	469	322	227	89	274	1,400	
2			679	734	625	625	370	227	89	227	1,340	
3			734	734	572	572	370	134	134	274	1,210	
4			790	679	572	572	370	134	134	274	1,270	
5			679	734	572	572	419	134	180	274	1,210	
6			625	679	572	572	419	134	180	847	1,210	
7			572	734	572	572	419	274	227	1,150	1,210	
8			572	790	572	520	370	322	134	1,400	1,210	
9			625	790	572	469	322	274	134	2,640	1,210	
10			572	790	572	469	322	274	180	1,910	1,150	
11			572	734	572	625	227	274	180	1,680	1,150	
12			679	734	520	572	180	274	134	2,080	1,150	
13			847	847	469	572	180	322	134	1,760	1,020	
14			847	847	469	572	180	322	134	1,270	1,020	
15			790	790	469	520	180	322	134	1,080	1,020	
16			734	734	469	520	180	322	227	2,080	1,020	
17			734	734	469	520	134	370	227	2,640	1,020	
18			847	790	669	520	134	370	227	2,840	1,020	
19			790	790	419	520	134	322	227	3,280	1,020	
20			790	734	419	520	134	322	180	3,650	1,020	
21			790	790	419	520	134	227	180	3,170	1,020	
22			790	790	419	469	134	227	180	2,950	1,020	
23			790	734	419	469	134	274	227	2,640	1,020	
24			679	734	572	469	134	227	180	2,440	1,020	
25			679	734	572	419	134	227	227	2,260	905	
26			679	734	520	419	134	227	180	2,000	847	
27			679	734	520	419	134	180	274	1,910	847	
28			790	679	572	570	134	180	227	1,830	847	
29			790	625	572	322	180	134	274	1,610	790	
30			790	625	572	322	180	134	274	1,680	790	
31			790		520		227	89		1,470		
1912.												
1				8,150	2,700	2,180	910	635	580	270	320	
2				8,530	2,590	2,080	855	525	470	270	320	
3				7,240	3,040	2,080	970	525	470	270	270	
4				6,080	2,810	1,890	1,030	525	470	270	270	
5	341			5,310	4,170	1,800	1,030	525	470	270	270	
6				4,590	3,900	1,710	910	525	470	270	320	
7		201		4,730	5,760	1,620	1,030	525	470	270	320	
8				4,450	7,070	1,540	1,160	525	420	270	320	
9				4,870	6,560	1,460	1,030	525	420	320	320	
10				3,640	6,900	1,460	970	525	420	320	270	
11				3,640	6,400	1,380	855	470	420	270	225	
12				3,640	6,730	1,380	1,030	470	370	370	270	
13				3,640	6,730	1,300	1,090	470	370	370	270	
14				3,520	6,560	1,230	970	420	370	370	320	
15				3,520	6,240	1,300	910	420	320	320	320	
16				3,160	5,760	1,300	910	420	370	320	270	
17				3,040	4,870	1,380	855	420	320	320	270	
18				3,160	4,730	1,300	855	470	370	320	225	
19				3,280	4,590	1,300	800	525	370	320	270	
20				3,400	3,900	1,300	855	470	370	320	270	
21				2,920	3,520	1,300	800	470	320	320	270	
22				3,400	3,400	1,230	745	580	320	320	270	
23				3,770	3,160	1,230	745	800	270	320	270	
24				3,640	3,040	1,160	745	910	270	320	180	
25			2,380	4,450	2,810	1,160	745	800	320	320	180	
26			2,920	3,640	2,810	1,160	745	745	320	320	225	
27			2,810	3,520	2,810	1,160	745	745	320	320	225	
28			2,920	3,640	2,480	970	745	690	320	320	225	
29			2,700	3,770	2,380	910	745	580	320	320	270	
30			4,730	3,640	2,280	910	745	635	270	320	270	
31			6,560		2,280		690	580		320		

Daily discharges computed from a fairly well-defined rating table which was applied indirectly prior to May 20, 1906. The 1910 estimates have been revised since being published in "Report of Water Resources Investigation of Minnesota during 1909-10."

Monthly discharge of Minnesota River near Mankato.

[Drainage area, 14,600 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1903.						
May (20-31)	38,700	7,560	18,900	1.29	0.58	C.
June	27,200	2,440	6,980	.478	.53	B.
July	6,960	2,980	5,110	.350	.40	B.
August	5,460	2,490	3,430	.235	.27	B.
September	27,300	2,980	10,200	.699	.78	B.
October	20,500	3,770	9,430	.646	.74	B.
November	5,650	970	2,000	.137	.15	B.
December	1,340	1,160	1,210	.083	.10	C.
1904.						
January	1,160	560	687	.047	.05	C.
February			[a]500	.034	.04	D.
April	7,740	2,540	5,130	.351	.39	B.
May	4,760	1,460	2,740	.188	.22	B.
June	3,040	1,420	2,120	.145	.16	B.
July	1,940	950	1,310	.090	.10	B.
August	1,102	540	751	.051	.06	B.
September	910	470	591	.040	.04	B.
October	1,050	470	701	.048	.06	B.
November	870	625	733	.050	.06	B.
December			[a]460	.032	.04	C.
1905.						
January			[a]300	.021	.02	D.
February			[a]400	.027	.03	D.
March	5,620	1,730	3,640	.249	.29	C.
April	3,520	1,180	2,330	.160	.18	B.
May	11,900	1,180	5,820	.399	.46	B.
June	4,900	2,160	3,220	.221	.25	B.
July	18,600	3,650	9,430	.646	.74	B.
August	3,460	1,380	2,160	.148	.17	B.
September	2,930	1,220	1,550	.106	.12	B.
October	1,420	1,060	1,270	.087	.10	B.
November	1,950	1,220	1,640	.112	.12	B.
December			[a]1,250	.086	.10	C.
The year			2,750	.188	2.58	
1906.						
April	9,290	4,580	6,590	.451	.50	C.
May	7,600	3,550	4,560	.312	.36	C.
June	9,940	7,780	8,680	.595	.66	C.
July	7,600	2,820	5,020	.344	.40	B.
August	7,600	2,720	5,250	.360	.42	B.
September	7,090	4,220	5,680	.389	.43	B.
October	5,700	2,200	3,630	.249	.29	B.
November	5,840	3,490	4,780	.327	.36	B.
1907.						
March (21-31)	10,200	7,780	9,050	.620	.25	C.
April	13,600	4,470	8,360	.573	.64	C.
May	6,460	3,600	4,480	.307	.35	C.
June	22,100	4,860	14,400	.986	1.10	B.
July	14,600	5,000	8,140	.558	.64	B.
August	4,860	1,900	3,010	.206	.24	B.
September	4,600	1,540	2,630	.180	.20	B.
October	2,300	1,060	1,510	.103	.12	B.
November	1,900	1,060	1,380	.094	.10	B.
1908.						
March (16-31)	4,600	3,490	3,920	.268	.16	C.
April	5,840	3,380	3,910	.268	.30	C.
May	32,000	3,720	10,900	.747	.86	C.
June	43,800	12,000	23,400	1.60	1.78	C.
July	30,500	7,260	16,500	1.13	1.30	C.
August	7,090	1,810	3,350	.229	.26	C.
September	1,810	835	1,100	.075	.08	C.
October	1,300	835	975	.067	.08	C.
November	1,380	835	969	.066	.07	C.

[a] Estimated from a few discharge measurements and climatological records.

Monthly discharge of Minnesota River near Mankato—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
March (16-31)	31,400	7,240	15,700	1.08	0.64	C.
April	29,900	7,420	16,000	1.10	1.23	C.
May	8,340	3,520	5,200	.356	.41	C.
June	13,300	6,080	8,250	.565	.63	C.
July	14,000	1,520	6,120	.419	.48	C.
August	2,950	925	1,510	.103	.12	C.
September	925	640	769	.053	.06	C.
October	695	475	613	.042	.05	C.
November	5,920	585	2,390	.164	.18	C.
1910.						
January			[a]800	.055	.06	D.
February			[a]575	.039	.04	C.
March	20,000	500	7,760	.532	.61	B.
April	3,780	2,170	2,650	.182	.20	B.
May	2,840	1,440	1,880	.129	.15	B.
June	1,440	805	1,040	.071	.08	B.
July	805	265	462	.032	.04	B.
August	475	165	246	.017	.02	B.
September	265	165	218	.015	.02	B.
October	265	215	231	.016	.02	B.
November	315	265	285	.020	.02	B.
December			[a]220	.015	.02	C.
The year	20,000		1,370	.094	1.28	
1911.						
January			[a]175	.012	.01	C.
February			[a]190	.013	.01	C.
March	847	572	723	.050	.06	A.
April	847	625	746	.051	.06	A.
May	625	419	524	.036	.04	A.
June	625	322	502	.034	.04	A.
July	419	134	227	.016	.02	A.
August	370	89	241	.017	.02	A.
September	274	89	184	.013	.01	A.
October	3,650	227	1,790	.123	.14	A.
November	1,400	790	1,070	.073	.08	B.
December			[a]740	.051	.06	C.
The year	3,650		596	.041	.55	[illegible]
1912.						
January			[a]300	.021	.02	C
February			[a]250	.017	.02	C
March	6,560		1,400	.096	.11	C
April	8,530	2,920	4,270	.292	.33	B
May	7,070	2,280	4,290	.294	.34	B
June	2,180	910	1,410	.097	.11	B
July	1,160	690	878	.060	.07	B
August	910	420	563	.039	.04	A
September	580	270	379	.026	.03	A
October	370	270	310	.021	.02	B
November	320	180	270	.018	.02	B

[a] Estimated from a few discharge measurements and climatological records.

WHETSTONE RIVER NEAR BIGSTONE, S. DAK.

Location.—At the State Line bridge, one-fourth mile southeast of Bigstone and nearly a mile above the mouth.

Records available.—March 8, 1910, to November 16, 1912. Records of United States Engineer Corps September 15, 1899, to May 14, 1904.

Drainage area.—441 square miles.

Gage.—Vertical staff.

Channel.—Somewhat shifting during flood stages.

Whetstone river carries little or no water except during the spring and as a result of heavy rains at other times.

Daily discharge, in second-feet, of Whetstone River at Bigstone, S. Dak.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1					14	36	23	2	39	6	10	9
2					13	40	20	2	34	6	10	10
3					14	51	17	2	32	6	10	9
4					21	77	18	2	26	6	10	9
5					29	103	19	2	24	6	11	11
6					32	233	17	2	19	6	10	10
7					29	1147	16	3	15	6	10	11
8					26	634	18	4	13	6	10	10
9					20	357	15	4	12	6	10	11
10					17	355	13	4	11	6	10	11
11					16	279	12	4	9	5	10	11
12					15	191	11	3	9	5	10	11
13					12	117	11	3	8	5	10	10
14					12	115	11	3	9	5	12	10
15				20	12	102	10	4	7	5	12	11
16				18	11	79	9	5	7	5	12	11
17				17	10	69	8	8	7	5	14	11
18				16	10	60	7	10	7	5	16	11
19				17	9	51	6	13	7	6	16	11
20				17	8	41	5	19	7	6	16	11
21				13	8	37	5	29	7	8	16	10
22				12	8	35	4	93	8	9	16	11
23				12	9	34	4	202	7	8	16	11
24				12	9	33	3	175	7	7	16	11
25				12	9	29	3	121	7	7	16	10
26				11	9	25	3	91	7	6	12	12
27				10	9	23	3	68	7	6	12	14
28				10	14	24	3	66	7	6	12	14
29				10	14	25	3	53	7	6	9	14
30				10	13	23	3	48	6	6	9	12
31					31		2	43		6		15
1900.												
1	13	8	10	119	19	3	1	0.1	1	14	11	9
2	13	9	10	571	20	3	1	.1	1	14	11	9
3	13	9	10	873	21	3	1	.1	1	14	12	8
4	13	12	10	591	19	3	2	.8	1	13	11	8
5	13	12	10	316	17	3	3	2	1	16	11	8
6	13	12	10	168	15	3	3	2	.8	15	11	8
7	13	10	10	130	16	3	3	4	.5	14	11	8
8	13	10	10	107	17	2	2	4	1	14	11	8
9	13	10	10	80	15	2	2	3	6	14	12	8
10	13	10	10	52	14	2	1	7	22	13	12	8
11	13	11	50	42	14	2	1	9	24	13	11	8
12	13	11	50	42	13	2	1	8	20	13	11	8
13	13	10	50	35	12	2	1	7	24	13	11	8
14	13	10	50	29	11	3	2	6	22	12	12	8
15	13	10	50	27	10	3	2	5	24	12	11	8
16	13	10	50	25	8	3	3	4	19	13	12	7
17	13	10	50	23	8	4	3	4	18	13	12	7
18	13	10	50	22	6	3	2	4	16	12	12	7
19	13	10	50	20	6	3	2	4	28	13	11	7
20	13	10	50	19	6	2	2	3	29	14	11	7

Daily discharge, in second-feet, of Whetstone River at Bigstone, S. Dak.—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
21	8	10	50	17	6	2	2	3	29	14	11	7
22	8	10	50	13	6	2	1	3	24	13	11	7
23	8	10	50	12	4	2	1	3	24	13	10	7
24	8	10	50	13	4	2	.9	3	23	12	10	7
25	10	10	50	13	4	1	.7	3	22	12	10	7
26	10	10	49	16	4	1	.6	3	22	12	10	7
27	9	10	46	20	4	1	.5	3	20	12	10	7
28	9	10	43	20	4	1	.5	3	19	12	9	7
29	9	......	43	19	4	1	.4	2	16	11	9	7
30	8	......	40	19	4	1	.1	2	14	12	9	7
31	8	......	30	......	4	......	.1	2	......	12	......	7
1901.												
1	7	5	4	253	46	6	4	0.5	0.1	7	2	6
2	7	5	6	314	54	5	3	.4	.1	6	2	6
3	6	5	4	250	51	5	3	.4	.1	6	2	6
4	6	5	4	186	38	5	2	.3	.1	5	2	6
5	6	5	4	141	30	5	2	.2	.1	5	2	6
6	6	5	4	107	26	6	2	.2	.1	5	2	6
7	6	5	6	82	28	5	2	.2	.1	4	2	6
8	6	5	4	192	34	5	1	.1	.1	4	2	6
9	6	5	4	350	34	5	2	.1	.2	4	3	6
10	6	5	6	326	29	5	2	.1	.2	4	4	6
11	6	5	10	210	25	5	1	.1	.3	5	5	6
12	6	4	11	133	24	5	1	.1	1	5	6	6
13	6	4	9	104	23	5	1	.1	1	5	6	6
14	6	4	8	84	21	6	1	.1	2	5	6	6
15	6	4	6	70	19	9	.9	.1	4	5	6	6
16	6	4	5	63	16	10	.8	.1	5	5	6	6
17	6	4	16	55	14	10	.8	.1	5	5	6	6
18	6	4	19	47	12	9	.7	.1	6	4	6	6
19	6	4	16	41	12	10	.5	.1	4	4	6	6
20	6	4	70	36	11	10	.3	.1	4	4	6	6
21	6	4	95	32	10	11	.2	.1	4	3	6	6
22	6	4	76	29	10	10	.2	.1	4	3	6	5
23	5	4	73	26	10	10	.2	.1	4	3	6	5
24	5	4	56	25	9	8	.2	.1	5	3	6	5
25	5	4	68	24	8	7	.2	.1	6	3	6	5
26	5	4	128	22	8	6	.2	.1	6	3	6	5
27	5	4	151	22	7	6	.3	.1	7	3	6	5
28	5	4	101	24	7	5	.6	.1	8	3	6	5
29	5	......	71	26	7	5	.7	.1	8	3	6	5
30	5	......	100	32	7	4	.8	.1	7	3	6	5
31	5	......	146	......	6	......	.6	.1	......	2	......	5
1902.												
1	5	4	4	6	8	3	3	5	1	0.5	2	0.9
2	5	4	4	6	9	3	3	21	1	.5	2	.9
3	5	4	4	6	10	3	4	21	1	.5	2	.9
4	5	4	4	6	10	3	4	18	.9	.5	2	.9
5	5	4	4	6	11	3	4	16	.9	.5	2	.9
6	5	4	4	6	12	3	4	13	.8	.5	2	.9
7	5	4	4	6	13	3	4	11	.8	.5	2	1
8	5	4	4	7	14	3	4	9	.8	.5	.9	1
9	5	4	4	7	15	3	4	8	.8	.5	.9	1
10	5	4	4	7	16	3	3	6	.8	.5	.9	1
11	5	4	4	8	17	3	3	5	.6	.5	.9	1
12	5	4	4	8	18	3	3	5	.6	.6	.9	1
13	5	4	4	8	20	3	3	3	.6	.6	.8	1
14	5	4	4	8	23	3	3	2	.6	.6	.8	1
15	5	4	4	8	22	3	3	1	.6	.6	.8	1
16	5	4	4	8	21	3	3	.6	.5	.6	.8	1
17	5	4	4	8	20	3	3	.6	.5	.6	.8	1
18	5	4	4	7	18	3	2	.6	.5	.6	.8	1
19	4	4	4	7	16	3	2	.6	.5	.6	.8	1
20	4	4	4	7	14	3	2	.6	.5	.6	.8	1
21	4	4	4	7	12	3	2	.5	.5	.6	.8	1
22	4	4	4	7	11	3	2	.5	.5	.8	.8	1
23	4	4	5	7	10	3	2	.5	.5	.8	.8	1
24	4	4	5	6	8	3	2	.5	.5	.8	.8	1
25	4	4	5	6	6	3	2	.5	.5	.8	.8	1

Daily discharge, in second-feet, of Whetstone River at Bigstone, S. Dak.—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
26	4	4	5	6	5	3	2	.5	.5	.8	.8	1
27	4	4	5	6	4	3	2	.5	.5	.9	.8	1
28	4	4	5	7	4	3	2	.5	.5	.9	.8	1
29	4	......	5	8	4	3	2	.5	.5	1	.9	1
30	4	......	5	8	4	3	2	.5	.5	1	.9	1
31	4	......	5	......	4	......	3	1	......	2	......	1
1903.												
1	1	1	1	177	18	26	10	11	9	17	7	4
2	1	1	1	200	18	28	11	14	9	26	6	4
3	1	1	1	248	21	29	28	23	10	26	6	4
4	1	1	1	200	28	28	32	44	7	26	6	4
5	1	1	1	184	24	21	415	86	6	26	6	4
6	1	1	1	164	26	16	312	70	3	28	5	4
7	1	1	1	132	36	9	190	70	3	65	5	4
8	1	1	16	126	44	9	115	60	3	70	5	4
9	1	1	49	121	44	9	83	23	3	55	5	4
10	1	1	88	118	36	8	62	12	3	11	5	4
11	1	1	570	88	24	8	44	12	2	11	5	4
12	1	1	548	78	24	7	44	11	2	11	4	4
13	1	1	548	73	24	6	32	2	534	20	4	4
14	1	1	534	65	24	6	28	.8	302	20	4	4
15	1	1	500	60	24	6	24	.6	312	17	4	4
16	1	1	284	53	21	6	28	.8	307	17	4	4
17	1	1	200	52	20	6	38	.8	180	7	4	4
18	1	1	240	40	20	5	21	.8	129	7	5	4
19	1	1	257	40	20	5	16	.9	88	7	5	4
20	1	1	275	38	21	5	28	2	86	8	5	4
21	1	1	284	36	21	5	21	3	62	8	5	4
22	1	1	284	36	23	5	18	3	51	9	5	4
23	1	1	261	34	23	6	40	3	46	9	5	4
24	1	1	261	34	23	6	32	3	40	11	4	4
25	1	1	240	32	26	5	36	2	36	12	4	4
26	1	1	228	29	26	5	26	1	32	12	4	4
27	1	1	219	28	28	4	21	1	23	12	4	4
28	1	1	180	28	28	6	21	1	23	9	4	4
29	1	......	180	24	28	8	16	1	21	9	4	4
30	1	......	167	21	26	9	13	3	3	8	4	4
31	1	......	174	......	26	......	14	9	......	8	......	4
1904.												
1	4	4	4	18	18	......	......	......	......	......	......	......
2	4	4	4	36	16	......	......	......	......	......	......	......
3	4	4	4	68	13	......	......	......	......	......	......	......
4	4	4	4	70	11	......	......	......	......	......	......	......
5	4	4	4	73	10	......	......	......	......	......	......	......
6	4	4	4	75	13	......	......	......	......	......	......	......
7	4	4	4	248	16	......	......	......	......	......	......	......
8	4	4	5	583	16	......	......	......	......	......	......	......
9	4	4	5	740	55	......	......	......	......	......	......	......
10	4	4	5	343	51	......	......	......	......	......	......	......
11	4	4	5	265	38	......	......	......	......	......	......	......
12	4	4	5	293	32	......	......	......	......	......	......	......
13	4	4	5	353	26	......	......	......	......	......	......	......
14	4	4	6	475	24	......	......	......	......	......	......	......
15	4	4	6	270	......	......	......	......	......	......	......	......
16	4	4	6	184	......	......	......	......	......	......	......	......
17	4	4	5	132	......	......	......	......	......	......	......	......
18	4	4	5	167	......	......	......	......	......	......	......	......
19	4	4	6	190	......	......	......	......	......	......	......	......
20	4	4	6	204	......	......	......	......	......	......	......	......
21	4	4	132	270	......	......	......	......	......	......	......	......
22	4	4	164	368	......	......	......	......	......	......	......	......
23	4	4	450	333	......	......	......	......	......	......	......	......
24	4	4	333	257	......	......	......	......	......	......	......	......
25	4	4	126	177	......	......	......	......	......	......	......	......
26	4	4	49	138	......	......	......	......	......	......	......	......
27	4	4	40	115	......	......	......	......	......	......	......	......
28	4	4	21	68	......	......	......	......	......	......	......	......
29	4	4	13	40	......	......	......	......	......	......	......	......
30	4	......	5	18	......	......	......	......	......	......	......	......
31	4	......	3	......	......	......	......	......	......	......	......	......

Daily discharge, in second-feet, of Whetstone River at Bigstone, S. Dak.—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1	......	......	......	52	121	13	5.0	4.5	5.0	6.0	6.0	......
2	......	......	......	46	106	13	4.5	4.5	5.0	6.0	6.0	......
3	......	......	......	49	76	13	4.5	4.5	5.0	6.0	6.0	......
4	......	......	......	49	64	10	4.5	4.5	5.0	5.5	8.0	......
5	......	......	......	43	61	10	5.0	4.5	5.0	5.0	8.0	......
6	......	......	......	37	55	10	5.0	4.5	5.0	5.0	8.0	......
7	......	......	......	37	55	10	5.0	4.5	5.0	5.0	8.0	......
8	......	......	2,070	37	49	10	5.0	4.5	4.5	4.8	8.0	......
9	......	......	......	37	49	16	5.0	4.5	4.5	4.5	9.0	......
10	......	......	......	34	49	19	5.0	4.5	4.5	4.5	8.0	......
11	......	......	......	30	43	19	5.0	4.5	4.5	4.5	14	......
12	......	......	......	27	37	23	5.0	4.5	4.5	4.5	9.0	......
13	......	......	......	25	37	23	5.0	5.0	4.5	4.5	9.0	......
14	......	......	......	23	32	19	5.0	5.0	4.5	4.5	9.0	......
15	......	......	......	25	27	16	5.0	5.0	4.5	4.5	8.0	......
16	......	......	248	34	27	13	5.0	6.0	4.5	4.5	13	......
17	......	......	206	34	27	10	5.0	6.0	4.5	4.8	9.0	......
18	......	......	174	27	27	10	4.5	6.0	4.5	5.0	8.0	......
19	......	......	158	30	27	8.0	4.5	6.0	4.5	8.0	12	......
20	......	......	152	34	23	6.0	4.5	6.0	4.5	10	8.0	......
21	......	......	141	102	23	6.0	4.5	6.0	4.5	10	14	......
22	......	......	131	1,300	23	5.0	4.5	6.0	4.5	10	9.0	......
23	......	......	116	1,030	23	5.0	4.5	6.0	4.5	8.0	10	......
24	......	......	102	447	19	4.5	4.5	6.0	4.5	8.0	12	......
25	......	......	88	308	19	4.5	4.5	5.0	4.8	8.0	8.0	......
26	......	......	80	255	19	7.0	4.5	5.0	7.0	8.0	9.0	......
27	......	......	68	227	18	10	4.5	5.0	8.0	8.0	10	......
28	......	......	61	192	16	7.0	4.5	5.0	8.0	6.0	10	......
29	......	......	58	163	16	6.0	4.5	5.0	8.0	6.0	10	......
30	......	......	61	136	16	5.5	4.5	5.0	8.0	6.0	10	......
31	......	......	55	......	13	......	4.5	5.0	......	6.0	......	......
1911.												
1	......	......	......	10	8.0	5.0	4.5	3.5	3.0	8.0	5.0	......
2	......	......	......	10	8.0	5.0	4.5	4.0	3.0	6.0	5.0	......
3	......	......	......	13	6.0	8.0	4.5	4.0	3.0	8.0	5.0	......
4	......	......	......	13	6.0	34	4.5	4.8	3.0	8.0	4.5	......
5	......	......	......	13	6.0	19	9.0	4.8	4.0	8.0	4.5	......
6	......	......	......	13	6.0	43	7.0	4.5	5.5	12	4.5	......
7	......	......	......	12	6.0	19	4.8	5.0	6.0	13	4.5	......
8	......	......	......	10	6.0	14	4.5	5.0	4.8	13	4.5	......
9	......	......	......	10	6.0	9.0	4.5	5.0	4.5	13	4.0	......
10	......	......	......	13	6.0	7.0	4.5	5.0	4.5	10	4.0	......
11	......	......	......	13	6.0	6.0	4.5	4.5	4.5	10	4.0	......
12	......	......	......	16	6.0	6.0	4.5	5.0	4.5	13	......	......
13	......	......	......	21	6.0	5.0	4.5	5.0	4.5	13	......	......
14	......	......	......	30	6.0	5.0	4.5	6.0	5.0	13	......	......
15	......	......	......	25	7.0	5.0	4.0	5.0	5.0	13	......	......
16	......	......	......	18	8.0	5.0	4.0	4.5	4.5	13	......	......
17	......	......	......	16	8.0	5.0	3.8	4.5	4.0	13	......	......
18	......	......	......	16	8.0	5.0	3.5	4.5	4.0	10	......	......
19	......	......	52	13	6.0	5.0	4.0	4.0	4.0	9.0	......	......
20	......	......	40	13	6.0	4.5	4.0	4.0	4.0	8.0	......	......
21	......	......	30	13	6.0	4.0	3.8	4.0	4.0	7.0	......	......
22	......	......	27	10	6.0	4.0	4.0	3.5	4.0	6.0	......	......
23	......	......	21	10	6.0	4.0	4.0	3.5	4.5	6.0	......	......
24	......	......	18	8.0	6.0	4.0	4.0	3.5	4.5	5.5	......	......
25	......	......	16	8.0	6.0	4.0	3.5	3.5	4.5	5.0	......	......
26	......	......	16	8.0	6.0	4.0	3.5	3.5	4.0	5.0	......	......
27	......	......	14	8.0	6.0	4.0	3.5	3.5	4.0	5.0	......	......
28	......	......	13	8.0	5.0	4.0	3.5	3.5	16	5.0	......	......
29	......	......	13	8.0	5.0	5.0	3.5	3.0	12	5.0	......	......
30	......	......	13	8.0	5.0	4.8	3.5	3.0	7.0	5.0	......	......
31	......	......	10	......	5.0	......	3.5	3.0	......	5.0	......	......
1912.												
1	......	......	......	174	52	32	4.5	9.0	4.5	4.5	3.5	......
2	......	......	......	152	37	30	4.5	8.0	4.5	4.5	3.5	......
3	......	......	......	131	40	21	4.5	5.5	4.5	4.5	3.5	......
4	......	......	......	98	49	18	8.0	5.0	4.5	4.0	3.5	......
5	......	......	......	61	227	16	19	4.5	4.0	4.0	3.5	......

Daily discharge, in second-feet, of Whetstone River at Bigstone, S. Dak.—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6				46	369	13	13	4.5	4.0	4.0	3.5	
7				43	285	12	9	4.5	4.0	4.0	3.5	
8				37	152	10	14	4.0	4.0	4.0	3.5	
9				30	93	10	19	4.0	4.0	4.0	3.5	
10				25	64	8	19	4.0	4.0	4.0	3.5	
11				23	52	10	13	4.0	4.0	4.0	3.5	
12				21	49	10	14	4.2	4.0	4.0	3.5	
13				21	49	13	16	4.5	4.0	4.0	3.5	
14				34	49	16	21	4.0	4.0	4.0	3.5	
15				507	43	19	30	4.0	4.0	4.0	3.5	
16				407	32	27	37	4.0	4.0	4.0	3.5	
17				199	21	40	37	4.0	4.0	4.0		
18				131	19	34	37	4.0	4.0	3.5		
19				102	19	25	32	4.5	4.0	3.5		
20				72	19	21	27	5.5	4.0	3.5		
21				61	16	18	19	5.5	4.0	3.5		
22				52	23	13	19	4.5	4.0	3.5		
23				46	40	13	27	4.5	4.0	3.5		
24				43	61	10	30	4.5	4.0	3.5		
25				46	46	9	32	4.2	4.0	3.5		
26				52	34	6	30	4.0	4.5	3.5		
27				76	30	5	40	4.0	4.5	3.5		
28				131	43	4.8	30	4.0	4.5	3.5		
29				111	58	4.5	19	4.0	4.5	3.5		
30				98	40	4.5	13	4.5	4.5	3.5		
31					34		10	4.5		3.5		

Monthly discharge of Whetstone River at Bigstone, S. Dak.

[Drainage area, 441 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1899.					
April (15-30)	20	10	13.6	0.031	0.02
May	32	8	15.1	.034	.04
June	1,147	23	148	.336	.37
July	23	2	9.7	.022	.03
August	202	2	35.1	.080	.09
September	39	6	12.4	.028	.03
October	9	5	6.0	.014	.02
November	16	9	12.1	.027	.03
December	15	9	11.1	.025	.03
1900.					
January	13	8	11.5	.026	.03
February	12	8	10.1	.023	.02
March	50	10	35.5	.080	.09
April	873	12	115	.261	.29
May	21	4	10.2	.023	.03
June	4	1.	2.3	.0052	.006
July	3	0.1	1.5	.0034	.004
August	9	.1	3.4	.0077	.009
September	29	.5	15.7	.036	.04
October	16	11	13.0	.029	.03
November	12	9	10.9	.025	.03
December	9	7	7.5	.017	.02
The year	873	0.1	19.7	.045	.60

Monthly discharge of Whetstone River at Bigstone, S. Dak.—Continued.

Month.	Discharge in second-feet.			Per square mile.	Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.			
1901.						
January	7	5	5.8	0.013	0.02	
February	5	4	4.4	.010	.01	
March	151	4	41.3	.094	.11	
April	350	22	110	.249	.28	
May	54	6	20.5	.046	.05	
June	10	4	6.8	.015	.02	
July	4	0.2	1.1	.0025	.003	
August	0.5	.1	.15	.00034	.0004	
September	8	.1	3.1	.0070	.008	
October	7	2	4.2	.0095	.01	
November	6	2	4.7	.011	.01	
December	6	5	5.7	.013	.02	
The year	350	0.1	17.3	.039	.54	
1902.						
January	5	4	4.6	.010	.01	
February	4	4	4.0	.0091	.009	
March	5	4	4.3	.0098	.01	
April	8	6	6.9	.016	.02	
May	23	4	12.2	.028	.03	
June	3	3	3.0	.0068	.008	
July	4	2	2.8	.0064	.007	
August	21	0.5	4.9	.011	.01	
September	1	.5	.64	.0015	.002	
October	2	.5	.69	.0016	.002	
November	2	.8	1.1	.0025	.003	
December	1	.9	.98	.0022	.003	
The year	23	0.5	3.8	.0086	.11	
1903.						
January	1	1	1.0	.0023	.003	
February	1	1	1.0	.0023	.002	
March	570	1	213	.483	.56	
April	248	21	85.3	.193	.22	
May	44	18	25.6	.058	.07	
June	29	4	10.1	.023	.03	
July	415	10	58.7	.133	.15	
August	86	0.6	15.3	.035	.04	
September	534	2	77.8	.176	.20	
October	70	7	18.8	.043	.05	
November	7	4	4.8	.011	.01	
December	4	4	4.0	.0091	.01	
The year	570	0.6	43.0	.098	1.34	
1904.						
January	4	4	4.0	.0091	.01	
February	4	4	4.0	.0091	.01	
March	450	3	46.3	.105	.12	
April	740	18	219	.497	.55	
May (1-14)	55	10	24.2	.055	.03	
1910.						
March (16-31)	248	55	119	.270	.16	C
April	1,300	23	162	.367	.41	D
May	121	13	38.6	.088	.10	B
June	23	4.5	11.0	.025	.03	B
July	5.0	4.5	4.73	.011	.01	C
August	6.0	4.5	5.10	.012	.01	C
September	8.0	4.5	5.18	.012	.01	C
October	10	4.5	6.16	.014	.02	C
November	14	6.0	9.20	.021	.02	C
1911.						
March (19-31)	52	10	21.8	.049	.02	C
April	30	8.0	12.9	.029	.03	B
May	8.0	5.0	6.23	.014	.02	C
June	43	4.0	8.54	.019	.02	C
July	9.0	3.5	4.32	.0098	.01	C
August	6.0	3.0	4.20	.0095	.01	C
September	16	3.0	4.99	.011	.01	C
October	13	5.0	8.82	.020	.02	C
November (1-11)	5.0	4.0	4.50	.010	.004	C

Monthly discharge of Whetstone River at Bigstone, S. Dak.—Continued.

Month.	Discharge in second-feet.			Per square mile.	Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.			
1912.						
April	507	21	101	0.229	0.26	C
May	369	16	69.2	.157	.18	B
June	40	4.5	15.8	.036	.04	B
July	40	4.5	20.9	.047	.05	B
August	9.0	4.0	4.64	.011	.01	C
September	4.5	4.0	4.15	.0094	.01	C
October	4.5	3.5	3.82	.0087	.01	D
November	....	....	3.27	.0074	.008	D

LAC QUI PARLE RIVER AT LAC QUI PARLE

Location.—At the highway bridge at Lac qui Parle in Sec. 26, T. 118 N., R. 42 W., in Lac qui Parle County, a short distance above the mouth of Threemile Creek.

Records available.—April 27, 1910, to November 15, 1912.

Drainage area.—677 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Shifting during flood stages. There are no dams on the stream which control its flow at the present time.

Discharge measurements.—Made from the bridge.

Winter flow.—The river is frozen over and the observations are discontinued from December to March.

Daily discharge, in second-feet, of Lac qui Parle River at Lac qui Parle.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1					161	32	28	5	5	8	9	
2					147	30	23	5	5	8	9	
3					134	28	21	7	5	9	9	
4					121	28	19	6	5	9	12	
5					109	28	17	7	5	8	12	
6					102	29	43	6	5	7	16	
7					97	30	21	5	5	7	12	
8					95	30	19	5	5	7	10	
9					89	36	17	5	5	7	9	
10					85	48	17	5	5	7	7	
11					79	70	15	5	5	6	10	
12					75	147	19	4	4	6	12	
13					70	161	19	5	5	6	9	
14					66	134	19	5	4	6	10	
15					62	105	17	7	5	6	9	
16					62	85	17	8	5	6		
17					66	66	15	18	5	6		
18					66	52	14	14	5	6		
19					66	42	11	10	5	9		
20					75	36	10	9	5	7		
21					68	34	9	10	5	7		
22					64	28	8	12	5	7		
23					62	25	8	9	5	8		
24					56	23	7	10	5	9		
25					52	21	7	9	5	9		

Daily discharge, in second-feet, of Lac qui Parle River at Lac qui Parle—Cont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
26					48	21	6	8	7	9		
27				276	46	21	6	7	7	9		
28				254	42	21	7	7	7	9		
29				223	40	25	6	6	8	9		
30				200	35	28	6	7	8	9		
31					34		6	6		9		
1911.												
1				35	20	5	4	3	2	4	29	
2				41	18	5	4	2	2	4	24	
3				35	17	6	4	2	2	5	16	
4				29	17	7	3	3	2	4	16	
5				29	16	8	3	3	2	4	16	
6				24	16	7	3	3	2	7	14	
7				24	14	7	3	3	4	13	16	
8				32	12	7	3	3	4	12	16	
9			20	35	12	7	3	3	4	14	20	
10			107	32	12	5	3	3	4	16	20	
11			220	32	10	5	3	3	4	20	18	
12			500	35	9	4	3	3	4	21		
13			375	47	9	4	3	3	5	28		
14			340	60	10	4	2	3	5	26		
15			263	60	8	4	2	3	4	35		
16			82	64	8	5	2	3	4	41		
17			72	60	9	4	2	3	3	47		
18			60	53	8	4	1	3	3	41		
19			29	44	9	4	2	3	3	36		
20			68	38	8	4	2	3	3	36		
21			77	32	9	3	2	3	3	40		
22			56	29	10	3	3	3	3	38		
23			53	29	10	3	3	3	3	41		
24			47	24	9	3	3	3	4	41		
25			44	24	9	3	3	3	4	38		
26			44	22	8	3	3	3	4	35		
27			20	24	7	3	3	3	3	32		
28			41	22	7	3	3	3	3	29		
29			24	22	7	3	2	2	3	26		
30			24	20	6	4	2	2	3	24		
31			29		6		3	2		24		
1912.												
1					151	85	24	9	18	9	12	
2					124	75	22	9	17	11	12	
3					670	70	20	7	15	11	12	
4					350	66	23	7	13	12	11	
5					1,550	62	27	9	11	13	11	
6				124	1,550	57	36	8	9	13	10	
7				107	1,390	50	24	7	9	12	13	
8				87	1,100	48	22	7	8	12	13	
9				77	760	42	20	7	7	12	13	
10				68	510	39	17	7	7	12	13	
11				60	410	36	15	7	7	11	13	
12				53	310	33	20	9	6	12	12	
13				50	290	34	15	9	5	11	12	
14				50	235	36	15	8	5	11	12	
15				56	220	42	14	7	5	11	13	
16				60	198	52	14	8	5	11	13	
17				92	182	205	15	11	5	11	11	
18				107	175	310	13	16	5	13	8	
19				102	152	212	11	18	5	13	11	
20				87	145	138	12	20	5	16	12	
21				118	138	107	11	21	5	16	13	
22				68	132	90	11	24	5	12	12	
23				60	132	77	20	27	5	13	15	
24				60	126	68	22	23	5	13	10	
25				60	126	59	21	23	7	13	11	
26				82	119	50	18	27	7	12		
27				97	107	44	18	23	8	12		
28				87	101	36	20	22	8	11		
29				188	95	33	17	20	9	12		
30				166	90	27	15	18	8	10		
31					85		12	16		11		

NOTE.—Daily discharges computed from a fairly well-defined rating curve.

Monthly discharge of Lac qui Parle River at Lac qui Parle.

[Drainage area, 838 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1910.						
May	161	34	76.6	0.091	0.10	B
June	161	21	48.8	.058	.06	B
July	43	6	14.7	.018	.02	C
August	18	4	7.5	.0090	.01	D
September	8	4	5.3	.0063	.007	D
October	9	6	7.6	.0091	.01	D
November (1-15)	16	7	10.3	.012	.007	D
1911.						
March (9-31)	500	20	113	.135	.12	C
April	64	20	35.2	.042	.05	B
May	20	6	10.6	.013	.02	C
June	8	3	4.6	.0055	.006	D
July	4	1	2.7	.0032	.004	D
August	3	2	2.8	.0033	.004	D
September	5	2	3.3	.0039	.004	D
October	47	4	25.2	.030	.03	C
November (1-11)	29	14	18.6	.022	.009	C
1912.						
January	....	....	[a] 3	.0036	.004	....
February	....	....	[a] 2	.0024	.003	....
March	....	....	[a]10	.012	.01	....
April	188	....	80.5	.096	.11	C
May	1,550	85	378	.451	.52	C
June	310	27	76.1	.091	.10	C
July	36	11	18.2	.022	.03	D
August	27	7	14.0	.017	.02	D
September	18	5	7.8	.0093	.01	D
October	16	9	12.0	.014	.02	D
November	15	....	11.4	.014	.02	D

[a] Estimated from climatological records and comparison of flow at Odessa, Watson and Montevideo.

CHIPPEWA RIVER NEAR WATSON.

Location.—At highway bridge 2½ miles northeast of Watson, on line between Secs. 10 and 15, T. 118 N., R. 41 W., 10 miles above the mouth of the river and about 2 miles below the mouth of Dry Weather Creek.

Records available.—July 6, 1909, to November 10, 1912.

Drainage area.—1,940 square miles.

Gage.—Chain gage attached to bridge; datum unchanged since established.

Channel.—Shifting at intervals.

Discharge measurements.—Made from the bridge.

Regulation.—At Montevideo there is a water power plant utilizing a head of 7 feet, but backwater from the dam does not extend to the gaging station. The first dam above the station is at Hagan, but the effect of the control is inappreciable at Watson.

Winter flow.—From December to March observations are discontinued because of ice.

Accuracy.—As the discharge measurements show some change in the channel, the records cannot be considered better than good.

Daily discharge, in second-feet, of Chippewa River near Watson.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1					384	82	15	12	12	17	17	
2					336	81	15	12	12	17	17	
3					315	75	15	12	12	17	16	
4					294	77	15	12	12	17	16	
5					266	75	15	11	12	14	17	
6					245	78	20	11	12	14	16	
7					224	77	17	11	12	14	15	
8					220	68	15	11	12	14	15	
9					202	77	15	11	12	14	15	
10				323	192	75	16	12	12	14	15	
11				325	180	77	17	12	11	14		
12				306	162	75	18	11	12	14		
13				278	154	68	17	12	12	14		
14				260	151	55	16	12	12	14		
15				327	146	48	15	13	12	14		
16				392	141	40	15	13	12	14		
17				392	162	37	14	13	12	15		
18				366	162	32	14	12	12	15		
19				555	157	28	14	12	12	14		
20				651	224	25	13	15	11	15		
21				665	224	20	13	14	11	15		
22				670	220	18	13	13	11	15		
23				593	220	18	12	13	11	15		
24				617	206	17	13	13	11	15		
25				627	185	18	12	13	13	16		
26				634	171	17	13	13	14	16		
27				593	154	16	13	13	14	16		
28				538	137	16	12	13	13	15		
29				474	135	17	12	12	13	14		
30				422	119	15	12	13	12	14		
31					100		12	12		14		
1911.												
1				58	67	27	51	10	21	43	150	
2				55	61	29	49	7.0	28	49	168	
3				52	56	78	49	6.0	21	53	148	
4				64	56	228	43	14	24	55	155	
5				64	55	133	41	18	28	58	140	
6				61	48	148	35	17	28	69	129	
7				65	50	155	34	21	35	69	120	
8				61	53	155	29	22	35	70	120	
9				61	49	142	34	22	32	71	120	
10				64	47	140	35	22	35	60	101	
11				77	37	155	32	22	35	69		
12				82	41	120	29	24	39	69		
13				86	35	120	28	22	41	74		
14				102	35	113	22	21	41	74		
15				97	35	113	20	20	39	74		
16				102	41	120	16	18	41	88		
17				102	41	133	15	18	37	92		
18				102	58	120	12	18	39	90		
19			91	94	62	140	15	18	37	99		
20			94	86	84	133	15	16	37	101		
21			97	86	74	120	14	15	38	103		
22			102	75	69	96	12	18	39	108		
23			108	75	62	81	11	18	37	113		
24			104	75	60	79	10	18	37	117		
25			99	65	51	67	9.4	18	37	120		
26			73	65	51	67	8.5	15	28	126		
27			48	65	41	60	7.0	24	34	129		
28			99	64	37	56	7	32	34	133		
29			75	65	32	77	6.0	22	39	140		
30			86	65	29	60	6	24	37	140		
31			75		27		8.5	22		140		
1912.												
1				200	273	282	57	49	48	65	59	
2				200	273	273	57	48	48	65	61	
3				200	1,220	264	59	44	46	63	63	
4				200	1,440	230	57	44	46	61	63	
5				650	1,580	230	63	49	46	57	61	

Daily discharge, in second-feet, of Chippewa River near Watson—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6	......	......	......	403	1,640	214	57	53	44	59	53	......
7	......	......	......	403	1,680	214	67	57	44	61	61	......
8	......	......	......	381	1,720	184	63	49	43	61	57	......
9	6	2	......	381	1,640	177	61	53	42	63	57	......
10	......	......	......	340	1,540	170	57	53	42	63	59	......
11	......	......	......	310	1,440	156	51	53	40	65	58	......
12	......	......	......	300	1,330	156	59	53	43	67	55	......
13	......	......	......	291	1,190	170	53	55	42	65	57	......
14	......	......	......	282	1,020	156	53	51	42	63	59	......
15	......	......	......	273	920	156	55	51	43	63	59	......
16	......	......	......	264	860	156	48	53	42	63	57	......
17	......	......	......	255	770	149	48	53	48	63	63	......
18	......	......	......	255	710	142	44	55	52	63	65	......
19	......	......	......	255	680	142	49	53	55	65	65	......
20	......	......	......	246	575	136	49	51	43	63	57	......
21	......	......	......	246	525	124	48	55	48	61	55	......
22	......	......	......	238	500	112	51	55	46	61	53	......
23	......	......	......	230	475	102	49	51	43	59	57	......
24	......	......	15	222	425	93	67	46	44	59	59	......
25	......	......	......	214	403	87	63	37	61	59	59	......
26	......	......	......	230	340	83	59	36	57	58	59	......
27	......	......	......	246	340	75	59	42	57	58	59	......
28	......	......	......	246	340	63	55	49	55	59	59	......
29	......	......	......	264	340	61	55	43	63	57	59	......
30	......	......	......	264	320	57	57	44	65	57	59	......
31	......	......	......	......	300	......	55	48	......	61	......	......

NOTE.—Daily discharges computed from a well-defined rating curve.

Monthly discharge of Chippewa River near Watson.

[Drainage area, 1,940 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1910.						
April (10-30)	670	260	477	0.246	0.19	B.
May	384	100	199	.103	.12	A.
June	92	15	47.3	.024	.03	A.
July	20	12	14.5	.0075	.009	A.
August	15	11	12.3	.0063	.007	A.
September	14	11	12.0	.0062	.007	B.
October	16	13	14.5	.0075	.009	B.
November (1-10)	17	15	15.5	.0079	.003	B.
1911.						
March (19-31)	108	48	88.5	.046	.02	B.
April	102	52	74.5	.038	.04	A.
May	84	27	49.8	.026	.03	A.
June	228	27	109	.056	.06	A.
July	51	6.6	22.7	.012	.01	B.
August	32	6.6	18.8	.0097	.01	B.
September	41	21	34.4	.018	.02	A.
October	140	43	90.0	.046	.05	B.
November	168	....	[a]73.2	.038	.04	C.
December	....	....	[a]28.0	.014	.02	D.
1912.						
January	....	....	[a] 6	.0031	.004	D
February	....	....	[a] 5	.0026	.003	D
March	....	....	[a]20	.010	.01	D
April	650	....	283	.146	.16	B
May	1,720	273	865	.446	.51	A
June	282	57	154	.079	.09	A
July	67	44	55.6	.029	.03	B
August	57	36	49.5	.026	.03	B
September	65	40	47.9	.025	.03	B
October	67	57	61.5	.032	.04	B
November	65	....	58.9	.030	.03	C

[a] Estimated.

REDWOOD RIVER NEAR REDWOOD FALLS.

Location. —At the first highway bridge above Redwood Falls, 3 miles distant.

Records available.—July 2, 1909, to November 30, 1912.

Drainage area.—703 square miles.

Gage.—Chain gage attached to bridge; datum unchanged since established.

Channel.—Permanent prior to 1912.

Discharge measurements.—Made from the bridge except at low stages when they are made by wading at different sections.

Regulation. —The nearest dam at Redwood Falls creates a pond extending upstream for a considerable distance, but owing to rapids just below the gaging station the backwater does not reach it.

Winter flow.—Ice exists from December to March, discharge measurements are made to determine the winter flow.

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

Daily discharge, in second-feet, of Redwood River near Redwood Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1								58	33	14	21	
2							772	52	33	12	18	
3							720	54	35	12	16	
4							641	50	32	12	16	
5							596	50	26	12	16	
6							538	42	26	12	18	
7							504	42	26	12	18	
8							500	40	25	12	18	
9							454	40	25	15	18	
10							430	40	23	14	18	
11							330	40	21	14	18	
12							338	48	25	14	18	
13							402	47	23	14	20	
14							375	65	20	14	20	
15							308	130	19	14	20	
16							272	158	16	14	20	
17							258	176	16	16	20	
18							279	185	16	14	20	
19							268	201	17	14	20	
20							240	207	16	14	42	
21							224	201	16	14	50	
22							188	185	17	14	50	
23							156	161	16	16	50	
24							133	130	16	16	33	
25							120	107	16	14	42	
26							107	92	16	14	50	
27							92	78	16	14	50	
28							80	65	16	12	50	
29							65	54	14	12	50	
30							65	48	14	13	50	
31							67	40		14		
1910.												
1				97	54	12	14	4	5.5	12	16	
2				92	50	12	11	4	4.6	14	18	
3				92	47	12	11	4	4.6	18	16	
4				92	33	12	9.5	4	4	20	14	
5				92	33	12	9.5	4	4	20	12	

Daily discharge, in second-feet, of Redwood River near Redwood Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
6	......	......	......	92	30	12	8	4	4	20	12	......
7	......	......	......	88	23	12	7	4	4	20	12	......
8	......	......	......	88	30	14	7	4	3.5	18	14	......
9	......	......	......	80	26	20	9.5	4	3.5	16	14	......
10	......	......	......	69	26	30	7	4	3.5	12	12	......
11	......	......	......	69	26	47	7	4	4	14	12	......
12	......	......	......	65	23	60	9.5	4	4	14	14	......
13	......	......	......	69	26	69	9.5	4	4	12	......	......
14	......	......	......	65	20	60	9.5	4	3.5	12	......	......
15	......	......	......	66	20	50	8	4	3.5	12	......	......
16	......	......	......	68	20	42	7	4	4	11	......	......
17	......	......	......	69	26	33	7	4	5.5	12	......	......
18	......	......	......	80	20	20	7	4	5.5	12	......	......
19	......	......	......	104	20	18	7	4.6	6.4	12	......	......
20	......	......	......	92	33	18	7	5.5	7	18	......	......
21	......	......	......	92	26	18	5.5	5.5	7	23	......	......
22	......	......	......	104	20	12	5.5	5.5	8	33	......	......
23	......	......	......	104	69	9.5	5.5	4.6	8	30	......	......
24	......	......	......	104	65	9.5	5.5	4.6	8	26	......	......
25	......	......	158	104	47	60	4	4.6	8	23	......	......
26	......	......	122	92	33	26	4	4.6	9.5	20	......	......
27	......	......	122	80	26	12	4	4	8	16	......	......
28	......	......	139	73	20	16	4	4	7	14	......	......
29	......	......	97	69	20	30	4	4	7	12	......	......
30	......	......	97	60	18	30	4	6.4	9.5	14	......	......
31	......	......	97	......	14	......	4	5.5	......	14	......	......
1911.												
1	......	......	......	28	17	10	2	1	5	15	......	......
2	......	......	......	31	15	9	1.6	1	5	14	......	......
3	......	......	......	19	13	7	1.6	2	5	14	......	......
4	......	......	......	23	14	5	1.6	2	5.8	14	......	......
5	......	......	......	28	14	3.5	1.6	8.2	6	14	......	......
6	......	......	......	26	15	3.5	1	7	7	150	......	......
7	......	......	......	23	15	4.4	1	5.8	7	54	......	......
8	......	......	......	28	15	5	1	5	8	23	......	......
9	......	......	......	26	15	5.8	1	3.5	9	34	......	......
10	......	......	......	26	15	5.8	1	2	10	28	......	......
11	......	......	......	28	14	5.8	1	7	11	50	......	......
12	......	......	158	42	14	5.8	1	5	12	92	......	......
13	......	......	153	50	12	5.8	1	3.5	11	65	......	......
14	......	......	144	42	12	5.8	1	2	10	50	......	......
15	......	......	144	34	12	5.8	1	2	10	54	......	......
16	......	......	104	34	14	5.8	1	1.6	9	50	......	......
17	......	......	80	34	12	5.8	1	5	9	60	......	......
18	......	......	50	28	12	5.8	1	5.8	9	50	......	......
19	......	......	28	28	10	5.8	.4	7	9	69	......	......
20	......	......	30	26	9	5.8	.4	9	7	54	......	......
21	......	......	32	23	14	5	.4	8.2	9	69	......	......
22	......	......	34	21	15	4.4	.4	8.2	8.2	65	......	......
23	......	......	36	19	15	3.5	3.2	9	7	54	......	......
24	......	......	39	19	14	3.5	2.6	9	5.8	54	......	......
25	......	......	34	19	14	3.2	2	7	5	50	......	......
26	......	......	34	17	12	3.5	1.6	8.2	7	42	......	......
27	......	......	28	17	12	2.6	9.6	7	8.2	34	......	......
28	......	......	23	15	10	2	3.5	7	8	34	......	......
29	......	......	23	15	10	2.6	1.6	5.8	8	37	......	......
30	......	......	26	19	10	3.5	1.2	5	8	34	......	......
31	......	......	28	......	10	......	3.5	4.4	......	34	......	......
1912.												
1	......	......	......	......	152	42	6	4	7.5	8.5	32	......
2	......	......	......	......	134	39	14	6	8.5	14	32	......
3	......	......	......	......	110	36	32	6	7.5	17	29	......
4	......	......	......	......	122	32	160	6	6	17	26	......
5	......	......	......	......	146	29	26	4	6	8.5	19	......
6	......	......	......	......	174	26	17	6	8.5	22	26	......
7	......	......	......	......	180	24	15	6	8.5	22	26	......
8	0.4	......	......	......	174	22	11	8.5	8.5	26	26	......
9	......	......	......	......	174	22	14	7.5	8.5	26	26	......
10	......	......	......	......	174	22	6	4	7.5	16	24	......

Daily discharge, in second-feet, of Redwood River near Redwood Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
11	......	......	......	56	127	17	11	5	8.5	26	22	......
12	......	......	......	56	110	26	11	5	8.5	39	26	......
13	......	......	......	66	76	22	10	5	7.5	39	26	......
14	......	......	......	56	56	26	6	5	7.5	26	22	......
15	......	......	......	56	66	36	5	3.5	7	14	17	......
16	......	......	......	24	76	32	8.5	8.5	6	22	26	......
17	......	......	......	56	88	32	7.5	8.5	8.5	22	22	......
18	......	......	......	66	76	26	7.5	8.5	11	26	22	......
19	......	......	......	60	76	22	8.5	14	8.5	39	22	......
20	......	......	......	56	60	22	4.6	6	6	22	17	......
21	......	......	......	72	122	22	11	11	7.5	26	24	......
22	......	......	......	60	122	19	8.5	11	8.5	32	26	......
23	......	......	......	66	99	17	11	11	10	32	26	......
24	......	......	......	66	88	16	8.5	11	8.5	32	24	......
25	......	......	......	110	56	16	4	6	14	17	17	......
26	......	......	......	110	66	14	9.5	11	14	22	24	......
27	......	......	......	99	56	14	11	8.5	14	32	22	......
28	......	......	......	134	48	12	11	7.5	14	26	24	......
29	......	......	......	134	39	12	9.5	7.5	13	32	26	......
30	......	......	......	146	48	11	5.4	9.5	14	22	16	......
31	......	......	......	......	42	......	6	9.5	......	26	......	......

NOTE.—Daily discharge computed from a well-defined rating curve.

Monthly discharge of Redwood River near Redwood Falls.

[Drainage area, 703 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Minimum.	Minimum.	Mean.	Per square mile.		
1909.						
July (2-31)	772	65	317	0.451	0.50	A.
August	207	40	93.1	.132	.15	A.
September	35	14	21.0	.030	.03	A.
October	16	12	13.6	.019	.02	B.
November	50	16	29.0	.041	.05	B.
1910.						
March (25-31)	158	97	119	.169	.04	B.
April	104	60	83.7	.119	.13	A.
May	69	14	30.5	.043	.05	A.
June	69	9.5	26.3	.037	.04	A.
July	14	4.0	7.16	.010	.01	A.
August	6.4	4.0	4.37	.0062	.007	B.
September	9.5	3.5	5.62	.0080	.009	B.
October	33	12	16.9	.024	.03	B.
November (1-12)	18	12	13.8	.020	.009	B.
1911.						
March (12-31)	158	23	61.4	.087	.06	B.
April	50	15	26.3	.037	.04	B.
May	17	9	13.1	.019	.02	B.
June	10	2	5.03	.0072	.008	C.
July	9.6	.4	1.67	.0024	.003	C.
August	9	1	5.30	.0075	.009	C.
September	12	5	7.97	.011	.01	B.
October	150	14	47.1	.067	.08	B.
November	....	....	[a]17.0	.024	.03	D.
December	....	....	[a]15.0	.021	.02	D.
1912.						
January	....	....	[a] 1	.0014	.002	....
February	....	....	[a] 2	.0028	.003	....
March	....	....	[a] 10	.014	.02	....
April	146	....	[a] 58.3	.083	.09	C
May	180	39	101	.144	.17	B
June	42	11	23.6	.034	.04	B
July	160	4	15.4	.022	.03	B
August	14	3.5	7.44	.011	.01	B
September	14	6	9.12	.013	.01	B
October	39	8.5	24.2	.034	.04	B
November	32	16	23.9	.034	.04	C

[a] Estimated—very approximate.

COTTONWOOD RIVER NEAR NEW ULM.

Location.—At Alwin highway bridge, 2 miles southeast of New Ulm, in Sec. 31, T. 110 N., R. 30 W., 15 miles below the mouth of Sleepy Eye Creek, the nearest tributary.

Records available.—July 2, 1909, to December 31, 1912.

Drainage area.—1,190 square miles.

Gage.—Chain gage attached to bridge. On August 12, 1909, the datum of the gage was lowered 2.28 feet. All readings prior to that date have been corrected, so that all gage heights apply to the new datum.

Channel.—Shifting after high water.

Discharge measurements.—Made from the bridge except during extreme low water when they are made at a wading section.

Regulation.—Two miles below the station is the dam of the Cottonwood Roller Mill, which prevents any possible effect of backwater from the Minnesota reaching the gate. The low water records show no systematic variation to indicate control from the dam, and it is therefore believed that the effect of such control is slight.

Winter flow.—From December to March observations of the flow are discontinued because of ice.

Accuracy.—Conditions at this station are good and records of flow should be reliable.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	......	......	......	......	......	......	1,980	133	129	61	70	......
2	......	......	......	......	......	......	1,820	157	123	55	73	......
3	......	......	......	......	......	......	1,590	141	129	52	76	......
4	......	......	......	......	......	......	1,300	139	109	52	76	......
5	......	......	......	......	......	......	1,040	139	113	50	76	......
6	......	......	......	......	......	......	898	131	95	48	73	......
7	......	......	......	......	......	......	876	121	93	43	67	......
8	......	......	......	......	......	......	831	125	93	43	62	......
9	......	......	......	......	......	......	786	121	82	52	61	......
10	......	......	......	......	......	......	759	129	80	78	67	......
11	......	......	......	......	......	......	732	145	80	76	55	......
12	......	......	......	......	......	......	660	178	87	66	52	......
13	......	......	......	......	......	......	644	876	85	58	58	......
14	......	......	......	......	......	......	660	1,590	78	58	52	......
15	......	......	......	......	......	......	652	1,620	78	66	48	......
16	......	......	......	......	......	......	564	1,460	72	70	40	......
17	......	......	......	......	......	......	500	1,240	70	68	136	......
18	......	......	......	......	......	......	542	939	67	67	285	......
19	......	......	......	......	......	......	612	732	67	62	315	......
20	......	......	......	......	......	......	660	572	67	62	238	......
21	......	......	......	......	......	......	592	451	79	67	212	......
22	......	......	......	......	......	......	500	367	76	82	212	......
23	......	......	......	......	......	......	416	321	67	80	210	......
24	......	......	......	......	......	......	342	318	73	68	208	......
25	......	......	......	......	......	......	288	294	85	62	185	......
26	......	......	......	......	......	......	240	264	82	55	155	......
27	......	......	......	......	......	......	215	240	76	66	150	......
28	......	......	......	......	......	......	190	290	70	67	150	......
29	......	......	......	......	......	......	159	195	67	67	145	......
30	......	......	......	......	......	......	145	180	64	67	145	......
31	......	......	......	......	......	......	151	149	......	67	......	......

Daily discharge, in second-feet, of Cottonwood River near New Ulm—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1				224	112	61	67	20	11	9	19	
2				207	96	58	61	21	10	9	19	
3				200	93	58	51	22	8	10	19	
4				187	88	56	47	20	7	11	15	
5				174	86	56	55	15	8	10	8	
6				164	80	61	54	14	10	10	10	
7				155	80	60	42	20	10	10	15	
8				149	76	61	38	21	10	10	18	
9				140	76	73	45	19	8	10	19	
10				139	74	100	45	19	6	10	14	
11			3,250	125	74	125	37	17	6	11	27	
12			1,380	123	72	202	36	16	10	11	27	
13			1,260	120	72	275	34	18	8	11	23	
14			1,060	109	73	193	36	18	8	11	26	
15			965	112	74	168	34	20	10	11	26	
16			893	109	80	144	33	21	10	11	27	
17			803	115	93	125	31	19	8	11	28	
18			731	142	98	109	29	18	7	11	37	
19			686	168	96	86	28	19	7	11	42	
20			597	160	96	78	26	22	7	12	35	
21			573	166	100	75	26	21	9	14	35	
22			517	187	104	70	24	21	8	14	37	
23			469	193	100	68	23	21	8	13	27	
24			438	180	94	64	23	19	10	14	19	
25			406	174	93	61	23	19	10	14	24	
26			334	160	84	55	20	17	12	15	23	
27			316	140	81	52	21	17	15	15	18	
28			286	132	72	51	23	16	13	15	19	
29			269	122	70	66	21	16	13	15	23	
30			252	114	68	70	20	15	12	14	28	
31			236		64		18	14		14		
1911.												
1				49	42	11	5.6	9.5	14	26	116	
2				53	42	28	5.2	7.6	13	26	109	
3				57	40	19	5.2	5.6	12	28	106	
4				54	40	18	6.4	6	11	31	103	
5				57	40	15	6.4	7.6	12	35	96	
6				59	36	12	5.2	11	14	61	94	
7				55	32	12	4.4	18	17	94	87	
8				54	28	10	4	28	18	414	83	
9				54	28	9	4	27	18	679	82	
10				59	28	9	4	26	18	537	80	
11				61	26	8.5	3.7	25	17	377	72	
12			377	61	25	8	3.4	24	16	349		
13			313	64	22	7.2	2.8	24	16	349		
14			245	68	25	7.2	2.8	28	14	342		
15			209	69	25	6.4	2.8	26	14	356		
16			152	70	28	6.0	2.5	26	13	464		
17			122	70	31	7.2	2.5	28	13	537		
18			101	68	22	7.2	3.4	29	13	545		
19			83	64	20	6.4	4	32	16	520		
20			75	59	20	5.6	4	32	17	492		
21			70	55	23	4	4	31	18	460		
22			70	47	25	4	4	28	20	384		
23			68	48	24	4	4	26	22	291		
24			66	49	22	4	4	25	25	232		
25			64	47	20	4	5	24	25	202		
26			61	47	19	5.6	6	23	25	152		
27			58	44	18	3.7	7	22	25	138		
28			55	44	16	3.4	8	22	25	134		
29			54	44	14	6	9	22	26	132		
30			54	42	13	6	10	20	26	126		
31			50		12		10	17		124		
1912.												
1					197	64	24	14	23	17	20	
2					185	50	24	14	23	17	20	
3					222	48	24	14	23	16	20	
4					250	48	24	14	23	13	20	
5					236	46	31	16	21	12	20	

Daily discharge, in second-feet, of Cottonwood River near New Ulm—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6	22			420	151	45	34	16	20	13	20	
7				404	141	44	42	16	17	15	20	
8		13		309	131	53	44	17	17	16	20	
9				264	131	48	50	18	16	14	20	
10				236	131	46	64	18	16	13	20	
11				185	122	36	64	14	16	13	20	
12				173	122	34	91	14	14	16	20	
13				173	113	32	53	14	12	21	20	
14				197	131	41	30	13	10	23	20	
15				210	131	70	29	13	10	23	20	
16				210	131	83	26	12	12	24	20	
17				210	122	80	24	12	13	28	23	
18				236	131	76	20	23	16	28	23	
19			94	236	105	83	23	36	16	24	23	
20				236	97	97	28	46	14	23	23	
21				210	83	78	24	50	14	23	23	
22				210	76	53	24	48	13	23	23	
23				185	76	46	24	45	13	23	23	
24				197	76	40	20	42	12	23		
25				210	76	40	20	40	12	21		
26				222	70	36	18	34	14	20		
27				236	68	30	17	28	16	20		
28				294	80	30	17	24	16	20		
29				279	80	28	16	20	16	20		
30				250	78	24	16	23	16	20		
31					76		15	23		20		

NOTE.—Daily discharge computed from a fairly well-defined rating curve. After July 10, 1910, the rating curve was applied indirectly. The 1912 rating curve was well defined.

Monthly discharge of Cottonwood River near New Ulm.

[Drainage area, 1,190 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July	1,980	145	689	0.579	0.67	A.
August	1,620	121	444	.373	.43	A.
September	129	64	84.5	.071	.08	A.
October	78	43	62.4	.052	.06	A.
November	315	40	135	.113	.13	B.
1910.						
March (11-31)	3,250	236	511	.429	.34	B.
April	224	109	297	.250	.28	B.
May	112	64	84.5	.071	.08	B.
June	275	51	92.7	.078	.09	B.
July	67	18	34.5	.029	.03	A.
August	22	14	18.5	.016	.02	B.
September	15	6	9.30	.008	.01	C.
October	15	9	11.8	.01	.01	B.
November	42	8	23.6	.02	.02	B.
1911.						
March (12-31)	377	50	117	.098	.07	B.
April	70	42	55.7	.047	.05	A.
May	42	12	26.0	.022	.03	A.
June	28	3.4	8.58	.0072	.008	B.
July	10	2.5	4.94	.0042	.005	B.
August	32	5.6	21.9	.018	.02	A.
September	26	11	17.8	.015	.02	B.
October	679	26	279	.234	.27	C.
November	116		60.9	.051	.06	D.
December			[a]55.0	.046	.05	D.

Monthly discharge of Cottonwood River near New Ulm—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy
	Maximum.	Minimum.	Mean.	Per square mile.		
1912.						
January			[a] 20	0.023	0.03	D
February			[a] 15	.017	.02	D
March			[a] 90	.104	.12	C
April			[a]233	.270	.30	C
May	250	68	123	.142	.16	B
June	97	24	51.0	.059	.07	B
July	91	15	31.0	.036	.04	B
August	50	12	23.6	.027	.03	C
September	23	10	15.8	.018	.02	C
October	28	12	19.4	.022	.03	C
November			21.4	.025	.03	C

[a] Estimated from a few discharge measurements and climatological records.

BLUE EARTH RIVER AT RAPIDAN MILLS.

Location.—At Rapidan Mills, 2 miles west of Rapidan. The nearest tributary is Watonwan River which enters about 4 miles upstream.

Records available.—July 20, 1909, to November 12, 1910.

Drainage area.—2,260 square miles.

Gage.—Chain gage used originally. April 29, 1910, it was necessary to discontinue the bridge station, owing to the erection of a 60 foot dam at that point. A new gage was installed a few hundred feet downstream and below the dam.

Discharge measurements.—Made by car and cable located near the gage.

Winter flow.—Ice causes backwater during the winter months; records discontinued.

Controlled flow.—After the erection of the dam, the flow was controlled by the operation of the gates.

Cooperation.—This station was maintained in cooperation with the Consumers Power Company.

Daily discharge, in second-feet, of Blue Earth River at Rapidan Mills.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.[1]												
1								310	150	150	148	
2								290	152	141	166	
3								275	152	138	531	
4								257	128	136	1,180	
5								229	136	134	1,240	
6								209	138	132	1,130	
7								200	134	130	957	
8								186	131	127	788	
9								178	127	125	677	
10								206	126	123	689	
11								166	120	120	525	
12								150	133	118	503	
13								154	131	138	565	
14								170	134	170	788	
15								189	141	178	1,390	
16								565	141	164		
17								601	145	175		
18								609	145	175		
19								542	150	152		
20							1,420	481	141	152		
21							990	435	143	145		
22							803	388	164	131		
23							677	352	170	127		
24							601	310	264	127		
25							508	283	310	128		
26							455	249	271	120		
27							388	232	235	123		
28							348	213	209	123		
29							352	195	189	126		
30							352	181	173	123		
31							335	166		143		
1910.[2]												
1				1,080	213	115	86	30	30	75	68	
2				981	199	123	82	38	36	68	54	
3				901	189	103	77	42	33	82	82	
4				803	173	115	71	26	32	66	86	
5				745	166	110	66	33	42	54	82	
6				711	163	103	68	21	45	40	75	
7				613	157	110	71	27	42	54	93	
8				613	151	108	96	23	45	38	108	
9				497	151	120	91	21	32	51	131	
10				478	148	133	86	22	33	64	82	
11				459	139	148	62	30	34	64	77	
12			13,100	440	136	186	58	30	45	64	54	
13			10,000	420	136	221	49	33	30	64		
14			9,000	450	139	258	51	36	24	64		
15			8,200	380	136	239	53	49	53	64		
16			7,010	340	142	199	64	53	30	64		
17			6,160	385	160	176	64	53	27	86		
18			5,820	335	157	154	49	40	28	75		
19			5,140	340	173	136	47	45	68	75		
20			3,650	320	173	126	42	105	66	64		
21			3,260	320	176	123	38	75	68	68		
22			2,960	300	189	96	54	53	39	68		
23			2,760	280	206	105	36	45	62	64		
24			2,520	300	210	86	49	36	60	68		
25			2,280	290	206	96	42	33	45	79		
26			2,040	230	206	91	42	38	49	79		
27			1,830	235	192	91	42	30	53	86		
28			1,620	225	176	91	30	30	53	79		
29			1,536	224	163	86	34	30	75	79		
30			1,290	217	151	86	28	39	54	86		
31			1,170		126		34	38		54		

[1] Daily discharge computed from a well-defined rating curve.

[2] Daily discharges for 1910 are computed from two rating curves that were well defined at the lower stages, but not so well at the higher stages.

Monthly discharge of Blue Earth River at Rapidan Mills.

[Drainage area, 2,260 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July (20-31)	1,420	335	602	0.266	0.12	A.
August	689	150	292	.129	.15	A.
September	310	120	163	.072	.08	A.
October	178	118	139	.062	.07	A.
November	....	....	[1]700	.310	.35	C.
1910.						
March (12-31)	13,100	1,170	4,570	2.02	1.50	C.
April	1,080	217	462	.204	.23	B.
May	213	126	168	.074	.09	A.
June	258	86	131	.058	.06	A.
July	96	28	56.8	.025	.03	A.
August	105	21	38.8	.017	.02	A.
September	75	24	44.4	.020	.02	B.
October	86	38	67.3	.030	.03	B.
November (1-12)	131	54	82.6	.037	.02	B.

[1] Estimated.

DEVELOPED WATER POWER.

Power is developed at only two places on Minnesota River, but at 10 points on tributaries. These developments are as follows:

MINNESOTA RIVER.

Granite Falls.—The city of Granite Falls has a 14-foot dam which is later to be raised to 21 feet as the demand for power increases. At the left end of the dam is located the City Power plant. Here are installed on horizontal shafts 2 units, each composed of two 27-inch S. Morgan Smith turbines of 88 horsepower capacity each or about 175 horsepower for each unit. The water is supplied direct from the pond. Each unit is controlled by an automatic governor, and is belt connected to a 150 KW, 3-phase, alternating current generator. At the present time only one unit is in use, the other being held in reserve. The plant operates continuously. There is an auxiliary steam plant of 70 horsepower. The power plant is designed for two additional units of larger size when needed.

Minnesota Falls.—The Montevideo Electric Light and Power Company has a dam at Minnesota Falls which creates a head of 16 feet. The pondage is small as no flashboards are used. In the power plant are located four 21-inch S. Morgan Smith wheels of 66 horsepower capacity each. They are controlled by a Woodward automatic governor, and are set on a horizontal shaft, direct connected to a 250 KW 3-phase, alternating current generator of 2300 volts. The current is carried at a voltage of 23,000, 18 miles to Montevideo where it furnishes light and power. Provision is made for two additional turbines to be installed later. The plant runs continuously. There is an auxiliary steam plant of 200 horsepower.

POMME DE TERRE RIVER.

Appleton.—The Appleton Mill Co. has a dam at Appleton which creates a head of 14 feet. At the left end of the dam is located the mill where a 56-inch New American turbine of 300 horsepower capacity is installed. The turbine has no governor. The water is supplied by means of a flume. The turbine is connected to a 35 KW Bullock generator used for lighting the mill and a smaller exciter generator. The plant is operated continuously. There is an auxiliary steam plant of 225 horsepower as the water supply is deficient at all times.

CHIPPEWA RIVER.

Millerville.—A water power plant at this point is utilized in developing probably not more than 50 horsepower.

Hagan.—At this point a flour mill formerly utilized about 45 horsepower which is developed by turbine working under 8 feet head. At present the dam is out.

Montevideo.—The Chippewa Milling Co. has a timber dam at Montevideo which creates a head of 7 feet. At the left end of the dam is located the mill in which are installed two 60-inch American turbines of 110 horsepower capacity each. Water is supplied to the turbines by means of a flume 60 feet long. The available head ranges from 5 to 7 feet. During the winter, the river freezes to such an extent as to make steam power necessary. There is an auxiliary plant of about 125 horsepower. The average power developed is about 75 horsepower. The plant operates continuously making storage impracticable.

EAST BRANCH OF CHIPPEWA RIVER.

Swift Falls.—A flour and feed mill utilizes a head of 20 feet by means of one 36-inch turbine of 40 horsepower and one 18-inch turbine of 21 horsepower capacity. The average power developed is about 45 horsepower.

Terrace.—A flour mill at Terrace utilizes a head of 16 feet by means of 2 turbines developing an average of 40 horsepower.

REDWOOD RIVER.

Redwood Falls.—The Redwood Falls Electric Light & Power Co. has a timber dam at this point which utilizes the natural fall and creates a head of 85 feet. From the pond above the dam, water is conveyed ¼ mile downstream to the power plant, by means of a rock canal and iron pipe of approximately 130 sec.-ft. capacity. In the power plant there are installed two 20-inch Trump turbines of 150 horsepower each, controlled by a Woodward automatic governor. Each turbine is connected to a 100 KW General Electric 3-phase, alternating current generator of 2300 volts, which furnishes light and power for Redwood Falls. The plant operates continuously. By means of 24-inch flashboards a draft of 3 feet is obtained on the pond above the dam. There is an auxiliary steam plant of 150 horsepower as the water supply is not sufficient at all times.

North Redwood.—A flour mill at this point utilizes a water power development of probably 50 horsepower.

COTTONWOOD RIVER.

New Ulm.—The Cottonwood Roller Mills have a timber dam at a point 1 mile above the mouth of the river where a head of 8½ feet is created. The dam backs the water 1½ miles upstream. At the left end of the dam is located the mill where are installed one 44-inch Leffel turbine of 35 horsepower capacity, and one 40-inch Leffel turbine of 30 horsepower capacity which are controlled by hand wheels. Water is supplied to the turbines by means of a short flume. The turbines are belt connected to the mill machinery. The plant is operated from 10 to 12 hours per day. There is an auxiliary steam plant of 60 horsepower as the water supply is not sufficient at all times.

BLUE EARTH RIVER.

Two miles west of Rapidan.—The Consumers Power Co. has recently built a hollow reinforced-concrete dam of the Ambursen type which creates a head of 60 feet. The valley is very narrow at this point affording good rock abutments for the dam, which backs the water upstream between 4 and 5 miles. The area of the pond is 470 acres. At the left end of the dam (and an integral part of it) is placed the power house. There are two 32-inch Pelton-Francis turbines of 1100 horsepower capacity each, which are supplied with water by means of short penstocks. Space is provided for 1 additional unit of the same size. The turbines are controlled by Pelton automatic governors. Each turbine is direct connected to a 750 KW General Electric 3-phase, alternating current generator of 2300 volts. From the power house an 11 mile transmission line conducts the power to Mankato at a voltage of 57,000. This plant is one unit in an extensive system supplying light and power to towns in the southern part of the State. There are auxiliary steam plants in the system as the water supply is not sufficient at all times.

AVAILABLE HORSEPOWER.

The records of flow for the upper Minnesota cover chiefly the very low flow of 1910 and 1911, and therefore, the estimated flow for an ordinary low year can only be considered approximate.

The following table shows the available continuous horsepower at the developed powers in the Minnesota basin. The records of Blue Earth River are too fragmentary on which to base an estimate of power.

Available horsepower at developed power sites.

Developed Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Minnesota River.							
Granite Falls	14	16	120	380	20	153	484
Minnesota Falls	16	17	122	385	25	177	560
Pomme de Terre River.							
Appleton	14	3	5	....	4	6	....
Chippewa River.							
Millerville	....	....	....	....	....	....	....
Hagan	8	5	10	....	4	7	....
Montevideo	7	6	12	....	4	8	....
E. Br. Chippewa River.							
Swift Falls	20	1	2	....	....	....	....
Terrace	16	1	2	....	....	....	....
Redwood River.							
Redwood Falls	85	2	12	....	15	93	....
N. Redwood	..	2	12	....	....	....	....
Cottonwood River.							
New Ulm	8.5	9	30	....	7	23	....

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

The United States Engineer Office at St. Paul made a topographic survey of Minnesota River in 1909-1910 which extended from Bigstone Lake to Mankato where it was tied to an older survey made by the same organization. A profile has been compiled from these surveys and published as Plate VI. From the profile, the following table of elevations and distances has been taken:

Elevations and distances along Minnesota River from Bigstone Lake to the mouth.

Stations.	Distance in miles		Elevation in feet above sea level	Descent in feet between points	
	From Bigstone Lake	Point to point		Total	Per mile.
Outlet Bigstone Lake	0	....	966	....	....
Whetstone River	2	2	956	10	5.0
Bridge southwest of Odessa	11	9	944	12	1.3
Yellow Bank River	15	4	940	4	1.0
Marsh Lake Bridge	22	7	936	4	0.6
Pomme de Terre River	29	7	935	1	0.1
Bridge southwest of Appleton	31	2	931	4	2.0
Lac qui Parle Bridge	36	5	926	5	1.0
Lac qui Parle River	46	10	924	2	0.2
....	48	2	923	1	0.5
Bridge southwest of Watson	51	3	921	2	.7
Bridge northwest of Montevideo	55	4	917	4	1.0
Chippewa River	62	7	913	4	.6
Bridge at Myers	70	8	910	3	.4
G. N. Ry. Bridge	79	9	907	3	.3
Dam at Granite Falls, crest	80	1	906	1	1.0
Granite Falls Bridge	81	1	891	15	15.0
Dam at Minnesota Falls, crest	84	3	883	8	2.7
Dam at Minnesota Falls, foot	84	0	867	16	....
Yellow Medicine River	96	12	861	6	0.5
Sacred Heart Bridge	103	7	848	13	1.9
Sacred Heart Creek	109	6	835	13	2.1
Bridge North of Delhi	111	2	831	4	2.0
Redwood R'ver	122	11	820	11	1.0
Morton Bridge	132	10	810	10	1.0
Bridge south of Franklin	141	9	803	7	.8
Fort Ridgely Bridge	158	17	793	10	.6
Henderman Bridge	164	6	791	2	.3
Bridge below New Ulm	189	25	784	7	.3
Cottonwood River	192	3	780	4	1.3
Courtland Bridge	198	6	774	6	1.0
Judson Bridge	212	14	762	12	0.9
Blue Earth River	224	12	757	5	.4
St. Peter	243	19	730	27	1.4
Ottawa	250	7	723	7	1.0
Le Sueur	258	8	716	7	.9
Henderson	268	10	710	6	.6
Faxon	282	14	700	10	.7
Belle Plaine	289	7	696	4	.6
Crest of Little Rapids	303	14	693	3	.2
Carver	308	5	690	3	.6
Bloomington Ferry	323	15	690	0	0
Mendota	339	16	690	0	0
Mouth of river	....	....	690	0	0

A set of blueprints of the Minnesota survey was furnished through the courtesy of the United States Engineer Office and from these it was seen that there were no feasible undeveloped power sites above Minnesota Falls.

In sec. 30, T. 114 N., R. 36 W.—One-half mile below the Delhi bridge there are two granite mounds which form a good dam site. A 35-foot dam at this point would back the water about 28 miles upstream or nearly to the Minnesota Falls dam, which is the controlling feature. The dam would be about 500 feet long, in addition to the main structure, a dam 15 feet high would be required to close a gap 700 feet long between the mound on the left bank, and a third granite mound located near the left bluff line. This development would overflow 2470 acres.

Although the river has considerable fall between this site, and the mouth of Cottonwood River there are no suitable dam sites. In order to secure a head of 10 feet or more, it would be necessary to build a dam nearly across the valley, which varies in width from one-half mile to a mile.

In sec. 33, T. 109 N., R. 28 W.—A short distance above the highway bridge in section 33, there is a site for a 20-foot dam, which would have a crest length of 500 feet. The pond formed by the dam would extend 22 miles upstream to New Ulm, and also nearly to the dam in Cottonwood River which would be the controlling feature. The area overflowed would be 1050 acres.

Between this site and Mankato, there is no suitable dam site. Below that point there are no detailed contour maps so it is impossible to state positively whether there are any dam sites. In sec. 21, T. 110 N., R. 29 W., just above St. Peter, the bluff lines approach within a half mile of each other, the narrowest point below Mankato. If a 20-foot dam were built at this point it would back the water 20 miles upstream to Mankato.

Below St. Peter the valley becomes wider, and the slope of the river less, making power development practically impossible.

AVAILABLE HORSEPOWER.

The ten years records of flow at Mankato show that during the latter part of 1910 and during 1911 the discharge of the river was much less than during any previous low year. In determining the flow at the first dam site it is necessary to utilize the records at Montevideo, and as these cover chiefly the extreme low water period it cannot be stated definitely what the low flow would be for an ordinary low year nor what the dependable flow would be during the six highwater months of an ordinary low year. There is such a difference between the runoff per square mile during the low winter months at Mankato and at Montevideo, that the Mankato records cannot safely be used in determining the upper river flow. Therefore, the estimated flow for ordinary low years at the first dam site can only be considered approximate, and that at the second site somewhat less so.

Undeveloped horsepower on Minnesota River.

Site	Head in feet.	Minimum Runoff			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Sec. 30, T. 114 N., R. 36 W.	35	20	125	425	64	398	1350
Sec. 33, T. 109 N., R. 28 W.	20	70	300	1100	127	545	2000
Sec. 21, T. 110 N., R. 29 W.	20	178	400	1900	324	727	3450

STORAGE.

RESERVOIR SITES.

Possibilities.—The largest reservoir site in the Minnesota basin is Bigstone Lake situated on the boundary between Minnesota and South Dakota. Records of flow at the outlet of the lake show that it is so far up on the headwaters that its tributary runoff is small, and hence its value as a reservoir in controlling the flow of the middle and lower portions of the river is small. The only other sites of importance on the Minnesota are Marsh Lake and Lac qui Parle. Of these two, the latter has the greater tributary runoff and the greater possible capacity and was the one studied in detail.

STORAGE STUDY OF LAC QUI PARLE.

Capacity.—When the Minnesota River was surveyed in 1909 by the Engineer Corps, a detailed survey was made of Lac qui Parle and surrounding topography. The results of this survey showed a dam site near the outlet of the lake in sec. 30, T. 118 N., R. 41 W. With a 20-foot dam having a crest length of 2,800 feet, a reservoir having the following capacity would be created:

Capacity of Lac qui Parle reservoir.

Contour	Area, acres	Capacity of Section	Total Capacity.	
			Acre-feet.	Cubic-feet
926[a]	2,260	....	....	....
930	4,651	13,824	13,824	....
935	8,020	31,680	45,504	....
940	16,410	61,075	106,579	4,643,000,000
945	23,630	100,100	206,679	9,003,000,000

[a] Water surface of Lac qui Parle.

If the dam were raised to the 950 contour the capacity would be increased to 14.8 billion cubic feet. This would necessitate a 5-foot earth embankment 3000 feet long, in secs. 15, 21, 22, T. 118 N., R. 41 W., to prevent overflow into Chippewa River.

In determining the runoff of Lac qui Parle, there are available records of flow at Mankato from 1903 to date, and at Montevideo from 1909 to date, also records of the Chippewa from 1910 to date. A comparison of the runoff per square mile at Mankato and at the reservoir site (which was taken as that above the Chippewa River at Montevideo) was made during the period of simultaneous records. This comparison showed that the runoff per square mile of the drainage area above the reservoir was about 70 per cent of that above Mankato. This may be accounted for by the smaller annual rainfall in the basin above Lac qui Parle which is about 90 per cent of that for the entire basin above Mankato, and also by the fact that the basin is flatter in the upper portion, and the valley slope more gentle, which tends to reduce the percentage of runoff. Thus to determine the monthly mean runoff at the reservoir outlet from 1903 to date, 70 per cent of the monthly mean runoff per square mile at Mankato was multiplied by the drainage area above the outlet (3520 square miles).

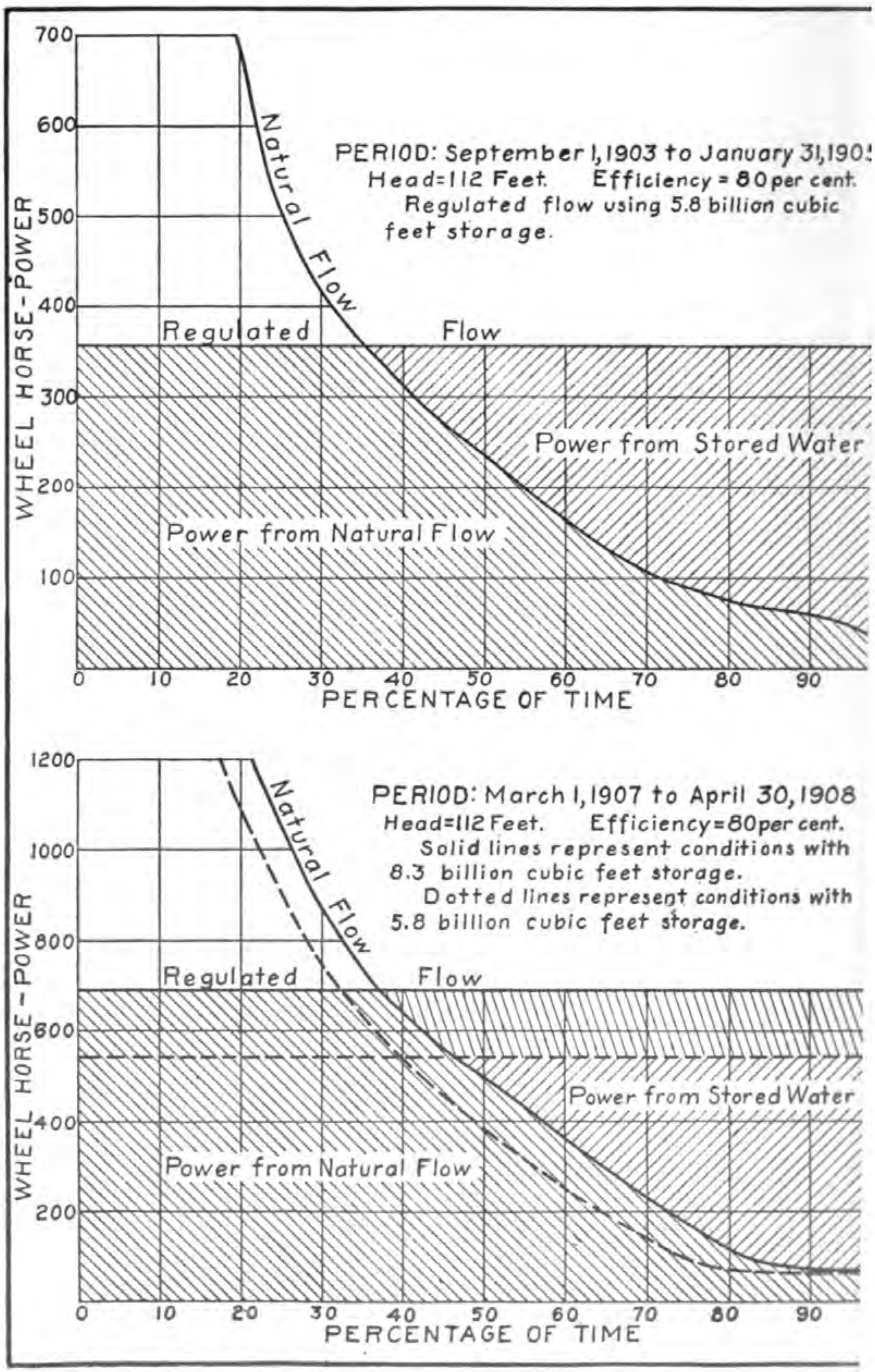
Had the reservoir been in operation, there would have been losses due to evaporation, as the water surface would have varied from 23,630 acres to 2,260 acres depending upon the stage. These monthly losses were determined by means of the evaporation records at Grand Forks, N. D. (The records at Grand Forks, N. D., Iowa City, Ia. and Grand River Lock, Wis. show a substantial agreement and therefore it is probable that the Grand Forks records apply closely.) The natural runoff less the loss from evaporation was taken as the available runoff from the reservoir.

To show the variation in flow at the reservoir and the amount of storage capacity necessary to regulate the flow, a mass curve was drawn (plate VII).

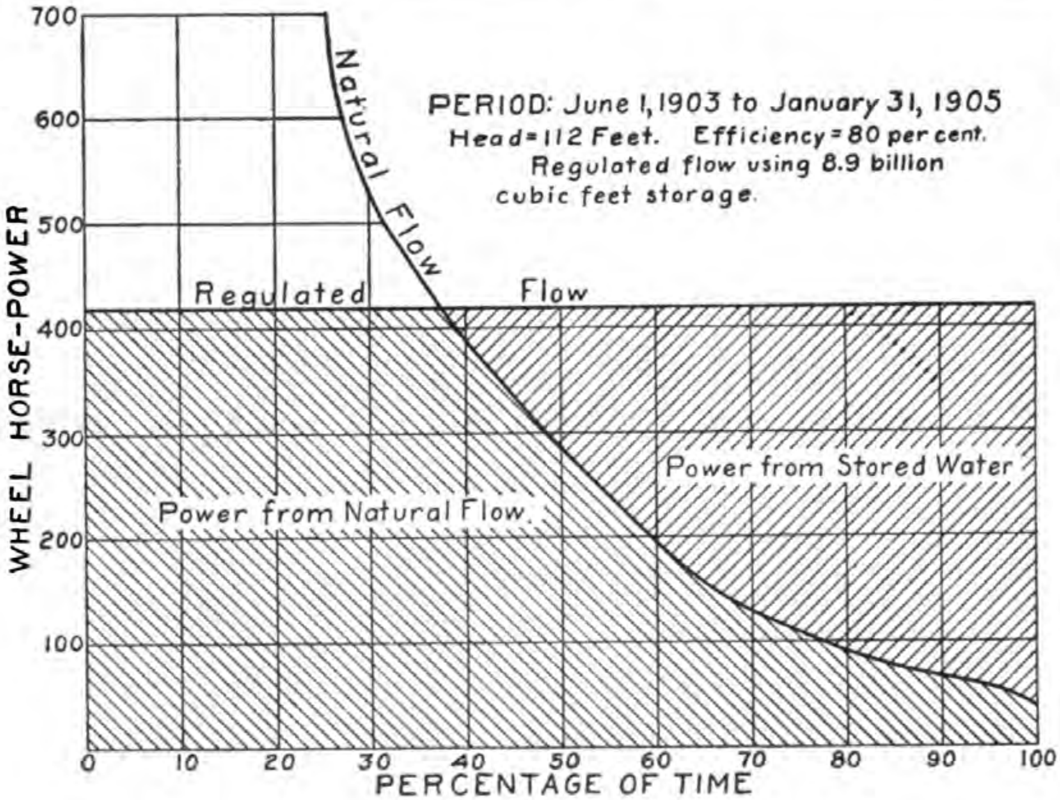
Uses of the Reservoir.—The chief interests benefited by the operation of the reservoir, would be water power, flood control and prevention, and navigation. As these interests are more or less conflicting in their requirements they will be considered separately to show the maximum effect to any one interest.

Water Power.—For water power there are two courses open—one is to develop power at the reservoir site itself with incidental benefits to other water powers further down the river and the other is to neglect any possible development at the reservoir site and build and operate the reservoir for the water powers below.

To create a minimum power head of 19 feet and have sufficient storage to regulate the flow of the river effectively would require a dam 24 feet high with a 5-foot earth embankment 3000 feet long in addition. The reservoir thus created would overflow 27,580 acres of bottom land. The available storage would be 5.8 billion cubic feet which would regulate the flow as shown on the mass curve. With the exception of the dry years of 1910 and 1911 the flow regulated by the 5.8 billion capacity, would have had a minimum of 340 second-feet which with a head of 19 feet would represent 587 continuous horsepower at 80 per cent efficiency. There would also be corresponding benefits to the water powers below, due to the increased flow during the low water months. There are five feasible power sites on the Minnesota below Lac qui Parle (of which two



700
600
500
400
300
200
100
WHEEL HORSE-POWER
Natural Flow
PERIOD: September 1, 1903 to January 31,190
Head=112 Feet. Efficiency = 80 per cent.
Regulated flow using 5.8 billion cubic feet storage.
Regulated Flow
Power from Stored Water
Power from Natural Flow
0 10 20 30 40 50 60 70 80 90
PERCENTAGE OF TIME
1200
1000
800
600
400
200
WHEEL HORSE-POWER
Natural Flow
PERIOD: March 1, 1907 to April 30, 1908
Head=112 Feet. Efficiency=80 per cent.
Solid lines represent conditions with 8.3 billion cubic feet storage.
Dotted lines represent conditions with 5.8 billion cubic feet storage.
Regulated Flow
Power from Stored Water
Power from Natural Flow
0 10 20 30 40 50 60 70 80 90
PERCENTAGE OF TIME



DIAGRAMS SHOWING INCREASED POWER ON MINNESOTA RIVER FROM STORED WATER AT LAC QUI PARLE RIVER.

are either fully or partially developed) with a total head of 112 feet. The effect of the regulation on the total head of 112 feet is shown for typical periods by means of the power-percentage of time curves on plate VIII.

If the reservoir is built only for benefit to the water powers below, a dam 19 feet high would overflow 23,630 acres or 6,210 acres less than the 24-foot dam described above. This dam would impound 9 billion cubic feet and as no power at the dam site is counted on, the entire capacity would be available to regulate the river. With the 9 billion storage the flow of the river could be regulated as shown on the mass curve (plate VII). The effect of this regulation upon the total power development of 112 feet is shown for typical periods by the power-percentage of time curves. These curves do not show the entire power development on the lower river but simply that due to the flow from the reservoir.

Flood control and prevention.—The severest flood since the records of the Minnesota were begun in 1903, occurred during the latter part of June 1908. Unfortunately, the Montevideo records are not available for that period and therefore, although the monthly mean flow at the Lac Qui Parle reservoir can be determined with a fair degree of accuracy for that period from the Mankato records, the *maximum* rate of runoff during the period is very uncertain, as the following analysis shows:

The chief cause of the highwater of June 26, 1908. in the lower valley was the heavy rainfall of June 23, which was recorded as 2.95 inches at Mankato, and 4.25 inches at St. Peter on the preceding day. This precipitation coming after a rainfall of 3 inches during the preceding 4 days, found its way chiefly into the river as the ground was in a saturated condition. The discharge at Mankato rose from 16,800 second-feet on the 22nd to 34,900 second-feet on the 24th, and to the maximum of 43,800 second-feet on the 26th, after which date it subsided slowly. The rain of the 23rd was general throughout the basin above Mankato, but nowhere in that area was it as heavy as at Mankato and below. At Montevideo, the precipitation was 1.74 inches on the 23rd, and at Milan, above the reservoir, it was 1.04 inches. For the preceding 5 days, the rainfall at Montevideo and Milan was less than 1 inch, so that the ground was in a less saturated condition than in the vicinity of Mankato, and as the upper valley has more gentle sides and slope, it is probable that the runoff per square mile following the rainfall of the 23rd was much less than in the lower valley. As the distance by river from Lac qui Parle to Mankato is 180 miles it would take several days for the water from the area controlled by the reservoir to reach the latter point. Thus the effect of the operation of the reservoir upon the maximum flow at Mankato cannot be determined accurately but in all probability it would have been small. Its chief result would have been to shorten the period of highwater after the maximum flood stage.

Until simultaneous records in the upper and lower valley are available it will be impossible to determine accurately the effect of the operation of the reservoir for flood control and prevention.

Navigation.—As the period of navigation lasts from May to October, when there is sufficient water, the reservoir to aid this interest to its fullest extent should be so operated that the entire supply should be sent down the river during the months of July, August, September, and October, to reinforce the natural low water flow. Although for navigation needs the reservoir could be shut down for the remainder of the year, yet on account of the riparian owners below, it would be necessary to pass at all times an amount at least equal to the normal low water flow. This has been approximately determined as 100 second-feet at Lac qui Parle.

To show the benefit to navigation, it is necessary to show the increase in stage of the lower river due to the reinforced flow from the reservoir. As no section of the river below Mankato has been rated and as no records of stage are available, it is not possible to show accurately the increased stage except by comparison with the increase at Mankato.

If the reservoir of 9 billion cubic feet capacity had been operated wholly in the interest of navigation, since 1904, the following increases of stage of the Minnesota at Mankato would have resulted.

Increased stage of Minnesota River at Mankato.

Month.	Increased flow, second-feet	Increased stage, feet	Month.	Increased flow, second-feet	Increased stage, feet
1904.			1908.		
July	688	0.4	July	−1,720	.....
August	783	.8	August	494	.4
September	812	.8	September	877	1.1
October	791	.8	October	895	1.1
1905.			1909.		
July	−510	....	July	−152	.....
August	717	.9	August	264	.4
September	820	1.4	September	369	.6
October	866	1.3	October	362	.7
1906.			1910.		
July	682	.5	July	0	.0
August	644	.4	August	0	.0
September	573	.3	September	0	.0
October	918	7	October	0	.0
1907.			1911 and 1912.		
July	−240	.	No increase.		
August	634	.6			
September	697	.6			
October	888	.9			

The decreased flow noted for July is due to the fact that the actual discharge at the reservoir for that month was greater than the uniform draft from July 1 to October 31 designed to utilize the entire contents during that period.

In actual practice, it is probable that instead of maintaining a uniform flow during the period from July to October, the flow would be varied in order to maintain a constant stage in the lower river.

As the flow of the Mississippi at St. Paul is so much greater than that of the Minnesota at Mankato, the effect of Lac qui Parle reservoir upon the stage at St. Paul would be very much less than at Mankato.

SANITARY STATISTICS.

To show the sanitary quality of the water in the Minnesota, and the extent to which this water is used for municipal purposes, data showing this source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more, located on the Minnesota or its tributaries. These data are given in the following table in order of location, beginning near the source of the river:

Municipal water supply and sewage disposal of towns on Minnesota River.

Town.	Distance above mouth	Population 1910	Water Works System.			Sewerage System.		Rural population per square mile above
			Source of Supply	Filtered	Amount gallons 24 hours.	Outlet	Treated	
Brown's Valley	379	1,058	springs	no	12,000	none	....	....
Ortonville	339	1,774	deep well	no	50,000	Bigstone Lake	Septic tank	....
Pomme de Terre River	310	....	....	....	....	....	....	....
Lac qui Parle River	293	....	....	....	....	....	....	....
Chippewa River	277		....	....	....	....	....	15.7
Granite Falls	259	1,454	Minn. R.	sand filter	60,000	Minn. R.	no	....
Hawk Creek	245	....	....	....	....	....	....	....
Yellow Medicine River	245	....	....	....	....	....	....	....
Redwood River	217	....	....	....	....	....	....	....
New Ulm	150	5,648	deep wells	no	200,000	Minn. R.	no	....
Cottonwood River	147	....	....	....	....	....	....	....
Blue Earth River	115			....	....	....	....	....
Mankato	112	10,365	artesian well	no	1,000,000	Minn. R.	no	18.8
North Mankato	112	1,279	artesian well	no	290,000	none	....	....
St. Peter	96	4,176	artesian well	no	....	Minn. R.	no	....
Le Sueur	81	1,755	artesian well	no	200,000	Minn. R.	no	....
Le Sueur Creek	80	....	....	....	....	....	....	....
Henderson	71	820	artesian well	no	4,500	none	....	....
Belle Plaine	50	1,204	....	no	2,000	none	....	....
Chaska	30	2,050	artesian well	no	5,000	none	....	....
Shakopee	25	2,302	deep well	no	....	Minn. R.	no	....
Bloomington	16	75	none	....	....	none	....	....
Fort Snelling	0	800	artesian well	no	170,000	Minn. R.	no	....
Mouth	0	....	....	....	....	....	....	20.0

Municipal water supply and sewage disposal of towns on tributaries of the Minnesota River.

			Pomme de Terre River.					13.4
Morris	50	1,685	shallow wells	no	150,000	river	Septic tank	....
Appleton	6	1,221	deep well	no	65,000	river	no	....
			Lac qui Parle River.					
Dawson	30	1,318	wells	no	15,000	none	....	....
			Chippewa River.					16.6
Glenwood	130	2,161	springs	no	(total flow 500,000)	lake	Septic tank	....
Benson	50	1,766	well	yes	30,000	river	no	....
Montevideo	1	3,056	springs	no	84,000	river	no	....
			Hawk Creek.					
Willmar	60	4,135	artesian wells	no	100,000	river	Septic tank	....
Clara City	......	587	well	no	2,000	none	....	....
			Yellow Medicine River.					
Minnesota	70	819	well	no	10,000	river	no	....
			Redwood River.					17.7
Marshall	60	2,152	artesian well	no	45,000	creek	no	....
Redwood Falls	5	1,806	springs	no	30,000	river	no	....
			Cottonwood River.					
Tracy	80	1,340	deep well	no	70,000	dry run	no	17.7
Springfield	50	1,482	....	....	....	....	....	....
			Minneopa Creek.					
Lake Crystal	12	1,231	deep well	no	2,500	no	no	....
			Blue Earth River.					20.3
Blue Earth	120	2,319	wells	no	50,000	Blue E R	no	....
Fairmont	120	2,958	Budd L.	no	120,000	Lake George	Septic tank	....
Winnebago	90	2,555	wells	no	50,000	tributary	no	....
Watonwan River	13	....	....	....	....	....	....	....
Le Sueur River	4	....	....	....	....	....	....	....
			Watonwan River.					20.0
St. James	60	2,102	deep wells	no	7,000	tributary	no	....
Madelia	45	1,273	wells	no	8,000	Watonwan	no	....
			Le Sueur River.					22.1
Mapleton	40	809	deep well	no	21,000	tributary	no	....
			Le Sueur Creek.					
Le Sueur Center	20	741	deep well	no	50,000	tributary	no	....

From the preceding table it is seen that from Bigstone Lake to the mouth of the Chippewa, a distance of 62 miles, the Minnesota receives no untreated urban sewage. The rural population of this portion of the drainage basin is 15.7 per square mile. The Pomme de Terre River brings in the drainage from 847 square miles having a rural population of 13.4 per square mile. No untreated urban sewage enters this stream. Lac qui Parle River drains an area of 900 square miles, but carries no urban sewage. The average fall of the river in this stretch is 0.9 foot per mile. For about 17 miles, the course of the river is through Marsh Lake and Lac qui Parle, both of which are shallow lakes where sedimentation and the action of sunlight are active agents in reducing any sewage bacteria in the water. No river water is used for municipal purposes.

At the mouth of the Chippewa, the Minnesota receives from that source, the drainage of 1990 square miles having a rural population of 16.6 per square mile. The Chippewa carries untreated sewage from an urban population of 4822.

From the Chippewa to Mankato, a distance of 165 miles, the Minnesota receives raw sewage from Granite Falls, New Ulm, and Mankato, representing a population of 17,500. The rural population for the entire basin above Mankato is 18.8 per square mile. For this stretch of the river the average fall is about 1 foot per mile. The only ponding effect is caused by the dams at Granite Falls and Minnesota Falls, and is comparatively slight. No untreated river water is used for municipal purposes between the Chippewa and Mankato. Yellow Medicine River brings in the drainage from an area of 550 square miles, and carries the raw sewage from an urban population of 819. Redwood River drains an area of 748 square miles having a rural population of 17.7 per square mile, and carries the raw sewage from an urban population of 4000. Cottonwood River drains an area of 1200 square miles having a rural population of 17.7 per square mile, and carries the untreated sewage from an urban population of 2822. Blue Earth River drains an area of 3430 square miles having a rural population of 20.3 per square mile and carries the untreated sewage from an urban population of 7100.

Between Mankato and the mouth, a distance of 112 miles, the Minnesota receives the untreated sewage from St. Peter, Le Sueur, Shakopee, and Fort Snelling, representing a population of 9000. The rural population of the entire basin above the mouth is 20 per square mile. The average fall of the river in this stretch is 0.6 foot per mile, with little or no ponding effect, except that afforded by the slow current itself. No river water is used for municipal purposes below Mankato.

ST. CROIX RIVER.

SOURCE, COURSE AND TRIBUTARIES.

St. Croix River, which forms throughout the greater part of its length the boundary between Minnesota and Wisconsin, drains an area 7290 square miles in extent lying in eastern Minnesota and northwestern Wisconsin. The river rises at an elevation of 1010 feet above sea level, in Lake St. Croix, on the Lake Superior divide, only 20 miles from Lake Superior, and flows southwest and then south until it joins the Mississippi opposite Hastings, Minn. In its total length of 160 miles it descends 338 feet, all but 20 feet in the upper 116 miles.

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

TOPOGRAPHY, GEOLOGY AND FORESTATION.

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

The country for the most part is gently undulating and is deeply trenched by the larger rivers which have cut through the drift and into the underlying rock.

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

In the Minnesota portion the lakes comprise less than 1 per cent of the area, and as logging is no longer carried on, few of these lakes are controlled.

The upper section of the drainage basin is timbered, but much of the growth is merely brush, as logging was carried on extensively in the basin for many years. The lower part of the basin is largely under cultivation.

RAINFALL AND RUNOFF.

The mean annual rainfall in the basin will average about 31 inches, of which 3½ inches are precipitated as snow. The nearest point to the upper basin at which long time rainfall records are available is Duluth. Since 1871 the wettest year was 1879 when the rainfall was 45.3 inches. The driest year was 1910 when the precipitation was 18.1 inches. In the lower portion of the basin, the wettest year since 1891 was 1903 when the rainfall was 43.6 inches at Osceola. The driest year was 1910 when the precipitation was 11.21 inches.

Runoff records of St. Croix River have been maintained since 1902. The runoff has varied from 15.92 to 5.51 inches.

NAVIGATION.

St. Croix River is navigable for small steamers from its mouth to the Dalles at Taylors Falls. The Federal Government has done considerable work to improve navigation, chiefly by dredging and removing snags.

DRAINAGE AREAS.

The following drainage areas have been measured in the St. Croix River Basin:

Drainage areas in St. Croix basin.

River.	Drainage area above	Square miles.
St. Croix	Taylors Falls (St. Croix Falls, Wis.)	5,930[a]
St. Croix	Mouth	7,290[a]
Tamarack	Mouth	200
Sand	Mouth	135
Sunrise	Mouth	304

[a] Revised since publication of W. S. P. 156.

GAGING STATION RECORDS.

ST. CROIX RIVER AT ST. CROIX FALLS.

Location.—At the power plant at St. Croix Falls. The nearest tributary is Dry Creek which enters from the Minnesota side several miles above.

Records available.—January 1, 1910, to December 31, 1912. The daily discharges are furnished through the courtesy of the Minneapolis General Electric Company. From January 10, 1902, to June 30, 1905, records of flow at this point were maintained by Loweth and Wolff, and were furnished through the courtesy of Mr. L. P. Wolf, Consulting Engineer, St. Paul. Hydrographs showing the flow from July 1, 1905, to Dec. 31, 1909, have been used to estimate the mean monthly flow.

Drainage area.—5,930 square miles.

Method of obtaining records.—The records by Loweth and Wolf were obtained from daily gage heights and frequent discharge measurements of the river. The present records are obtained by recording the flow through the turbines in the power house, and the flow over the dam.

Regulation.—The flow of the river, especially during low water, is controlled by the operation of the gates at the power plant, and also by the storage and release of water at Never's dam, located several miles upstream.

Daily discharge, in second-feet, of St. Croix River at St. Croix Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	......	1,820	2,420	2,910	3,930	5,150	6,690	2,270	1,720	2,330	5,190	2,480
2	......	1,880	2,440	2,840	4,090	5,010	4,490	1,740	1,730	2,390	3,950	2,560
3	......	1,930	2,460	300	3,910	4,480	4,830	1,790	1,680	2,400	3,290	2,550
4	......	1,700	2,300	400	3,920	9,800	4,700	1,820	1,840	1,680	4,740	2,530
5	......	1,760	2,370	2,750	3,940	11,900	7,350	1,870	1,700	2,150	3,910	2,510
6	......	1,760	2,420	2,520	4,900	11,000	5,200	2,040	2,560	2,440	4,180	2,490
7	......	1,750	2,270	2,280	3,980	10,600	12,100	2,260	2,550	2,390	4,030	2,470
8	......	1,770	2,460	2,280	4,880	9,900	11,700	1,980	2,220	2,290	4,740	2,450
9	......	1,760	2,660	2,190	4,560	9,260	11,100	1,660	4,110	2,050	4,500	2,440
10	1,890	1,760	2,860	2,110	4,590	10,500	12,960	1,990	3,500	930	3,290	2,420
11	1,910	1,750	3,060	1,990	4,450	6,810	8,980	3,970	1,720	2,950	2,960	2,400
12	1,860	1,750	3,260	1,870	5,850	7,600	7,980	1,680	1,500	1,950	3,200	2,390
13	1,850	1,820	3,450	1,470	6,150	8,290	6,700	1,120	1,640	2,040	4,300	2,370
14	1,680	1,870	3,650	2,060	5,250	4,780	6,060	1,020	1,550	2,000	4,530	2,260
15	1,760	1,990	3,850	2,020	4,780	6,350	5,780	1,570	1,360	1,920	4,900	2,150

Daily discharge, in second-feet, of St. Croix River at St. Croix Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
16	1,780	1,990	4,050	2,170	4,880	4,220	4,860	1,590	1,360	800	4,600	2,080
17	1,800	1,990	4,250	2,070	4,820	3,420	4,380	1,560	1,540	845	4,700	2,020
18	1,880	1,990	4,450	5,190	4,940	3,580	3,800	1,500	1,480	3,600	4,580	2,110
19	1,860	1,990	4,650	1,510	5,060	6,350	5,210	1,510	1,120	1,940	5,160	2,180
20	1,920	1,990	5,000	1,000	5,300	3,780	2,850	1,500	510	1,920	3,690	2,080
21	1,880	1,990	4,650	500	5,870	960	3,400	1,480	2,800	2,040	4,660	2,040
22	1,930	1,990	4,600	5,540	7,080	3,300	3,530	1,480	2,070	1,980	4,160	2,060
23	1,860	2,030	4,040	540	9,600	3,400	3,600	1,580	2,540	2,040	4,250	2,090
24	1,950	2,060	3,470	510	7,250	6,060	3,180	1,500	2,360	850	4,060	2,090
25	1,980	2,110	3,110	1,050	6,420	3,560	2,560	1,400	1,060	1,100	3,720	2,090
26	1,980	2,180	3,120	2,760	5,580	4,140	7,250	3,850	1,140	2,300	3,560	2,080
27	1,950	2,260	3,120	3,020	5,760	4,380	850	1,860	1,120	2,310	3,680	2,080
28	1,930	2,480	3,120	3,290	5,090	4,200	750	1,740	3,050	2,660	3,060	2,080
29	1,920	......	3,120	3,480	6,070	2,550	2,520	1,460	2,210	2,890	3,050	2,080
30	1,900	......	3,040	3,750	4,930	4,690	2,520	6,000	2,310	1,880	2,050	2,060
31	1,890	......	2,950	......	5,290	......	2,610	1,800	......	2,840	......	2,040
1903.												
1	2,060	1,950	1,940	6,770	8,920	7,680	251	4,570	1,060	7,380	5,600	3,090
2	1,940	1,940	1,920	9,800	9,560	10,400	3,030	4,800	2,000	7,480	5,220	2,850
3	1,940	1,760	1,920	10,800	11,400	9,490	4,440	5,050	2,970	8,930	5,250	3,060
4	1,910	1,830	1,960	12,200	13,300	8,560	6,000	6,170	3,920	12,100	3,490	2,940
5	1,880	1,900	1,960	11,300	15,200	7,910	7,220	6,710	2,970	17,400	850	3,000
6	1,930	2,020	1,880	10,400	15,600	7,340	8,640	1,600	2,000	18,400	5,610	2,950
7	1,940	1,930	1,990	8,850	15,200	6,800	8,760	7,900	960	......	7,000	2,900
8	2,010	1,920	2,050	11,600	13,800	6,270	8,880	7,000	5,500	......	5,700	2,800
9	1,930	1,900	2,110	18,000	12,200	6,010	10,200	7,280	11,600	......	4,970	2,860
10	1,850	1,940	2,350	16,400	10,700	5,760	10,900	6,970	15,100	......	5,200	2,870
11	1,880	1,950	2,590	18,300	9,240	5,160	11,600	7,170	15,600	......	4,930	2,680
12	1,900	1,880	2,830	20,200	16,200	6,190	10,500	4,830	16,700	23,600	4,790	2,610
13	1,930	1,980	3,070	18,600	15,900	7,320	9,240	5,510	......	18,400	4,810	2,540
14	1,950	1,930	3,310	17,000	15,600	6,910	7,250	5,340	......	15,800	4,850	2,470
15	1,980	1,870	3,550	15,400	15,300	6,500	7,200	5,360	......	15,600	4,200	2,400
16	1,870	1,840	3,790	14,100	15,000	5,820	6,920	4,800	......	13,600	4,560	2,350
17	1,770	1,870	4,030	12,800	14,700	5,130	6,790	4,230	......	12,800	6,200	2,500
18	1,820	1,970	4,530	12,600	14,400	5,760	6,040	4,150	......	11,600	7,600	2,530
19	1,870	1,850	6,480	12,500	14,100	4,300	5,590	3,460	......	10,300	2,440	2,440
20	1,780	1,700	9,890	10,300	13,800	3,380	5,150	3,680	......	9,560	2,680	2,560
21	1,980	1,740	11,400	9,400	13,800	2,460	4,540	4,360	18,400	9,370	3,130	2,690
22	1,730	1,830	11,500	8,600	10,600	1,540	4,380	3,980	15,100	8,610	3,300	2,750
23	1,820	1,910	11,500	7,700	11,200	2,700	3,990	3,600	14,300	7,370	3,460	2,820
24	1,800	1,950	10,700	6,800	11,700	2,710	1,830	3,220	10,800	7,600	3,480	2,650
25	1,860	1,940	9,660	9,740	12,100	2,640	5,590	3,280	9,050	8,000	3,360	2,850
26	1,930	1,820	10,100	9,260	9,580	2,540	4,670	3,300	9,910	8,410	3,170	3,650
27	1,990	1,880	9,530	8,790	12,000	2,480	3,750	3,180	9,050	6,680	3,120	3,240
28	2,050	1,970	8,720	10,500	12,600	2,420	4,770	3,620	8,140	6,180	3,090	3,440
29	1,980	......	8,590	10,100	11,400	2,360	4,730	5,040	7,570	5,930	3,050	2,630
30	1,840	......	8,440	8,920	10,600	907	4,480	4,730	6,960	5,750	3,130	2,420
31	1,970	......	8,160	......	9,160	......	4,570	4,410	......	5,610	......	2,410
1904.												
1	2,390	2,110	2,580	5,560	8,400	6,340	6,170	840	3,800	3,950	8,780	1,690
2	2,390	2,090	2,570	6,130	7,590	5,520	5,850	1,080	4,530	3,840	8,040	1,760
3	2,640	2,060	2,520	7,000	7,540	6,050	3,630	1,480	4,610	3,720	7,590	2,210
4	2,890	2,040	2,390	8,080	7,480	7,950	1,410	3,460	4,750	3,360	6,780	2,400
5	3,140	2,080	2,290	9,870	7,380	12,600	3,010	2,250	4,900	11,300	3,280	2,620
6	3,400	2,070	2,390	12,400	8,290	17,200	4,610	1,990	4,870	1,240	4,230	2,740
7	3,660	2,040	2,490	15,900	8,790	17,900	4,780	2,040	5,640	2,800	5,230	2,890
8	3,140	2,020	2,600	16,900	10,300	17,500	4,610	2,100	4,690	4,690	5,440	2,970
9	2,810	2,160	2,590	18,300	11,800	15,600	4,970	2,210	4,600	3,400	5,700	2,770
10	2,820	2,110	2,560	16,600	13,400	12,900	2,960	2,100	4,030	2,120	4,900	2,820
11	2,840	2,000	2,590	15,100	11,300	12,600	950	2,000	3,460	10,400	5,330	2,820
12	2,600	2,160	2,640	14,000	9,490	12,100	3,480	2,300	2,820	15,000	5,600	2,830
13	2,340	2,000	2,650	10,600	8,550	11,500	3,860	2,340	2,380	14,300	5,540	2,500
14	2,660	2,140	2,660	7,910	8,980	11,300	3,750	1,750	1,940	13,800	5,470	2,420
15	2,680	2,280	2,700	12,600	8,650	7,880	3,890	1,150	2,150	12,600	5,250	2,220

NOTE.—From September 13 to 20 and October 7 to 11, 1903, the discharge exceeded 20,000 second-feet.

Daily discharge, in second-feet, of St. Croix River at St. Croix Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
16	2,630	2,430	2,740	10,000	8,310	8,540	3,990	950	3,480	11,400	4,970	2,380
17	2,410	2,430	2,690	9,460	7,280	7,630	2,530	1,430	3,190	10,100	4,770	2,330
18	2,200	2,460	2,700	8,920	7,820	8,140	1,080	3,370	3,160	10,800	4,570	2,320
19	2,480	2,410	2,750	8,380	6,860	8,710	1,140	1,920	3,140	10,300	4,480	2,300
20	2,460	2,450	2,800	7,850	5,250	9,280	3,760	2,240	2,890	12,700	4,340	2,380
21	2,440	2,370	2,850	7,490	6,390	6,730	3,420	3,760	2,750	15,700	4,190	2,160
22	2,630	2,290	2,900	7,530	6,900	5,630	3,170	5,290	2,380	18,700	4,020	2,440
23	2,620	2,330	2,940	11,300	7,500	5,820	3,270	4,390	2,490	18,000	4,000	2,340
24	2,570	2,230	2,990	10,800	8,000	4,960	2,240	2,520	2,700	17,300	4,120	2,390
25	2,520	2,280	3,040	10,400	7,790	5,190	1,210	2,970	3,240	16,200	3,720	2,420
26	2,330	2,410	3,090	11,200	8,760	3,380	1,050	2,510	3,790	15,500	3,710	2,450
27	2,390	2,460	3,370	11,200	8,030	1,570	2,580	2,480	3,330	12,700	3,300	2,460
28	2,280	2,480	3,660	10,800	7,390	4,850	2,780	2,230	3,500	12,900	2,890	2,440
29	2,270	2,520	3,300	10,800	6,700	5,330	2,720	1,960	3,580	10,600	2,800	2,420
30	2,250	......	3,770	9,490	6,060	5,320	2,810	2,260	3,880	10,400	2,250	2,400
31	2,180	......	4,510	......	6,440	......	2,800	3,000	......	10,200	......	2,380
1905.												
1	2,350	2,100	2,640	5,240	5,130	4,380	......	......	......	......	......	......
2	2,310	2,120	2,780	5,760	3,710	3,620	......	......	......	......	......	......
3	2,370	2,120	2,920	6,270	5,110	3,150	......	......	......	......	......	......
4	1,810	2,000	3,060	8,350	5,960	2,400	......	......	......	......	......	......
5	1,680	1,970	3,060	10,300	7,960	1,610	......	......	......	......	......	......
6	2,220	1,950	3,670	12,200	9,350	10,000	......	......	......	......	......	......
7	2,430	1,960	3,530	11,400	10,500	12,400	......	......	......	......	......	......
8	2,450	2,020	3,390	10,700	10,600	14,600	......	......	......	......	......	......
9	2,480	2,030	3,240	8,850	10,400	15,100	......	......	......	......	......	......
10	2,370	2,000	3,100	7,000	9,470	14,800	......	......	......	......	......	......
11	2,910	1,980	3,120	6,760	9,970	14,200	......	......	......	......	......	......
12	2,990	1,980	2,980	5,840	11,700	13,700	......	......	......	......	......	......
13	3,030	1,980	2,840	5,830	13,500	10,800	......	......	......	......	......	......
14	3,100	2,030	2,680	5,370	14,200	11,600	......	......	......	......	......	......
15	3,070	2,000	3,020	5,030	15,000	12,300	......	......	......	......	......	......
16	3,040	2,030	2,800	4,500	14,600	9,270	......	......	......	......	......	......
17	3,010	2,060	2,630	3,940	12,600	10,900	......	......	......	......	......	......
18	2,960	2,060	2,640	3,680	12,200	10,200	......	......	......	......	......	......
19	2,980	2,070	2,680	3,580	11,800	9,530	......	......	......	......	......	......
20	2,700	2,090	2,730	3,560	10,600	10,200	......	......	......	......	......	......
21	2,390	2,160	2,860	4,440	10,200	8,860	......	......	......	......	......	......
22	2,370	2,160	2,900	3,440	9,810	7,520	......	......	......	......	......	......
23	2,360	2,120	3,150	3,140	10,100	9,060	......	......	......	......	......	......
24	2,300	2,090	3,690	2,840	8,890	8,410	......	......	......	......	......	......
25	2,330	2,100	4,330	3,070	7,760	8,660	......	......	......	......	......	......
26	2,350	2,230	4,600	580	5,790	8,900	......	......	......	......	......	......
27	2,380	2,370	4,890	3,990	6,670	10,900	......	......	......	......	......	......
28	2,370	2,510	4,660	4,310	7,460	11,800	......	......	......	......	......	......
29	2,240	......	4,990	4,230	9,180	10,600	......	......	......	......	......	......
30	2,100	......	5,240	4,670	4,160	9,860	......	......	......	......	......	......
31	2,100	......	5,030	......	4,840	......	......	......	......	......	......	......
1910.												
1	3,218	3,035	3,820	5,588	2,652	3,174	1,684	1,446	1,701	1,396	1,385	1,953
2	3,470	2,925	4,035	5,455	2,413	2,165	1,112	1,451	1,701	728	1,390	1,440
3	3,204	2,790	3,825	5,170	3,878	2,044	610	1,400	1,821	1,569	1,405	1,048
4	3,164	3,565	4,255	5,588	3,478	1,923	1,122	1,398	606	1,579	1,458	648
5	2,495	3,351	3,030	5,158	2,660	2,610	1,635	1,496	1,172	1,585	1,668	1,190
6	2,710	3,725	2,952	5,118	2,893	2,584	1,425	1,258	1,699	1,583	725	1,238
7	2,946	2,825	2,875	4,744	2,656	1,903	1,555	452	1,674	1,611	1,694	1,403
8	3,220	2,795	2,940	4,779	2,335	1,928	1,685	1,353	1,773	1,951	1,543	1,725
9	3,495	3,511	2,965	2,158	2,045	2,354	1,227	1,700	1,644	602	1,549	1,741
10	2,905	2,801	3,015	2,650	5,457	2,439	500	1,501	1,591	1,638	1,502	1,743
11	2,856	2,801	3,210	4,103	1,873	1,933	1,804	1,466	680	1,766	1,557	629
12	2,797	2,960	4,563	3,093	1,407	1,760	1,363	1,399	1,736	1,777	1,508	1,417
13	3,055	3,725	5,125	3,127	4,658	1,929	1,799	1,290	1,733	1,770	671	1,343
14	2,880	2,850	5,800	3,162	5,202	1,936	1,790	393	1,411	1,738	1,291	1,139
15	2,940	2,650	6,845	3,043	1,950	1,897	1,668	1,398	1,234	1,732	1,449	1,311
16	3,725	2,810	7,240	3,163	1,835	1,937	1,268	1,554	1,383	629	1,500	1,473
17	3,020	2,620	8,018	3,725	1,510	2,227	75	1,359	1,519	1,643	1,214	1,535
18	2,960	2,900	9,393	2,949	1,185	1,398	1,838	1,412	666	1,513	991	638
19	2,561	3,212	8,959	4,278	2,043	550	1,799	1,404	1,317	1,700	1,348	1,270
20	2,921	3,525	8,525	3,113	3,325	1,822	1,774	1,320	1,446	1,725	728	1,408

Daily discharge, in second-feet, of St. Croix River at St. Croix Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
21	2,770	2,458	9,871	3,079	2,057	1,853	1,815	452	1,456	1,760	1,607	1,266
22	2,850	2,545	8,010	4,625	790	1,737	1,723	1,475	1,453	1,780	1,526	1,245
23	3,725	2,876	8,203	3,923	2,330	1,622	1,297	1,637	1,221	635	1,727	1,219
24	3,080	2,715	8,238	3,675	2,628	1,672	343	1,633	1,098	1,663	691	1,518
25	3,030	2,510	8,234	4,958	3,033	1,113	1,408	1,597	759	1,776	1,362	842
26	2,821	3,520	7,911	5,159	3,553	555	1,482	1,567	1,407	1,826	1,600	850
27	3,095	4,150	7,675	4,307	4,633	1,734	1,493	1,564	1,639	1,662	674	1,106
28	2,605	4,045	6,695	1,957	4,455	2,208	1,488	521	1,659	1,699	1,474	1,296
29	3,050	......	6,021	3,282	2,950	1,454	1,494	1,531	1,666	1,743	1,513	1,261
30	3,950	......	6,274	2,892	2,315	1,569	1,495	1,538	1,614	634	1,518	1,206
31	2,945	......	6,528	......	1,493	......	358	1,687	......	1,578	......	1,714
1911.												
1	653	1,580	1,508	2,816	2,580	4,456	2,160	2,030	1,505	1,597	2,669	2,000
2	935	1,429	1,543	3,161	2,662	3,633	1,111	1,870	1,466	2,582	2,474	2,213
3	1,693	1,372	1,563	2,744	2,280	3,020	1,573	2,012	1,012	2,448	2,464	1,104
4	1,413	1,616	1,574	1,851	2,181	2,327	1,188	2,032	1,552	2,450	2,431	2,256
5	1,333	1,068	819	2,065	2,180	3,362	1,970	1,824	1,725	2,480	1,213	2,173
6	807	1,556	1,458	2,473	2,440	5,241	1,845	1,011	1,576	2,871	2,216	2,165
7	1,484	1,576	1,522	2,511	962	4,771	1,620	1,887	1,577	3,250	2,486	2,208
8	719	1,591	1,557	2,494	2,099	5,207	1,623	2,133	1,699	4,106	2,462	2,247
9	1,336	1,493	1,527	2,593	2,216	5,026	1,104	2,115	1,706	4,255	2,536	2,198
10	1,301	1,457	1,476	2,625	2,164	3,960	2,134	2,084	1,022	4,914	2,463	1,149
11	1,293	1,571	1,567	2,120	2,198	5,870	2,186	2,046	1,726	3,895	2,554	2,073
12	1,116	938	1,796	2,126	2,144	3,972	2,170	2,046	1,640	3,368	1,338	2,122
13	1,130	1,597	2,243	2,840	2,234	3,014	2,109	1,158	1,798	3,143	2,426	2,200
14	1,053	1,506	2,427	4,313	4,259	3,794	2,117	1,958	1,766	3,351	1,905	2,228
15	557	1,357	2,640	4,369	4,616	3,143	2,102	2,095	2,712	4,350	1,894	2,193
16	1,200	1,343	2,168	4,346	3,763	2,960	928	1,992	3,065	4,593	1,710	2,224
17	1,103	1,268	2,394	4,373	3,330	2,702	3,468	2,148	3,214	5,010	1,994	1,063
18	1,112	1,593	2,761	3,887	4,251	1,877	2,097	2,100	2,760	5,184	1,883	2,165
19	1,077	808	2,753	3,574	5,995	2,981	1,734	2,072	4,422	4,901	1,101	2,204
20	1,102	1,440	2,634	3,830	7,249	2,831	1,669	1,000	2,678	5,193	1,730	2,227
21	1,104	1,583	2,508	4,696	6,853	2,725	1,582	1,917	2,264	4,952	1,948	2,245
22	725	1,495	2,962	5,088	7,041	2,227	1,562	1,841	2,311	4,972	2,114	2,302
23	1,297	1,589	3,287	4,780	7,496	2,124	936	1,575	2,351	5,153	2,075	2,162
24	1,231	1,535	3,326	4,818	5,572	2,184	1,555	1,646	1,605	4,654	2,082	1,043
25	1,641	1,512	3,130	4,040	5,490	1,053	1,735	1,558	3,190	5,386	2,102	884
26	1,400	793	3,154	3,285	5,251	1,607	1,838	1,558	3,055	4,879	1,099	1,987
27	1,240	1,508	3,402	4,831	4,854	2,827	2,129	841	2,330	4,571	2,080	2,238
28	1,393	1,504	3,266	4,486	5,749	1,859	2,017	1,526	2,375	3,113	1,985	2,366
29	621		2,812	3,163	5,376	2,122	1,858	1,599	2,245	1,006	2,113	2,432
30	1,361		2,688	2,530	4,459	2,132	989	1,763	2,277	3,089	1,298	2,380
31	1,437		2,753	......	4,801	......	1,739	1,532	......	2,995	......	1,139
1912.												
1	1,470	1,420	1,670	4,790	8,560	8,510	2,260	1,210	1,030	1,830	......	......
2	2,190	1,110	1,720	5,960	6,890	7,500	1,640	1,940	1,410	1,760	......	......
3	2,040	1,660	920	6,090	7,050	7,370	1,550	1,790	1,770	1,600	......	......
4	2,070	1,110	1,820	5,670	10,800	6,880	989	922	2,110	1,780	......	......
5	1,660	1,460	1,120	8,350	18,900	5,400	1,700	866	2,530	1,960	......	......
6	1,650	1,260	1,310	9,670	33,500	4,590	1,580	1,710	2,750	1,530	......	......
7	1,230	1,420	1,370	8,470	28,700	4,100	866	1,700	2,830	1,340	......	......
8	1,510	1,510	1,670	6,590	24,300	1,340	1,910	1,170	1,900	2,360	......	......
9	1,620	1,430	1,700	8,040	19,100	4,170	1,820	1,500	1,980	2,060	......	......
10	1,570	1,580	930	7,420	14,200	4,580	3,830	2,010	2,310	1,740	......	......
11	1,580	1,180	1,680	4,170	11,400	2,700	2,850	928	4,450	1,750	......	......
12	1,320	2,000	1,350	5,140	9,830	2,530	1,380	1,880	2,140	1,960	......	......
13	1,730	1,160	1,220	5,400	8,740	2,570	1,380	2,140	2,280	1,690	......	......
14	1,280	1,280	1,480	5,340	7,230	2,440	822	2,080	2,120	2,020	......	......
15	1,010	1,420	1,750	5,780	9,540	2,230	5,160	2,010	1,300	2,090	......	......
16	1,290	1,460	1,710	5,890	8,330	2,540	2,090	1,760	2,240	2,100	......	......
17	940	1,750	900	8,260	7,920	3,230	1,720	1,640	2,390	2,090	......	......
18	1,280	950	1,650	6,420	4,950	3,940	1,670	1,120	2,120	2,060	......	......
19	1,410	1,860	1,390	7,280	4,040	3,480	1,680	2,170	1,800	2,000	......	......
20	1,620	1,210	1,120	6,430	4,520	2,300	1,560	2,430	1,900	1,840	......	......
21	1,120	1,310	1,930	6,070	4,610	2,270	899	2,510	2,010	1,900	......	......
22	1,440	1,570	1,900	5,480	4,510	2,500	1,940	2,380	1,410	1,720	......	......
23	1,380	1,470	1,970	5,560	4,760	1,550	1,620	2,080	1,910	1,830	......	......
24	1,430	1,830	710	5,240	4,870	2,140	1,690	1,690	1,800	1,750	......	......
25	1,430	970	1,890	5,610	5,220	2,330	1,620	937	1,960	1,840	......	......

Daily discharge, in second-feet, of St. Croix River at St. Croix Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
26	1,420	1,980	1,490	5,990	4,330	2,360	1,770	1,820	1,820	2,080	......	......
27	1,510	1,520	1,860	9,590	5,130	2,620	1,640	1,910	2,000	1,580	......	......
28	1,170	1,490	1,950	11,300	5,510	2,650	823	1,860	1,990	1,700	......	......
29	1,810	1,570	1,910	10,500	5,550	2,450	1,530	1,940	1,300	1,800	......	......
30	1,550	......	1,830	8,910	4,960	1,470	1,900	2,000	2,140	1,760	......	......
31	1,430	......	1,460	......	5,270	......	1,820	1,930	......	1,710	......	......

Monthly discharge of St. Croix River at St. Croix Falls.

[Drainage area, 5,930 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1902.					
January	1,980	1,680	1,880	0.317	0.37
February	2,480	1,700	1,880	.317	.33
March	5,000	2,270	3,310	.558	.64
April	5,560	300	2,220	.374	.42
May	9,600	3,910	2,020	.341	.39
June	11,900	960	5,950	1.00	1.12
July	12,100	750	5,500	.927	1.07
August	6,000	1,020	1,860	.314	.36
September	4,110	510	1,860	.314	.35
October	3,600	800	2,000	.337	.39
November	5,190	2,050	4,080	.688	.77
December	2,560	2,020	2,250	.379	.44
The year	12,100	300	2,900	.489	6.65
1903.					
January	2,060	1,730	1,920	.324	.37
February	2,020	1,700	1,880	.317	.33
March	11,500	1,880	5,560	.938	1.08
April	20,200	6,770	11,900	2.01	2.24
May	16,200	8,920	12,700	2.14	2.47
June	10,400	907	5,180	.873	.97
July	11,600	251	6,190	1.04	1.20
August	7,900	1,600	4,820	8.13	.94
September	(a)	1,060	13,000	2.19	2.44
October	(a)	5,610	13,100	2.21	2.55
November	7,600	850	4,270	.720	.80
December	3,440	2,350	2,750	.464	.53
The year	(a)	251	6,940	1.17	15.92
1904.					
January	3,660	2,200	2,610	.440	.51
February	2,520	2,000	2,240	.378	.41
March	4,510	2,290	2,850	.480	.55
April	18,300	5,560	10,700	1.80	2.01
May	13,400	5,250	8,180	1.38	1.59
June	17,900	1,570	8,870	1.50	1.67
July	6,170	950	3,140	.529	.61
August	5,290	840	2,330	.393	.45
September	5,040	1,940	3,540	.597	.67
October	18,700	1,240	10,600	1.79	2.06
November	8,780	2,250	4,840	.816	.91
December	2,970	1,690	2,440	.411	.47
The year	18,700	840	5,200	.877	11.91

[a] In excess of 20,000 second-feet.

Monthly discharge of St. Croix River at St. Croix Falls—Continued.

Month.	Discharge in second-feet.				Run-off. (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1905.					
January	3,100	1,680	2,500	0.422	0.49
February	2,510	1,950	2,080	.351	.37
March	5,240	2,630	3,410	.575	.66
April	12,200	580	5,630	.949	1.06
May	15,000	3,710	9,330	1.57	1.81
June	14,800	1,610	9,620	1.62	1.81
July			7,850	1.32	1.52
August			3,900	.658	.76
September			5,460	.921	1.03
October			3,840	.648	.75
November			4,330	.730	.81
December			2,980	.503	.58
The year			5,080	.856	11.66
1906.					
January					
February					
March					
April					
May			8,100	1.37	1.58
June			10,700	1.80	2.01
July			4,640	.782	.90
August			3,460	.583	.67
September			4,790	.808	.90
October			4,060	.685	.79
November					
December					
1907.					
January					
February					
March			7,380	1.24	1.43
April			10,800	1.82	2.03
May			7,370	1.24	1.43
June			4,580	.772	.86
July			3,410	.575	.66
August			2,770	.467	.54
September			4,680	.789	.88
October			3,150	.531	.61
November			2,410	.406	.45
December			2,510	.423	.49
1908.					
January			2,650	.447	.52
February			3,030	.511	.55
March			2,820	.476	.55
April			6,630	1.12	1.25
May			11,800	1.99	2.29
June			10,500	1.77	1.98
July			3,500	.590	.68
August			1,790	.302	.35
September					
October			2,210	.373	.43
November			2,660	.449	.50
December			2,620	.442	.51
1909.					
January			3,020	.509	.59
February			2,880	.486	.51
March			3,180	.536	.62
April			4,410	.744	.83
May			8,490	1.43	1.65
June			4,200	.708	.79
July			2,720	.459	.53
August			4,610	.777	.90
September			2,570	.433	.48
October			3,510	.592	.68
November			4,440	.749	.84
December			5,120	.863	.99
The year			4,100	.690	9.41

Monthly discharge of St. Croix River at St. Croix Falls—Continued.

Month.	Discharge in second-feet.				Run-off. (depth in inches on drainage area.)
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	3,950	2,495	3,050	0.514	0.59
February	4,150	2,458	3,080	.519	.54
March	9,871	2,875	5,970	1.01	1.16
April	5,588	1,957	3,930	.663	.74
May	5,457	790	2,760	.465	.54
June	3,174	550	1,870	.315	.35
July	1,838	75	1,360	.229	.26
August	1,700	393	1,340	.226	.26
September	1,821	606	1,420	.239	.27
October	1,951	602	1,520	.256	.30
November	1,727	671	1,340	.226	.25
December	1,953	629	1,290	.218	.25
The year	9,871	75	2,410	.406	5.51
1911.					
January	1,693	557	1,160	.196	.23
February	1 597	793	1,420	.239	.25
March	3,402	819	2,300	.388	.45
April	5,088	1,851	3,430	.578	.64
May	7,249	962	4,020	.678	.78
June	5,870	1,053	3,170	.535	.60
July	3,468	928	1,770	.298	.34
August	2,148	841	1,770	.298	.34
September	4,422	1,012	2,150	.363	.40
October	5,386	1,006	3,830	.646	.74
November	2,669	1,099	2,030	.342	.38
December	2,432	884	1,990	.336	.39
The year	7,249	557	2,420	.408	5.54
1912.					
January	2,190	940	1,490	.251	.29
February	2,000	950	1,450	.245	.26
March	1,970	710	1,540	.260	.30
April	11,300	4,170	6,850	1.16	1.29
May	33,500	4,040	9,780	1.65	1.90
June	8,510	1,470	3,590	.605	.68
July	5,160	822	1,800	.304	.35
August	2,510	866	1,740	.293	34
September	4,450	1,030	2,060	.347	.39
October	2,360	1,340	1,850	.312	.36

NOTE.—The mean monthly discharge from July, 1905 to December, 1909, was estimated from hydrographs furnished by the Minneapolis General Electric Co.

DEVELOPED WATER POWER.

Water power is developed at the following places on St. Croix and Sunrise rivers:

St. Croix Falls.—The Stone and Webster Co. are the owners of a plant at St. Croix Falls which furnishes power to the Minneapolis General Electric Company. A reinforced concrete dam 750 feet long creates a head of 56 feet which is increased to 59 feet by the use of flashboards. The dam backs the water nearly to Nevers dam 10 miles above and the latter, which is used as a storage dam, backs up the water 17 miles further. At the left, or Wisconsin, end of the dam is located the power plant. This contains six units, each consisting of four 36-inch Victor turbines of 1100 horsepower capacity, each, on horizontal shaft. Water is supplied the turbines by a short penstock. Each unit is controlled by a Lombard automatic governor, and is direct connected to a 2500 KW Westinghouse alternating current generator of 2300 volts. Power is transmitted 40 miles to Minneapolis at a tension of 23,000 volts. The plant is operated continuously. Auxiliary steam power is used in Minneapolis. Beside the six units installed there is space for 2 additional units which will be installed when required.

Sunrise.—A flour mill at Sunrise, on Sunrise River utilizes a head of 12 feet in developing an average of 80 horsepower by means of 3 turbines.

From the records of flow of St. Croix River it is seen that the lowest month recorded was 1160 second-feet; the lowest month of an average low year, 2,080 second-feet; and the lowest flow of the six highest months of an ordinary low year, 2960 second-feet, corresponding to available horsepower of 6220, 11150, 15880, respectively at the St. Croix Falls development.

No estimate of available power at the Sunrise development has been made owing to lack of records of flow.

UNDEVELOPED WATER POWER.

A profile of St. Croix River from the mouth to St. Croix Lake was made by the U. S. Engineer Corps. The results of this survey are given in Water Supply Paper, U. S. Geological Survey No. 156, p. 119, from which the following table of elevations and distances has been taken:

Elevations and distances along St. Croix River from mouth to St. Croix Lake.

Point.	Distance in miles.		Elevation in feet above sea level	Ascent in feet between points	
	Above mouth.	Point to point		Total	Per mile
Mississippi River	0.0		667.0		
Kinnikinnic River	5.0	5.0	668.0	1.0	0.2
Apple River	28.0	23.0	672.0	4.0	.2
Osceola	42.0	14.0	683.0	11.0	.8
St. Croix Falls (head of navigation)	48.0	6.0	687.0	4.0	.7
Crest of dam			750.0	63.0	
Trade River	60.0	12.0	753.0	3.0	.2
Sunrise River	65.0	5.0	758.5	5.5	1.1
Rush City ferry	75.0	10.0	773.0	14.5	1.4
Sec. 35, T. 38 N., R. 20 W	79.0	4.0	782.0	9.0	2.2
Snake River	86.0	7.0	790.0	8.0	1.1
Foot of Kettle River Rapids	89.0	3.0	801.0	11.0	3.7
Kettle River	90.0	1.0	816.0	15.0	15.0
Head of Kettle River Rapids	93.0	3.0	850.0	34.0	11.3
Clam River	101.0	8.0	868.0	18.0	2.2
Sec. 1 T. 40 N., R. 18 W	103.5	2.5	874.0	6.0	2.4
Yellow River	115.0	11.5	888.0	14.0	1.2
Namekagon River	127.0	12.0	908.0	20.0	1.7
Moose River	139.0	12.0	1,001.0	93.0	7.7
Sec. 35, T. 44 N., R. 13 W					
Below dam	144.0	5.0	1,001.5	.5	.1
Above dam	144.0	.0	1,005.3	3.8	
St. Croix Lake	160.0	16.0	1,010.0	4.7	.3

From the mouth of the river to the head of navigation near St. Croix Falls (Taylors Falls, Minn.) the river has a very slight fall. With the exception of the fall near St. Croix which has been developed, the river has a moderate slope until Sunrise River is reached. From Sunrise River to the head of Kettle River Rapids the river has a heavy fall, but beyond that point to Namekagon River the slope becomes less.

No topographic map of the river is available and therefore, it is not possible to locate feasible dam sites. The total power only, in each section of the river is shown in the following table:

Undeveloped horsepower on St. Croix River.

Section of River	Distance in miles.	Total fall in feet.	Minimum Runoff.[a]			Horsepower (80% Efficiency)		
			Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Sunrise River to Rush City Ferry	10	14.5	1,010	1,760	2,520	1,330	2,320	3,320
Rush City Ferry to foot of Kettle River Rapids	14	28	836	1,460	2,090	2,130	3,720	5,320
Foot to Head of Kettle River Rapids	4	49	704	1,180	1,760	3,140	5,260	7,840
Namekagon River to Moose River	12	93	225	360	522	1,900	3,040	4,410

[a] Based on the mean drainage area for the section.

SANITARY STATISTICS.

To show the sanitary quality of the water in St. Croix River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on the river. These data are given in the following table, in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on St. Croix River.

Town.	Distance above mouth	Population 1910	Water Works System			Sewerage System		Rural Population per square mile above
			Source of supply.	Filtered	Amount gallons 24 hours.	Outlet.	Treated.	
Mouth Kettle River	90							10.8
Mouth Snake River	86							
Mouth Sunrise River	65							
Taylor's Falls	48	454	none			none		
St. Croix Falls	48	700	wells	no	10,000	none		
Osceola	42	925	no			none		
Mouth Apple River	28							
Stillwater	22	10,198	Lake and springs	no	1,300,000	river	no	
South Stillwater	20	1,343	[a]Perros Creek	no		none		
Mouth Willow River	17							
Hudson	16	3,220	deep wells	no		river	no	

[a] Used only for sprinkling and fire protection.

Above the mouth of Kettle River, the country is very sparsely settled, the rural population being 4.3 per square mile. Kettle River carries the runoff from 1030 square miles of drainage area, but this contains no urban sewage. The rural population of this area is 10.1 per square mile.

Four miles below the Kettle, Snake River enters the St. Croix carrying the drainage from 948 square miles of drainage area, having a rural population of 20.1 per square mile. No urban sewage enters Snake River.

From the mouth of Snake River to Stillwater, a distance of 64 miles no urban sewage enters the river nor is the river water used for municipal purposes. At the latter point untreated sewage from a population of 10,198 enters the St. Croix. Six miles above Stillwater, Apple River enters the St. Croix with the runoff from a drainage area of 427 square miles having a rural population of 11.4 per square mile. The only town having a population in excess of 500 that is located on the Apple or its tributaries is Amery with 659 inhabitants.

Below Stillwater the slope of the St. Croix is very small, being about 0.2 foot per mile. In addition to having a very flat slope the river widens into Lake St. Croix.

Six miles below Stillwater untreated sewage from Hudson, with a population of 3220 enters Lake St. Croix, but the very sluggish current in the lake is an active aid to sedimentation. The effect of this is to reduce greatly the sewage bacteria which reach the Mississippi.

KETTLE RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Kettle River, an important tributary of the St. Croix, drains an area in the eastern part of Minnesota, chiefly in Pine and Carlton counties. It rises in T. 49 N., R. 19 W. in Carlton County and flows southward into St. Croix River in T. 39 N., R. 19 W. Its chief tributaries are Moose, Willow, Moose Horn, Dead Moose, Split Rock, Pine, and Grindstone rivers.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The general surface of the basin is gently undulating, and the elevations range from 850 to 1300 feet above sea level. The basin contains about 35 lakes, chiefly in its central part. The combined area of the lakes comprises less than 1 per cent of the drainage area. The region is covered with red till—a mixture of sand and gravel and clay deposited by a glacier. In the northern part of the basin the drift is underlain by Archean greenstones and gneisses; in the southern part it rests on Cambrian sandstones, shales, and limestones.

Throughout the lower portion of its course, Kettle River has cut through the drift into the sandstones, which yield water to the many springs found along the river.

The entire basin was originally densely forested, although it is now for the most part covered with brush. Much of the present growth consists of poplar and jack pine. Conditions are favorable for reproduction of the forest, as the forest fires which have occurred at various times have not seriously injured the soil. There is very little cleared land.

RAINFALL AND RUNOFF.

The mean annual rainfall ranges from 27 inches in the northern part, to 29 inches in the southern. Of these amounts about 3½ inches occur as snow. In the northern portion of the basin, the nearest long time record is at Sandy Lake Dam. Since 1893 this record has shown the wettest year to be 1905 when the rainfall was 36.2 inches. The driest year was 1910 when the precipitation was 20.0 inches. In the lower portion of the basin for the same period, the wettest year was 1905 when the rainfall was 41.7 inches, and the driest 1910 with a rainfall of 14.0 inches.

Runoff records of Kettle River are continuous since 1909. During this period the runoff varied from 3.81 to 8.14 inches or from 18.8 to 27.2 per cent of the rainfall.

REGULATION OF FLOW.

There is little or no regulation of the flow either artificially or naturally, as there are no reservoirs in the basin, except a small one on Pine Lake used in connection with the power plants at Sandstone. The lakes in the basin are so small and have such a small tributary runoff that their natural regulating effect is slight.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Kettle River basin.

River.	Drainage area above	Square miles.
Kettle	Mouth Moose River	346
Do	Gaging station near Sandstone	825
Do	Mouth	1,030
Moose	Mouth	140
Willow	Mouth	134
Pine	Mouth	110
Grindstone	Mouth	104

GAGING STATION RECORDS.

KETTLE RIVER NEAR SANDSTONE.

Location.—At the quarries of the Barber Asphalt Company at Banning, 3 miles above Sandstone; no tributaries within several miles.

Records available.—October 18, 1908, to December 31, 1912.

Drainage area.—825 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Permanent; bed rock.

Regulation.—The nearest dam is at Sandstone, 3 miles below, but as the fall between the two points is heavy, the station is above its influence.

Winter flow.—The gage is 50 feet above decided rapids which remain open through the winter except for very short periods of extremely cold weather when they may freeze and cause backwater. The river very seldom freezes entirely over at the gage, so it is probable that except for the few days when the rapids freeze the open channel rating-curve applies closely to the winter flow. This curve has therefore been used in computing winter discharge.

Cooperation.—The station was established by the Kettle River Company to determine the power available, as the river has a heavy fall. The gage heights prior to October 1, 1909, have been furnished through the courtesy of the company, but since that date the station has been maintained in cooperation with the United States Geological Survey. The company has also furnished a rating from the station made by current meter, and as the stream flows through solid rock at the measuring section this rating should hold permanently. It has been checked by the Geological Survey.

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

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1											1,000	186
2											930	186
3											565	186
4											675	186
5											216	186
6											216	
7											216	186
8											216	
9											216	173
10											216	
11											201	160
12											186	
13											201	148
14											160	
15											160	
16											160	148
17											160	
18											201	148
19											186	
20											186	
21											186	148
22											186	
23											186	136
24											186	
											186	148

Daily discharge, in second-feet, of Kettle River near Sandstone—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
26	......	......	......	......	......	......	......	......	......	......	186	......
27	......	......	......	......	......	......	......	......	......	......	186	160
28	......	......	......	......	......	......	......	......	......	......	186	......
29	......	......	......	......	......	......	......	......	......	......	186	160
30	......	......	......	......	......	......	......	......	......	......	186	......
31	......	......	......	......	......	......	......	......	......	......	......	......
1909.												
1	......	136	101	288	515	1,000	201	565	288	375	288	......
2	......	......	101	330	592	1,600	173	565	250	352	269	......
3	......	124	101	420	705	1,440	160	540	216	330	269	......
4	136	......	101	540	828	1,410	160	490	186	309	250	......
5	......	124	101	675	930	1,520	160	420	186	309	250	......
6	......	......	112	735	1,840	1,600	148	375	201	309	250	......
7	......	......	112	735	2,660	1,440	136	309	216	288	250	......
8	148	112	112	765	2,410	1,220	136	288	216	250	250	......
9	......	......	112	795	2,500	930	124	250	216	250	250	......
10	......	......	112	735	2,320	795	124	330	201	269	269	......
11	148	......	112	705	2,160	675	112	2,750	201	288	269	......
12	......	......	112	675	1,920	620	112	3,810	186	809	269	......
13	136	......	112	620	1,760	540	112	3,630	201	330	288	......
14	......	......	112	620	1,920	655	112	3,090	216	330	352	......
15	136	112	112	565	2,040	620	101	2,580	186	309	860	......
16	......	......	112	620	2,000	592	90	2,240	186	309	795	......
17	......	......	124	620	1,920	565	90	1,760	186	309	735	......
18	112	......	124	592	1,920	565	80	1,220	186	309	675	......
19	......	112	124	675	1,840	565	70	1,070	216	288	648	......
20	101	......	124	795	1,760	515	112	860	216	288	620	......
21	......	......	124	930	1,440	465	160	765	420	288	592	......
22	124	112	136	860	895	420	465	675	675	288	565	......
23	......	......	136	795	1,370	375	930	592	735	309	565	......
24	......	101	148	735	1,300	375	795	565	675	309	540	......
25	136	......	148	860	1,140	330	735	515	648	309	540	......
26	......	101	160	765	1,110	330	705	490	592	288	520	......
27	136	......	160	735	1,000	288	620	465	515	288	500	......
28	......	101	160	735	965	269	565	420	465	269	490	......
29	136	......	160	765	828	250	540	398	465	250	480	......
30	......	......	173	648	860	250	465	375	398	250	470	......
31	......	......	201	......	828	......	565	330	......	250	......	......
1910.												
1	190	148	186	1,070	375	250	101	52	90	160	112	70
2	190	148	201	965	375	233	101	52	90	186	101	70
3	190	160	216	860	352	216	90	61	90	186	112	70
4	190	160	269	828	330	201	90	70	90	160	112	70
5	190	148	352	860	330	216	80	70	90	148	112	90
6	190	148	375	828	309	233	70	70	101	148	61	90
7	190	148	375	795	288	216	70	61	101	136	112	112
8	190	148	398	735	269	201	80	70	80	136	90	90
9	190	148	420	705	250	186	80	80	80	124	112	80
10	190	160	398	675	233	173	70	70	80	112	52	80
11	190	160	420	620	216	216	90	61	80	112	90	70
12	190	148	442	565	216	269	90	61	80	112	90	70
13	190	148	442	540	216	288	90	101	70	101	112	80
14	190	148	442	515	201	269	70	101	70	101	90	70
15	190	148	515	490	201	216	70	90	70	101	80	70
16	186	148	620	490	186	160	70	80	70	101	101	70
17	186	160	795	515	216	148	70	80	80	112	101	70
18	186	201	860	515	216	148	61	80	80	124	90	80
19	173	250	1,070	565	250	148	61	70	70	136	90	80
20	173	216	1,300	620	288	148	52	70	70	160	80	80
21	160	186	1,370	648	309	148	52	70	70	148	80	70
22	160	173	1,370	620	288	148	52	70	80	136	90	90
23	160	160	1,370	620	269	148	36	70	80	124	112	80
24	160	160	1,410	565	269	160	80	70	70	124	101	70
25	173	160	1,370	515	288	160	80	70	112	124	90	160
26	186	173	1,330	490	288	148	70	70	250	124	112	112
27	186	173	1,300	465	269	136	61	70	250	124	101	80
28	173	173	1,220	442	250	124	61	61	216	112	90	70
29	160	......	1,220	420	250	112	52	61	186	112	112	70
30	160	......	1,140	398	269	101	52	90	160	112	90	112
31	160	......	1,110	......	288	......	52	90	......	112	......	101

Daily discharge, in second-feet, of Kettle River near Sandstone—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1	......	80	70	186	540	515	201	375	136	216	288	136
2	......	70	70	201	515	465	160	465	136	216	288	136
3	......	70	70	216	465	420	160	515	186	233	269	136
4	......	70	70	216	420	675	288	490	288	250	250	136
5	......	70	80	201	375	860	930	515	330	233	233	124
6	......	70	80	201	352	930	1,560	465	375	288	216	124
7	......	70	90	186	288	895	1,440	465	515	420	216	112
8	......	80	112	216	288	795	1,140	442	540	490	216	112
9	......	80	148	186	288	1,040	1,000	420	565	465	233	124
10	......	70	148	233	288	1,070	795	375	620	420	250	124
11	......	80	160	309	288	1,040	620	330	515	398	233	160
12	......	80	201	675	288	860	465	330	465	375	233	173
13	......	70	233	860	269	895	375	250	420	352	233	160
14	......	70	288	1,000	565	795	330	216	420	375	216	160
15	......	70	250	930	785	675	250	201	465	375	216	136
16	......	80	233	795	1,300	565	250	186	515	375	233	148
17	......	80	186	735	1,600	515	216	186	515	420	216	160
18	......	80	186	675	1,760	515	186	173	465	465	216	186
19	......	80	173	860	2,080	465	186	160	420	565	201	......
20	......	90	173	1,370	2,240	375	160	160	375	565	201	......
21	......	80	186	1,220	2,000	309	160	186	330	620	186	......
22	......	70	216	1,070	1,680	269	136	186	288	565	186	......
23	......	70	216	795	1,520	250	136	173	250	565	173	......
24	......	70	288	735	1,300	201	160	160	250	515	160	......
25	......	80	250	705	1,140	186	216	148	250	515	160	......
26	......	70	250	620	930	186	233	136	233	465	160	......
27	......	70	233	648	765	288	201	148	216	442	148	......
28	......	70	216	565	675	288	186	160	233	420	148	......
29	......	......	201	592	648	269	160	173	233	375	148	......
30	......	......	201	515	565	250	186	160	233	330	136	......
31	......	......	186	......	540	......	250	160	......	288	......	......
1912.												
1	......	......	......	490	3,440	1,090	186	136	288	124	112	......
2	......	......	......	515	3,440	1,050	173	124	269	112	112	......
3	......	......	......	705	3,560	1,090	160	124	233	101	112	......
4	......	......	......	1,010	4,390	1,010	160	124	201	90	112	......
5	......	......	......	1,340	5,390	935	201	112	186	112	112	......
6	......	......	......	1,340	5,770	935	216	201	186	112	112	......
7	......	......	......	1,430	5,900	800	201	216	186	124	112	......
8	......	......	70	1,700	4,640	768	216	186	173	112	112	......
9	......	......	70	1,520	4,030	675	233	186	173	101	112	......
10	......	......	70	1,340	3,100	620	216	160	160	90	112	......
11	131	......	52	1,340	2,860	515	201	148	148	101	112	......
12	......	......	70	1,170	2,750	490	186	136	148	160	112	......
13	......	......	70	1,010	2,530	420	201	136	148	148	112	......
14	......	......	80	935	2,420	465	186	124	136	136	112	......
15	......	......	80	935	1,990	515	160	124	136	136	112	......
16	......	......	70	865	1,700	865	148	136	136	124	112	......
17	......	......	70	935	1,430	768	136	136	148	124	101	......
18	......	......	80	1,260	1,340	735	136	148	148	124	90	......
19	......	......	52	1,520	1,340	675	148	160	136	124	90	......
20	......	......	52	1,520	1,170	675	160	148	124	124	80	......
21	......	......	61	1,430	1,340	565	160	136	124	124	70	......
22	......	......	70	1,520	1,890	465	173	124	124	124	61	......
23	......	90	80	1,430	1,700	442	160	124	112	112	52	......
24	......	......	70	1,340	1,610	375	186	112	124	112	52	......
25	......	......	90	1,010	1,520	288	160	112	136	112	44	......
26	......	......	90	2,310	1,430	269	160	124	160	101	37	......
27	......	......	136	3,320	1,430	250	148	112	148	112	24	......
28	......	......	201	3,670	1,340	216	148	186	136	112	24	......
29	......	......	216	2,980	1,170	186	136	201	112	112	18	......
30	......	......	250	2,860	1,170	186	136	216	112	112	12	......
31	......	......	330	......	1,090	......	148	288	......	112	......	......

Daily discharges computed from a well defined rating curve.

Monthly discharge of Kettle River near Sandstone.

[Drainage area, 825 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
November	1,000	160	271	0.328	0.37	
December	186	136	165	.200	.23	
1909.						
January	148	101	132	.160	.18	
February	136	101	114	.138	.14	
March	201	101	127	.154	.18	
April	930	288	678	.822	.92	
May	2,660	515	1,490	1.81	2.09	
June	1,600	250	738	.894	1.00	
July	930	70	292	.354	.41	
August	3,810	250	1,060	1.28	1.48	
September	735	186	325	.394	.44	
October	375	250	297	.360	.42	
November	860	250	446	.541	.60	
December			[a]200	.242	.28	
The year	3,810	70	492	.596	8.14	
1910.						
January	190	160	180	.218	.25	B.
February	250	148	164	.199	.21	A.
March	1,410	186	784	.950	1.10	A.
April	1,070	398	631	.765	.85	A.
May	375	186	269	.326	.38	A.
June	288	101	184	.223	.25	A.
July	101	36	71.1	.086	.10	A.
August	101	52	72.3	.088	.10	A.
September	250	70	104	.126	.14	A.
October	186	101	129	.156	.18	A.
November	112	52	95.9	.116	.13	A.
December	160	70	83.1	.101	.12	A.
The year	1,410	36	231	.278	3.81	
1911.						
January			[b]65	.079	.09	C.
February	90	70	74.6	.090	.09	B.
March	288	70	176	.213	.25	A.
April	1,370	186	591	.716	.80	A.
May	2,240	269	863	1.05	1.21	A.
June	1,070	186	562	.681	.76	A.
July	1,560	136	411	.498	.57	A.
August	515	136	274	.332	.38	A.
September	620	136	359	.435	.49	A.
October	620	216	406	.492	.57	A.
November	288	136	209	.253	.28	A.
December			152	.184	.21	B.
The year	2,240		347	.421	5.70	
1912.						
January			[b]130	.158	.18	C.
February			[b]90	.109	.12	C.
March	330		[b]96.9	.117	.13	B.
April	3,670	490	1,490	1.81	2.02	B.
May	5,900	1,090	2,540	3.08	3.55	A.
June	1,090	186	611	.741	.83	A.
July	233	136	172	.208	.24	A.
August	288	112	152	.184	.21	A.
September	288	112	158	.192	.21	A.
October	160	90	117	.142	.16	B.
November	112	12	84.9	.103	.11	C.

[a] Estimated.

[b] Estimated from a few discharge measurements and climatological records.

DEVELOPED WATER POWER.

Power is developed at two points on Kettle River and at one point on Grindstone River. These developments are as follows:

Sandstone.—The Kettle River Co. has a timber dam at Sandstone which creates a head of 13½ feet. At the right end of the dam is located the power house in which are installed on vertical shafts one 36-inch Ohio turbine of 175 horsepower capacity and one 32-inch Samson Leffel turbine of 125 horsepower capacity. These turbines are belt connected to the machinery used by the stone saws, and air compressors in the nearby quarry. The plant is operated 10 hours per day.

One Mile below Sandstone.—The Kettle River Co. has recently built a plant at this point which furnishes power to Sandstone, and to the quarries owned by the same company. A concrete dam creates a head of 18 feet which is increased to 20 feet by the use of flashboards. This dam backs the water to the foot of the old dam at Sandstone. There is very little storage as flashboards are used continuously to increase the head. There is one hydraulic unit consisting of four 24-inch S. Morgan Smith turbines of 121 horsepower capacity each set horizontally, arranged in 2 pairs and controlled by a Woodward automatic governor. The turbines are direct connected to a 375 KW Fort Wayne 3-phase alternating current generator. Power is transmitted one and one-half miles at a tension of 6,600 volts. The plant is operated 20 hours per day. There is no auxiliary steam power. It is the intention of the company to increase the height of the dam to 30 feet when the demand for power warrants. This will submerge the upper dam.

Near Hinckley.—A water power plant near Hinckley on Grindstone River furnishing light to Hinckley, utilizes a head of 13 feet in developing 30 horsepower by means of a 20-inch Samson Leffel turbine of 34 horsepower capacity.

From the records of flow of Kettle River, the following table has been compiled, showing the available continuous horsepower at the developed sites:

Available horsepower at developed power sites.

Developed Site	Head in feet	Minimum Runoff.			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Kettle River.							
Sandstone	13.5	66	116	330	81	142	405
1 mile below Sandstone	20	66	116	330	120	211	600
Grindstone River.							
Hinckley	13	8	13	38	9	15	45

UNDEVELOPED WATER POWER.

Altho no topographic survey of Kettle River has been made a profile of the river was made from Pine River to the mouth, by the Kettle River Company. From the results of this profile and from approximate elevations above Pine River the following table of elevations and distances has been compiled:

Elevations and distances along Kettle River from mouth to source.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
St. Croix River	0	....	816	....	....
....	1	1	821	5	5.0
Township line 39-40	3	2	846	25	12.5
....	4	1	861	15	15.0
....	5	1	871	10	10.0
....	6	1	889	18	18.0
Range line 19-20	9	3	894	5	1.7
Foot of rapids	18	9	899	5	.5
Township line 41-42	19	1	910	11	11.0
Foot of lower dam Kettle River Co	22	3	913	3	1.0
Crest of lower dam Kettle River Co	22	0	938	25	....
Foot of upper dam Kettle River Co	24	2	938	0	0.0
Crest of upper dam Kettle River Co	24	0	954	16	....
Banning Bridge	26	2	983	29	14.5
Sec. 11, T. 43 N., R. 22 W	29	3	1,000	17	5.7
Kettle River	34	5	1,016	16	3.2
Township line 45-46	46	12	1,050	34	2.8
Sec. 8, T. 46 N., R. 20 W	53	7	1,100	50	7.1
Sec. 9, T. 49 N., R. 20 W	62	9	1,200	100	11.1
Sec. 35, T. 48 N. R. 20 W	67	5	1,250	50	10.0
Source	79	12	1,300	50	4.2

As no topographic survey is available it is not possible to locate the feasible dam sites. The estimates of possible power developments are made for those sections of the river which have the heaviest fall, and sufficient drainage area to insure a considerable discharge.

Undeveloped horsepower on Kettle River.

Section of River	Distance in miles	Total fall, feet	Minimum Runoff.[a]			Horsepower (80% Efficiency)		
			Lowest month	Lowest month average low year	6 Highest months average low year	Lowset month	Lowest month average low year	6 Highest months average low year
St. Croix River to Range line 19-20	9	78	82	144	410	581	1,020	2,910
Foot of Rapids to foot of lower dam Kettle River Co	4	14	68	120	340	86	153	433
Crest of upper dam to Banning Bridge	2	29	66	116	330	174	306	870
Banning Bridge to sec. 11, T. 43 N., R. 22 W.	3	17	65	114	325	100	176	502
Sec. 11, T. 43 N., R. 22 W. to Township line 45-46	17	50[b]	43	75	215	195	341	977

[a] Based on the mean drainage area for the section.
[b] Approximate.

SANITARY STATISTICS.

To show the sanitary quality of the water in Kettle River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more, located on the river or its tributaries. These data are given in the following table:

Municipal water supply and sewage disposal of towns located on Kettle River and tributaries.

Town	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems.		Rural Population per square mile.
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
			Kettle River.					10.1
Mouth Moose River..	44	....	....	....	....	....	....	....
Sandstone...........	24	1,818	artesian well	no	225,000	none	....	....
Mouth Grindstone....	13	....	....	....	....	....	....	....
			Grindstone River.					
Hinckley...........	6	673	wells	no	....	none	....	....
			Moose River.					
Moose Lake.........	10	526	well	no	60,000	none	....	....

From the preceding table it is seen that no urban sewage enters Kettle River as none of the towns on the river or its tributaries have sewerage systems. The rural population of the basin is very sparse being only 10.1 per square mile. Very little of the basin has been cleared, being chiefly second growth timber and brush.

None of the water is used for municipal purposes.

SNAKE RIVER.

SOURCE, COURSE AND TRIBUTARIES

Snake River which drains an area lying southwest of Kettle River Basin, rises in T. 45 N., R. 23 W., in Aitkin County and flows south and east into St. Croix River in T. 39 N., R. 19 W., in Pine County.

In its upper course the river flows through a wide shallow valley, but below Cross Lake the valley becomes deeper and narrower and the stream swifter, although it does not cut through the glacial drift into the underlying rock. In the lower section the river falls 130 feet in some 11 miles. Its chief tributaries are Knife, Ground House, and Little Snake rivers.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The slightly undulating surface is covered with glacial red till, which rests on the Archean granites, gneisses, and schists in the upper part of the basin, and on Cambrian sandstones and limestones in the southeastern part. Rock outcrops at various points along the upper river, notably at the upper and lower falls in the northern part of Kanabec County. The upper falls are two-thirds of a mile below the mouth of Cowans Brook and are caused by granite outcrops on both banks of the river, which here flows between vertical walls for a distance of 10 rods, with a fall of about 3 feet. At the lower falls, which are located a short distance farther downstream, the river descends 20 feet in a distance of three-fourths of a mile. The upper part of the area is so flat that considerable tracts are swampy. The basin contains a dozen lakes, comprising less than 1 per cent of the total area.

The basin was originally densely forested, but is now for the most part covered with brush as it has been extensively cut over. Conditions are favorable for forest reproduction, as the fires which have occurred at various times have not seriously damaged the soil. Less than 25 per cent of the land is cleared.

RAINFALL AND RUNOFF.

The mean annual rainfall varies from 28 inches in the upper part of the basin to 30 inches near the mouth. Of these amounts 3½ inches occur as snow. In the former the wettest year since 1887 was 1902 when the rainfall was 45.9 inches. The driest year was 1910 when the rainfall was 11.7 inches. In the lower part of the basin the wettest year since 1893 was 1905 when the rainfall was 41.7 inches and the driest year, 1910 with 13.86 inches.

Runoff records of Snake River have been maintained since 1909. These show a variation from 2.81 to 3.27 inches or from 10.2 to 20.3 per cent of the rainfall.

REGULATION OF FLOW.

The flow of the upper river is unregulated except for the slight effect that logging dams at Knife Lake outlet and White Pine have. The absence of lakes in the upper portion of the basin deprives the flow of natural regulation. There is some swamp land which exerts a slight regulation. Below Cross Lake the flow is regulated by the dam at the outlet of the lake in the interest of power development. This dam backs the water up Snake River for 15 miles and holds the water in Pokegama Lake which is tributary to Snake River about 4 miles above Cross Lake.

DRAINAGE AREAS.

The following drainage areas have been measured in Snake River basin:

Drainage areas in Snake River basin.

River.	Drainage area above.	Square miles.
Snake	Little Snake River	185
Do	Gaging station near Mora	422
Do	Mouth	948
Little Snake	Mouth	29
Ann	Mouth	83
Ground House	Mouth	138
Mud	Mouth	81

GAGING STATION RECORDS.

SNAKE RIVER AT MORA.

Location.—At the highway bridge three-fourths mile south of Mora, in Sec. 14, T. 39 N., R. 24 W., below the mouth of Ann River.

Records available.—June 11, 1909, to December 31, 1912.

Drainage area.—422 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Permanent prior to 1912 when a shift occurred.

Discharge measurements.—Made from the bridge except during low stages when they are made at a wading section.

Regulation.—The logging dams on the river have not produced marked effect on the gage heights. The only dam below Mora is at Pine City, at the outlet of Cross Lake; backwater from this dam extends to a point several miles below the gaging station.

Winter flow.—From December to March measurements are made through the ice to determine the approximate winter discharge.

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

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							148	140	97	66	71	
2							140	140	86	61	71	
3							97	407	83	61	71	
4							97	326	81	61	71	
5							97	242	71	61	71	
6							97	148	71	61	71	
7							97	140	71	61	71	
8							61	140	71	61	71	
9							51	132	61	61	71	
10							51	140	56	61	71	
11						156	53	500	51	66	71	
12						148	56	1,340	43	66	71	
13						140	53	1,560	61	61	71	
14						125	49	1,620	61	61	97	
15						111	43	1,400	61	61	125	
16						111	43	1,370	61	61	300	
17						125	51	1,150	61	61	300	
18						125	51	990	61	61	250	
19						128	51	675	61	61	225	
20						114	71	442	61	61	200	
21						104	143	311	71	61	150	
22						118	242	268	94	61	150	
23						160	390	242	104	66	125	
24						160	652	217	114	71	125	
25						153	541	148	111	71	125	

Daily discharge, in second-feet, of Snake River at Mora—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
26						140	390	140	97	71	125	
27						156	268	140	97	71	100	
28						206	217	140	83	71	100	
29						190	194	132	83	71	100	
30						174	174	118	77	71	100	
31							140	108		66		
1910.												
1			20	345	96	49	36	40	167	43	42	
2			22	321	91	49	36	37	167	39	40	
3			25	304	86	49	36	36	103	42	40	
4			30	298	83	49	36	36	90	43	37	
5			30	309	78	50	36	36	73	42	36	
6			35	301	73	60	36	33	62	39	37	
7			40	264	71	60	37	36	58	37	47	
8			70	247	71	58	37	36	51	36	40	
9			100	219	67	56	42	36	51	36	43	
10			150	197	58	56	40	36	51	36	53	
11			150	197	51	51	37	36	47	36	71	
12			200	167	49	49	42	36	43	37	51	
13	60		300	150	49	47	36	45	43	36	47	
14			500	155	49	47	36	36	43	36	37	
15			715	138	48	47	36	36	40	36	30	
16			890	125	48	47	36	36	36	36	43	
17			740	148	53	43	37	40	36	36		
18			715	150	56	43	36	37	36	36		
19			715	144	58	43	36	36	36	39		
20			665	176	59	40	36	36	36	43		
21			665	174	66	36	37	36	36	42		
22			620	167	71	36	37	36	36	39		
23			620	167	66	36	36	36	36	40		
24			642	155	60	36	42	36	36	39		
25			665	141	60	36	40	36	36	39		
26			620	125	59	43	36	36	56	39		
27			490	122	55	43	36	35	51	39		
28			490	277	51	43	36	195	51	39		
29			431	116	51	36	42	309	47	39		
30			394	99	51	36	40	315	43	39		
31			377		50		40	237		39		
1911.												
1			23	38	73	66	668	86	53	96	196	
2			23	36	69	66	368	83	52	107	200	
3			25	36	71	71	165	126	58	128	170	
4			25	32	64	104	71	123	72	120	126	
5			25	36	59	256	71	103	96	126	110	
6			25	42	58	503	67	91	71	190	96	
7			25	42	51	580	118	82	69	290	96	
8			25	36	51	496	140	73	71	357	96	
9			30	36	49	217	129	67	73	352	96	
10			40	39	51	73	113	72	83	319	96	
11			50	40	47	374	102	70	88	266		
12	9.5		83	51	53	306	86	64	88	232		
13			71	77	56	346	76	60	73	208		
14			51	126	60	388	64	66	150	196		
15			58	134	71	280	59	55	439	180		
16			86	104	78	232	55	46	1,000	190		
17			73	90	103	221	50	42	638	192		
18			96	78	143	190	44	42	433	210		
19			51	83	239	178	50	42	332	230		
20			56	93	682	159	48	42	258	221		
21			51	152	445	113	44	47	210	217		
22			42	161	377	102	42	58	174	226		
23			60	134	296	95	40	46	145	246		
24			49	116	258	239	46	34	133	256		
25			42	104	223	93	44	30	112	268		
26			43	97	184	83	40	33	103	258		
27			77	90	152	69	37	43	96	246		
28			47	84	128	357	42	43	95	223		
29			43	83	103	118	50	43	93	196		
30			48	83	86	464	45	40	93	180		
31			36		77		56	51		176		

Daily discharge, in second-feet, of Snake River at Mora—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
1					990	320	52	36	110	43	34	
2					815	295	56	36	125	40	36	
3					1,450	320	53	36	118	40	34	
4					2,700	320	60	36	113	40	34	
5					3,100	320	62	36	113	36	36	
6					3,600	245	59	46	77	33	35	
7					3,200	211	60	48	66	34	34	
8					2,800	179	67	49	56	33	34	
9					2,030	160	68	68	54	34	34	
10	31				1,870	151	61	71	47	34	34	
11					1,550	142	55	66	45	33	34	
12					1,230	134	51	67	40	47	34	
13				320	1,080	125	57	67	40	43	34	
14				710	938	125	52	56	40	40	33	
15				920	850	125	50	52	36	40	34	
16				990	780	270	47	47	36	40	36	
17				1,060	675	430	47	52	37	40	32	
18				1,210	610	400	42	52	40	40	33	
19				1,450	550	320	40	48	40	40	33	
20				1,210	520	245	40	47	38	38	33	
21				990	490	200	40	44	36	36	34	
22		38		1,020	520	179	40	42	36	40	33	
23				1,130	610	142	75	40	36	40	33	
24				710	675	125	59	40	35	36		
25				780	610	110	49	40	40	36		
26			30	1,210	520	96	44	40	40	36		
27				1,730	490	83	43	40	38	36		
28				1,650	490	77	39	36	36	36		
29				1,410	430	71	40	40	40	35		
30				1,170	400	60	40	66	45	34		
31					345	....	39	60		34		

Note.—These discharges are based on a well defined rating curve, except March 1 to 14, 1910, and March 1 to 11, 1911, when the discharge is estimated.

Monthly discharge of Snake River at Mora.
[Drainage area, 422 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (11-30)	206	104	142	0.336	0.25	A.
July	652	43	155	.367	.42	A.
August	1,620	108	483	1.14	1.31	A.
September	114	43	75.4	.179	.20	A.
October	71	61	64.1	.152	.18	A.
November		71	131	.310	.33	B.
December			[a]80.0	.190	.22	C.
1910.						
January			[a]60.0	.142	.16	C.
February			[a]35.0	.083	.09	D.
March	890	20	391	.927	1.07	C.
April	345	99	197	.467	.52	A.
May	96	48	62.4	.148	.17	A.
June	60	36	45.8	.109	.12	A.
July	42	36	37.5	.089	.10	A.
August	315	33	65.9	.156	.18	A.
September	167	36	56.6	.134	.15	B.
October	43	36	38.6	.091	.10	B.
November	71		[a]38.8	.092	.10	C.
December			[a]18.0	.043	.05	D.
The year	890		37.2	.207	2.81	

[a] Estimated from a few ice measurements, semi-weekly gage heights and climatological records.

Monthly discharge of Snake River at Mora—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
January	....	....	[a]10	0.024	0.03	C.
February	....	....	[a]15	.036	.04	C.
March	96	23	47.7	.113	.13	B.
April	161	32	78.4	.186	.21	A.
May	682	49	144	.341	.39	A.
June	580	66	228	.540	.60	A.
July	668	37	97.7	.232	.27	A.
August	126	30	61.4	.145	.17	A.
September	1,000	52	182	.431	.48	A.
October	357	96	216	.512	.59	A.
November	200	....	80.7	.191	.21	C.
December	....	....	[a]53	.126	.15	D.
The year	1,000	....	101	.239	3.27	
1912.						
January	....	....	[a]30	.071	.08	C
February	....	....	[a]35	.083	.09	C
March	....	....	[a]40	.095	.11	C
April	1,730	....	756	1.79	2.00	B
May	3,600	345	1,190	2.82	3.25	B
June	430	60	199	.472	.53	A
July	75	39	51.2	.121	.14	B
August	71	36	48.5	.115	.13	B
September	125	35	55.1	.131	.15	A
October	47	33	37.6	.089	.10	B
November	....	....	33.7	.080	.09	B

[a] Estimated from a few ice measurements, semi-weekly gage heights and climatological records.

STORAGE AND POWER.

There are a number of lakes in the Snake River basin, but with the exception of Cross and Pokegama lakes, they have too small a tributary runoff to be of any considerable value for power development. To determine the storage capacity of Cross and Pokegama lakes and the power possibilities of the lower river—the portion having the greatest fall—a survey was made in 1912 extending from the mouth of the river to a point four miles below Grasston. The results of this survey are given on Plates 74 and 75 of the atlas and from these sheets the following table of elevations and distances has been compiled:

Elevations and distances on Snake River from St. Croix River to a point above Lake Pokegama Outlet.

Point.	Distance in miles.		Elevation in feet above sea level.	Distance in feet between points.	
	Above mouth.	Point to point.		Total feet.	Per mile.
Mouth	0	....	802	....	....
....	0.56	0.56	814	12	21
....	1	.44	818	4	9
....	2	1	830	12	12
....	3	1	842	12	12
....	4	1	858	16	16
....	5	1	876	18	18
....	6	1	885	9	9
....	7	1	888	3	3
....	8	1	889	1	1
Sec. line 19-30, R. 20 W.	8.57	.57	890	1	1.8
....	9.0	.43	896	6	14
....	10	1	907	11	11
....	11	1	916	9	9
Chengwantana Dam, tailwater	11.34	.34	923	7	21
Chengwantana Dam, headwater	11.34	.00	932.8	9.8	....
Cross Lake	12.0	.66	932.9	.1	....
Pokegama Lake, outlet	17.37	5.37	932.9	0.0	0
....	24.0	6.63	935	2.1	0.3

CROSS LAKE RESERVOIR.

There is a power dam at the outlet of Cross Lake in Sec. 26. T. 39 N., R. 21 W., which controls the water level on Cross and Pokegama lakes. The normal water surface elevation is about 933 feet above the sea level. It would be possible by increasing the height of the dam at the outlet of Cross Lake to raise the water surface to an elevation of 940 feet, which would overflow about 3,000 acres additional. The following table shows the capacity of the reservoir having a draft of 7 feet:

Capacity of Cross Lake Reservoir.

Contour.	Area Acres.	Capacity of Section Acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
933	2,742	....	....	....
935	3,484	6,226	6,226	271,000,000
936	4,268	3,876	10,102	440,000,000
937	5,068	4,668	14,770	643,000,000
940	6,025	16,638	31,408	1,368,000,000

REGULATION OF FLOW.

To show the regulation of flow possible with a storage capacity of 1.37 billion cubic feet, which would insure a minimum head of 10 feet for power development at the dam, a mass curve was constructed. The basis of the mass curve was the record of flow at Mora showing the runoff per square mile in the Snake River basin.

The drainage area at the outlet of Cross Lake is 906 square miles, on which the flow available for storage in Cross Lake Reservoir was based. To determine the loss due to evaporation from the reservoir surface, the records of evaporation at Grand River Lock, Wisconsin, were utilized. The total evaporation at Grand River Lock, Wisconsin, and University, North Dakota, is practically the same, and as Cross Lake lies between the two points and has conditions somewhat similar, it is probable that the Grand River Lock records represent closely the actual evaporation.

From the mass curve (not given) it is seen that with a total storage capacity of 1.37 billion cubic feet, it would have been possible to secure a uniform flow from Cross Lake of 240 second-feet from July 1, 1909 to January 31, 1910; 115 second-feet from March 1, 1910 to February 28, 1911; 200 second-feet from May 1, 1911 to March 31, 1912; and 160 second-feet from May 1 to December 31, 1912. As the reservoir is not sufficiently large to regulate the flow entirely, the discharge for the intervening periods would have been considerably larger. As the discharge for 1910 was the lowest for many years on account of the very small rainfall, it is very probable that with a storage capacity as described that the continuous flow of 115 second-feet may be considered the lowest to be expected in many years.

WATER POWER.

Between the foot of the dam at Cross Lake and the mouth of the river there is a fall of 121 feet in 11.3 miles. In addition to this is the minimum head of 10 feet at the dam itself. With the flow from Cross Lake regulated, as indicated, there would be available power as follows:

Available horsepower on Snake River.

Site.	Head in feet.	Minimum Regulated Run-off.		Horsepower (80% Efficiency).	
		Lowest year.	Average year.	Lowest year.	Average low year.
Chengwantana Dam	10	115	160	105	145
Foot of dam to mouth	121	120	170	1,320	1,870

POWER PLANT OF PINE CITY ELECTRIC POWER COMPANY.

This company has a plant at Chengwantana Dam at the outlet of Cross Lake. Water is supplied to the power house by means of a canal 2,500 feet long, having a capacity of about 333 second-feet. In the power house are two hydraulic units consisting of two

29-inch improved New American turbines. These turbines are set horizontally in draft tubes. One unit is controlled by a Woodward automatic governor. Each unit is belt-connected to a 200 KW Fort Wayne 3-phase alternating current generator of 2200 volts. The current is transmitted at a tension of 13,000 volts. There is an auxiliary steam plant of 150 horsepower.

SANITARY STATISTICS.

To show the sanitary quality of the water in Snake River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage, have been compiled for all towns of 500 inhabitants, or more, located on the river. These data are given in the following table:

Municipal water supply and sewage disposal of towns on Snake River.

Town.	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems.		Rural Population per square mile.
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
Mora	40	892	well	no	10,000	none	....	....
Pine City	14	1,258	none	....	....	none	....	20.1

From the preceding table it is seen that no urban sewage enters Snake River as neither of the two towns located on the river have a sewage system. The rural population of the basin is 20.1 per square mile. River water is not used for municipal purposes.

CANNON RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Cannon River drains an area comprising 1490 square miles located chiefly in Goodhue, Rice, Le Sueur, and Steele counties. The river rises in Shields Lake, in the western part of Rice County, flows westward into Le Sueur County, then southward and eastward into Rice County again, passing through several lakes (the largest being 4 miles long and one-half to three-fourths mile wide) and finally taking a general northeasterly course to its junction with the Mississippi a short distance above Red Wing.

Cannon Lake, the last lake on the river, is several square miles in area. From Cannon Lake to Dundas the river flows through a narrow valley 40 to 50 feet below the general surface level. Below Dundas the valley widens and gradually deepens, but a few miles above Cannon Falls it again contracts, and it remains narrow and steep sided, until it joins the Mississippi Valley, a few miles above the mouth. Throughout its length the river has considerable fall, much of which has been utilized by power dams.

The principal tributaries of the Cannon are Devil, Wolf, Heath, and Chub creeks from the north, and Straight and Little Cannon rivers, and Belle, Hay, and Wells, creeks from the south. Straight River, the most important of the tributaries, rises in lakes and springs scattered among the moranic hills in the southern part of the area, flows northward over the drift until it reaches a point about 2 miles north of Owatonna, where it first encounters bed rock, and joins the Cannon just below Cannon Lake.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

In general the surface is undulating, but the lower part of the area is deeply cut by the gravel terraced river valleys.

Except in the valleys the area is covered with a red till—a glacial deposit consisting of a mixture of sand, clay, and gravel, which, in the upper part of the basin is underlain by Silurian and Cambrian sandstones. The sandstones yield water to the many springs along the river. In the southern part of the area the red till gives way to a clay-loam soil.

The basin contains few lakes below Cannon Lake. Above that point are 25 lakes, lake surface forming about 10 per cent of the 274 miles of drainage area.

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

RAINFALL.

The mean annual rainfall increases from 28 inches in the upper part of the basin to 30 inches at the mouth. About 4½ inches occur in the form of snow. The nearest rainfall record exceeding 20 years in length is at Farmington. This shows that since 1888 the wettest year was 1906 when the rainfall was 38.3 inches. The driest year was 1910 when the precipitation was 12.4 inches. The longest record in the state, is at St. Paul which is continuous since 1837. In that period the wettest year was 1849 when the rainfall was 49.7 inches. The driest year was 1910 with a rainfall of 10.2 inches.

FLOODS.

As the sides of the main valley are very steep the rainfall quickly reaches the stream and causes sudden rises, giving the stream a flashy character. However, as the valley is so narrow there is very little bottom land and therefore, the damage from floods is not very great. The highest stage of record was a flood in April 1888 which caused a rise of about 15 feet above low water stage at Welch.

REGULATION OF FLOW.

The only reservoir on the river is Cannon Lake. Altho this lake has an area of several square miles, it has no great storage capacity, as the head used at the outlet, would be seriously impaired if the water were drawn down more than a few feet. The most effective regulation comes from the many springs found in the bluffs. This source of supply makes the flow of Cannon River very uniform, except for the sudden rises due to heavy rains.

DRAINAGE AREAS.

The following drainage areas have been measured in the drainage basin:

Drainage areas in Cannon River basin.

River.	Drainage areas above.	Square miles.
Cannon	Cannon Lake Outlet	274
Do	Sec. line 27-34, T. 111 N., R. 20 W.	884
Do	Sec. 14, T. 112 N., R. 19 W.	1,020
Do	Sec. 10, T. 112 N., R. 12 W.	1,230
Do	Gaging station at Welch	1,290
Do	Mouth	1,490
Straight	Crane Creek	279
Do	Mouth	443

GAGING STATION RECORDS.

CANNON RIVER AT WELCH.

Location.—At highway bridge at Welch, just below a very small tributary and 3 miles above the mouth of Belle Creek.

Records available.—June 7, 1909, to December 31, 1912.

Drainage area.—1,290 square miles.

Gage.—Chain, attached to bridge; datum unchanged since established.

Channel.—Permanent.

Discharge measurements.—Made from the bridge.

Regulation.—About 800 feet above the bridge is a dam at which about 40 horsepower is developed. This dam leaks so badly that the operation of the turbine has little effect on the flow.

Winter flow.—Ice is present from December to March and during that period measurements are made to determine the winter discharge.

Maximum flow.—In April of 1888 the highwater reached the eaves of the wheel house at the mill—20.1 feet above the datum of the present gage. It is said that this highwater was not caused by ice gorging.

Accuracy.—The angle which the current makes at the gaging station necessitates a correction, and owing to the daily fluctuation of the river during low stage caused by artificial control, the records of flow cannot be considered better than good.

Daily discharge, in second-feet, of Cannon River at Welch.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	......	......	......	......	......	......	495	245	272	407	606	......
2	......	......	......	......	......	......	453	245	276	383	2,160	......
3	......	......	......	......	......	......	453	308	250	517	2,020	......
4	......	......	......	......	......	......	394	272	512	272	1,570	......
5	......	......	......	......	......	......	308	182	489	403	1,020	......
6	......	......	......	......	......	......	308	182	403	437	701	......
7	......	......	......	......	......	683	278	245	445	371	667	......
8	......	......	......	......	......	658	264	200	480	399	667	......
9	......	......	......	......	......	609	200	200	526	411	639	......
10	......	......	......	......	......	562	250	237	471	517	489	......
11	......	......	......	......	......	539	308	224	437	558	467	......
12	......	......	......	......	......	539	324	725	1,190	620	620	......
13	......	......	......	......	......	585	358	735	1,970	634	1,500	......
14	......	......	......	......	......	609	340	2,470	1,020	634	2,350	......
15	......	......	......	......	......	633	340	3,660	825	554	2,220	......
16	......	......	......	......	......	633	264	3,320	667	512	2,100	......
17	......	......	......	......	......	658	302	1,860	696	467	1,980	......
18	......	......	......	......	......	735	308	869	454	454	2,200	......
19	......	......	......	......	......	658	196	935	463	480	2,210	......
20	......	......	......	......	......	539	189	924	445	363	2,090	......
21	......	......	......	......	......	495	284	995	445	355	1,850	......
22	......	......	......	......	......	495	293	544	667	449	1,520	......
23	......	......	......	......	......	495	278	530	995	445	1,530	......
24	......	......	......	......	......	453	168	453	891	449	1,430	......
25	......	......	......	......	......	453	200	417	775	454	1,250	......
26	......	......	......	......	......	453	149	390	687	403	1,320	......
27	......	......	......	......	......	375	278	375	582	437	1,530	......
28	......	......	......	......	......	375	229	327	403	411	1,550	......
29	......	......	......	......	......	413	394	311	411	407	1,530	......
30	......	......	......	......	......	453	421	324	344	395	1,500	......
31	......	......	......	......	......	......	394	308	......	403	......	......
1910.												
1	......	......	......	836	383	256	223	112	135	157	80	......
2	......	......	......	775	371	226	235	146	148	127	199	......
3	......	......	......	785	241	241	194	106	112	127	109	......
4	......	......	......	750	244	241	152	226	88	139	110	......
5	......	......	......	735	221	480	199	165	109	92	127	......
6	......	......	......	715	215	424	235	93	150	135	82	......
7	......	......	......	535	212	256	185	89	135	135	135	......
8	......	......	......	498	144	263	100	144	164	102	127	......
9	......	......	......	355	126	253	250	223	157	109	135	......
10	......	......	......	387	226	250	109	165	114	164	127	......
11	......	......	......	363	256	180	131	100	88	157	135	......
12	......	......	......	367	296	269	232	107	98	116	123	......
13	......	......	......	498	333	175	137	152	109	112	142	......
14	......	......	......	480	307	263	223	168	139	286	152	......
15	......	......	......	445	221	256	238	129	127	127	129	......
16	......	......	......	325	199	269	170	144	103	89	114	......
17	......	......	......	307	199	250	175	173	103	141	122	......
18	......	......	......	272	226	303	107	177	103	152	152	
19	......	......	......	204	272	282	139	173	116	93	112	
20	......	......	......	199	282	250	98	164	127	83	95	
21	......	......	......	194	489	272	109	103	109	109	95	
22	......	......	......	263	480	263	182	123	89	131	127	
23	......	......	......	263	454	116	116	175	148	170	139	
24	......	......	......	269	355	194	112	110	103	127	135	
25	......	......	......	263	303	152	88	95	88	95	142	
26	......	......	......	293	272	180	213	125	135	135	142	
27	......	......	......	420	253	154	116	135	152	116	93	
28	......	......	......	445	395	253	148	112	157	83	92	
29	......	......	......	535	363	109	250	127	185	120	80	
30	......	......	......	437	395	226	157	175	139	166	100	
31	......	......	......	......	256		150	135		95	......	
1911.												
1	......	......	200	154	94	168	124	314	145	170	1,170	280
2	......	......	281	209	229	115	147	223	235	217	1,220	280
3	......	......	190	85	116	130	102	139	201	442	978	280
4	......	......	190	72	220	499	165	126	113	226	384	280
5	......	......	113	99	107	295	206	147	229	254	175	270

Daily discharge, in second-feet, of Cannon River at Welch—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6			180	147	115	306	192	113	274	908	608	270
7			134	91	170	136	141	203	268	3,900	654	280
8			215	84	91	206	134	248	264	1,970	908	280
9			242	80	128	136	113	195	268	1,520	1,060	300
10			180	90	145	165	107	242	217	1,440	1,020	903
11			168	143	118	134	139	220	161	1,400	903	2,120
12			122	136	145	192	122	242	268	1,220	961	1,880
13			102	170	85	195	113	220	264	1,020	795	1,290
14			178	175	122	147	85	295	264	951	380	1,150
15			185	175	158	152	88	310	268	851	295	1,120
16			154	111	165	170	104	285	254	1,500	254	851
17			101	134	161	248	96	278	152	4,900		563
18			180	209	168	158	105	268	161	4,720		711
19			97	209	145	147	126	254	223	4,350		524
20			101	158	107	195	145	94	254	2,490		482
21			248	209	94	136	120	192	274	2,450		520
22			185	212	91	170	81	268	274	2,120		608
23			91	158	101	220	115	274	274	1,950		599
24			105	104	136	143	75	261	215	1,510		542
25			83	209	175	116	76	281	143	1,300		446
26			71	122	192	147	113	203	257	1,000		418
27			65	107	96	139	122	134	154	1,850		350
28			85	212	101	165	122	192	242	1,630		250
29			115	115	126	152	107	251	242	1,530		200
30			156	165	97	170	115	139	175	1,430		180
31			116		122		91	132		701		150
1912.												
1				2,230	851	306	161	209	182	147	165	
2				1,850	800	271	139	446	223	156	209	
3				1,630	800	306	182	104	209	156	168	
4				1,370	851	271	128	99	223	175	128	
5		318		1,070	851	458	209	170	209	271	170	
6				1,120	701	499	342	195	209	78	170	
7				1,240	542	418	288	195	195	90	170	
8				1,180	499	380	238	104	143	170	165	
9				1,180	458	324	209	94	195	143	182	
10				1,240	499	306	209	170	209	136	143	
11				1,120	654	238	195	158	195	170	195	
12				1,120	520	209	254	182	195	223	195	
13				1,010	418	238	288	195	195	165	209	
14				1,070	209	223	399	223	209	147	170	
15				1,300	324	254	342	223	152	223	209	
16				1,300	324	288	306	223	111	170	195	
17				1,070	399	238	342	195	182	147	126	
18			903	956	361	209	342	152	158	145	122	
19			1,100	851	209	209	288	136	149	149	195	
20		307	1,300	750	438	209	288	182	149	122	195	
21			903	903	851	238	271	128	165	170	209	
22			678	1,850	1,010	154	288	209	111	182	152	
23			631	2,310	903	81	288	209	116	182	143	
24			631	2,000	800	132	288	288	209	143	165	
25			631	1,560	750	209	254	288	139	149	170	
26			726	1,560	701	165	223	165	149	149	195	
27			1,070	1,300	701	132	238	254	141	126	209	
28			1,700	1,180	438	96	238	195	195	170	223	
29			2,000	903	399	122	238	130	109	156	136	
30			2,160	851	361	104	209	88	85	165	195	
31			2,390		324		195	116		170		

Daily discharges for 1909 computed from two fairly well-defined rating curves. Daily discharges for 1910, 1911 and 1912 computed from one fairly well-defined rating curve. Daily discharges for March 1, Nov. 17 to Dec. 9 and Dec. 27 to 31, 1911, estimated because of ice.

Monthly discharge of Cannon River at Welch.

[Drainage area, 1,290 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (7-30)	735	375	546	0.423	0.38	B.
July	495	149	304	.236	.27	B.
August	3,660	182	742	.575	.66	B.
September	1,970	250	616	.478	.53	B.
October	634	272	452	.350	.40	B.
November	2,350	46	1,440	1.12	1.25	D.
1910.						
April	836	194	440	.341	.38	B.
May	489	126	290	.225	.26	B.
June	480	109	244	.189	.21	B.
July	250	88	167	.129	.15	B.
August	226	89	141	.109	.13	B.
September	185	88	124	.096	.11	B.
October	286	83	129	.100	.12	B.
November	199	80	122	.095	.11	B.
1911.						
March	281	65	149	.116	.13	B.
April	212	72	145	.112	.12	B.
May	229	85	133	.103	.12	B.
June	499	115	182	.141	.16	B.
July	206	75	119	.092	.11	B.
August	314	94	218	.169	.19	B.
September	274	113	224	.174	.19	B.
October	4,900	170	1,670	1.29	1.49	A.
November	1,220	175	500	.388	.43	B.
December	2,120	250	606	.470	.54	B.
1912.						
January			[a]275	.213	.25	D
February			[a]310	.240	.26	C
March	2,390		[a]718	.557	.64	C
April	2,310	750	1,300	1.01	1.13	C
May	1,010	209	579	.449	.52	C
June	499	81	243	.188	.21	D
July	399	128	254	.197	.23	C
August	446	88	185	.143	.16	B
September	223	85	170	.132	.15	C
October	271	78	160	.124	.14	B
November	223	122	176	.136	.15	B

[a] Estimated from discharge measurements, observer's records and climatological records.

DEVELOPED WATER POWER.

Cannon River has a larger number of developed water powers than any other stream in the State, altho with one exception the developments are relatively small. There are 9 developed sites on the main river and 2 on Straight River which is tributary to the Cannon River. These developments are as follows:

CANNON RIVER.

Cannon Lake.—The Sheffield King Manufacturing Co. has a dam at the outlet of Cannon Lake which creates a head of 14 feet. In the mill are installed an old 56-inch American turbine, a 48-inch, and a 36-inch turbine of the same make. The combined capacity of the three is about 400 horsepower. There are no governors for the wheels. The 36-inch wheel is direct connected to a 22 KW Bullock direct current generator used to light the mill. The other two turbines are belt connected to the mill machinery. Water is supplied the wheels by means of a flume. The dam backs water on Cannon Lake which has an area of about 4 square miles. The plant is operated continuously. There is an auxiliary steam plant of 1200 horsepower as there is not sufficient water to run the entire mill.

Faribault.—The Faribault Woolen Mill Co. has a dam just above the mouth of Straight River and 3 miles below Cannon Lake, which creates a head of 8 feet. This dam backs the water nearly to Cannon Lake. In the mill are installed a 45-inch Samson Leffel turbine of 92 horsepower capacity and a Leffel turbine of 32 horsepower capacity. These are supplied with water by means of a flume. The turbines are belt connected to the mill machinery which is operated 10 hours per day. There is an auxiliary steam plant, but this is rarely used as the water supply is usually sufficient, except during dry years.

Dundas.—A flour mill at this point has a dam which is in two sections, being divided by an island in the river. This dam creates a 9-foot head which is raised to 10¼ feet by the use of 15-inch flashboards. The water is backed upstream 1½ miles. A short flume supplies water to a 48-inch Trump turbine of 160 horsepower capacity, which is belt connected to the mill machinery. A small electric generator is used to light the mill which runs from 10 to 24 hours per day. There is an auxiliary steam plant but it is not in use as the water supply is sufficient except during a short period during the winter.

Northfield.—The Ames Mill at Northfield has a timber crib dam which creates a head of 9 feet, which is raised to 10 feet with flashboards. This backs the water upstream for a mile or more. A short flume supplies water to two 45-inch American turbines of 85 horsepower capacity each, which are located in the mill at the left end of the dam. One turbine has an automatic governor. The turbines are belt connected to the mill machinery which is operated from 8 to 12 hours per day, usually. There is no auxiliary steam plant, as the water supply is usually sufficient.

Waterford.—The Northfield Light, Heat and Power Co. has leased the Waterford mill which utilizes a head of 7 feet created by a dam. The mill is located at the left end of the dam and contains a 45-inch McCormick turbine of 170 horsepower capacity. A short flume supplies water to the turbine, which is connected to a 120 KW Westinghouse 3-phase alternating current generator of

2200 volts. The current is transmitted 2½ miles to Northfield at the same voltage for use in furnishing light and power. The plant is operated continuously. There is no auxiliary steam plant.

One and one-half miles above Cannon Falls.—The Consumers Power Co. has recently built a reinforced concrete dam of the Ambursen type which creates a head of 56 feet. This is increased to 58½ feet by the use of 30-inch flashboards. The pondage amounts to 1500 acres. With a draft of 5 feet this affords a storage of 7500 acre-feet. Within the dam at one end but not under the spillway, are located 2 Pelton-Frances turbines of 750 horsepower capacity each, set horizontally in scroll cases. They are controlled by Pelton automatic governors. Space is provided for two additional turbines to be installed later. Each turbine is direct connected to a 550 KW General Electric-3 phase alternating current generator of 2300 volts. The current is transmitted at a tension of 57,000 volts to Northfield and Faribault, as this plant is only one unit in an extensive system furnishing light and power to towns in the southern part of the state. It is operated continuously. There is an auxiliary steam plant for this unit.

Cannon Falls.—There are two developed water powers at Cannon Falls. The Cannon Valley Milling Co. has a dam ½ mile above Cannon Falls which creates a head of 15 feet by the aid of 3 foot flashboards. Water is backed upstream less than ½ mile and the pond area is about 150 acres. At one end of the dam is located the Goodhue Mill in which is installed a 45-inch S. Morgan Smith turbine of 200 horsepower capacity. There is no governor for the turbine which is supplied with water by means of a short flume. The turbine is belt connected to the mill machinery which is operated continuously. There is a 4½ KW Crocker-Wheeler direct current generator of 110 volts for lighting the plant. There is no auxiliary steam plant as the water supply is sufficient.

The Cannon Falls Mill Co. has a dam nearly 1 mile below the upper dam which creates a head of 9 feet. No flashboards are used. The pond reaches nearly to the tailwater of the upper dam. At the right end of the dam is located the flour mill in which are installed 3 turbines the details of which are not available. The average power developed at this plant is 225 horsepower. The turbines are belt connected to the mill machinery which is operated 10 hours per day. There is no auxiliary steam plant as the water supply is sufficient.

Welch.—The Welch Mill and Elevator Co. has a timber crib dam at Welch which creates a head of 6 feet. Flashboards are not used. This dam does not back the water upstream further than a few hundred yards. At the left end of the dam is located the mill in which is installed a 44-inch Leffel turbine of 25 horsepower capacity, and a 40-inch American turbine of the same capacity, arranged as a pair; no governor is used. Water is supplied to these turbines by means of a canal 200 feet long. The turbines are belt connected to the mill machinery which is operated about 5 hours, per day. There is no auxiliary steam plant as a water supply is ample at all times.

STRAIGHT RIVER.

Owatonna.—The L. G. Campbell Milling Co. operates a flour mill at this point by water power. A single turbine generates about 35 horsepower under a head of 8 feet.

Clinton Falls.—A flour and feed mill has a dam which creates a head of 10 feet. The mill is operated by a 24-inch McCormick turbine of 33 horsepower capacity.

As explained for the undeveloped powers on Cannon River, the estimates of flow for an ordinary low year can be considered only approximate and no estimate can be made of the flow for the six highest months. The following table has been compiled to show the available continuous power at the developed sites:

Available horsepower at developed power sites.

Developed Site.	Head in feet.	Minimum Run-off		Horsepower (80% Efficiency).	
		Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Cannon Lake	14	45	85	57	108
Faribault	8	50	90	36	65
Dundas	10.2	76	124	70	115
Northfield	9	82	133	67	109
Waterford	7	83	135	53	86
1.5 Miles above Cannon Falls	58.5	103	167	548	888
Cannon Falls:					
Upper dam	15	103	168	140	229
Lower dam	9	112	182	92	149
Welch	6	119	194	65	106

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

To determine the power available on Cannon River a survey was made in 1909 which extended from the mouth to Cannon Lake outlet above Faribault. The results of this survey are given on plates 11 to 13 inclusive of the atlas, and from these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Cannon River from mouth to Cannon Lake.

Stations.	Distance.		Elevation above sea level	Ascent between points.	
	From mouth	Point to point		Total	Per mile
Mouth of river	0.0	....	666	....	....
Spring Creek	4.0	4.0	673.5	7.5	1.9
Section line 19-20	7.4	3.4	680.5	7.0	2.1
Belle Creek	10.8	3.5	690	9.5	2.8
Dam at Welch: foot	13.8	3.0	706	16	5.3
crest	13.8	0	712	6	....
Upper end of pond	14.1	0.3	712	0	0.0
Township line 112-113	16.2	2.1	723	11	5.2
Trout Brook	18.5	2.3	733	10	4.4
Section line 10-11	20.8	2.3	748	15	6.5
Lower dam at Cannon Falls: foot	25.0	4.2	773.5	25.5	6.1
crest	25.0	0	782	8.5	....
Upper dam at Cannon Falls: foot	25.8	0.8	782.5	0.5	0.6
crest	25.8	0	796	13.5	....
Upper end of pond	26.1	0.3	796	0	0.0
[a]Dam above Cannon Falls: foot	27.7	1.6	805	9	5.6
crest	27.7	0	863	58	....
Upper end of pond	33.8	6.1	863	0	0.0
Dam at Wallace: crest	33.8	0	866	3	....
Upper end of pond	34.4	0.6	866	0	0.0
Dam at Waterford: foot	40.2	5.8	881.5	15.5	2.7
crest	40.2	0	888	7.5	....
Dam at Northfield: foot	42.4	2.2	889	1	....
crest	42.4	0	899	10	....
Upper end of pond	43.4	1.0	899	0	0.0
Dam at Dundas: foot	45.5	2.1	908	9	4.3
crest	45.5	0	916	8	....
Upper end of pond	46.0	0.5	916	0	0.0
Section line 3-4	50.7	4.7	932.5	16.5	3.5
Abandoned dam: foot	54.5	3.8	941	8.5	2.2
crest	54.5	0	943	2	....
Dam at Faribault: foot	58.6	4.1	955	12	2.9
crest	58.6	0	964	9	....
Dam at Cannon Lake: foot (Sheffield dam)	60.3	1.7	964.5	0.5	....
crest	60.3	0	977.5	13	....

[a] Not shown on survey sheets.

Above Cannon Lake the drainage area is so small that there are no power possibilities of importance.

On sec. line 27-34, T. 111 N., R. 20 W.—A 26-foot dam at mile 49.2, 4 miles above Dundas would back the water 9 miles upstream to the foot of the dam at Faribault. This dam would have a crest length of 500 feet and would overflow 720 acres of land which is largely under cultivation.

Between this dam site and the upper end of the pond formed by the Dundas dam there is a fall of 10 feet.

In sec. 14, T. 112 N., R. 17 W.—If a 12-foot dam were built at mile 35.5, 4½ miles below Waterford, it would back the water 4 miles upstream, nearly to the dam at Waterford. The crest length of the dam would be 300 feet and as the banks are high there would be very little overflow.

There is less than 10 feet fall between this dam site and the upper end of the pond formed by the high dam above Cannon Falls (not shown on sheets) which extends to the abandoned Wallace dam and partially submerges it.

In sec. 10, T. 112 N., R. 17 W.—A 20-foot dam at mile 21.2, 1½ miles below the mouth of Pine Creek would back the water 3 miles upstream or within a half mile of the lower dam at Cannon Falls. The crest length of the dam would be about 300 feet, and as the banks are high, there would be very little land overflowed. It might be possible to secure an additional 3 feet head as there is that fall between the lower dam and the upper end of the pond formed by this dam.

In sec. 31, T. 113 N., R. 16 W.—The banks of the river are sufficiently high at mile 17.5, 1 mile below the mouth of Trout Brook, to permit of a development of 14 feet. A dam of this height would back the water 2 miles upstream and would have a crest length of about 250 feet. There would be very little land overflowed on account of the high banks.

Below this site the topography is unsuited to important developments, and the slope of the river becomes less.

AVAILABLE HORSEPOWER.

Records of flow of Cannon River have been maintained since 1909. As the years 1910 and 1911 were unusually low, the records show the minimum flow to be expected for many years, but do not indicate as accurately the flow for an ordinary low year. Therefore, the estimates of power for the lowest month in an ordinary low year cannot be considered wholly reliable nor can any estimates be made for the dependable flow during the six highest months of an ordinary low year.

The following table shows the available power at the sites described above:

Undeveloped horsepower on Cannon River.

Site.	Head in feet.	Minimum Run-off.		Horsepower (80% Efficiency).	
		Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Sec. line 27-34, T. 111 N., R. 20 W.	26	81	133	191	314
Sec. 14, T. 112 N., R. 19 W.	12	94	153	102	167
Sec. 10, T. 112 N., R. 17 W.	20	113	184	205	334
Sec. 31, T. 113 N., R. 16 W.	14	119	194	151	247

SANITARY STATISTICS.

To show the sanitary quality of the water in Cannon River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply, and disposal of sewage have been compiled for all towns of 500 inhabitants or more, located on the river. These data are given in the following table, in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on Cannon River.

Town.	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems.		Rural population of basin per square mile
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
			Cannon	**River.**				17.7
Waterville	78	1,273	deep well	no	25,000	none		
Morristown	70	592	none			none		
Faribault	59	9,001	deep well	no	400,000	river	no	
Mouth Straight River.	59							
Northfield	42	3,215	deep well	no	225,000	river	no	
Cannon Falls	25	1,385	deep well	no	12,000	river	no	
			Straigh	**t River.**				
Owatonna	35	5,658	deep well	no	350,000	river	no	

From the preceding table it is seen that Cannon River receives no urban sewage above Faribault, nor is the water used for municipal purposes.

At Faribault, Straight River empties into the Cannon the drainage from an area of 443 square miles having a rural population of about 18 per square mile. Straight River carries the raw sewage from Owatonna and as this this town is only located 35 miles above the mouth, sewage bacteria from this source are brought into the Cannon.

Between Faribault and the mouth of the river, a distance of 59 miles, the Cannon receives untreated sewage from Faribault, Northfield, and Cannon Falls, representing a population of 13,600. The average slope of the river in this section is 4.9 feet per mile. Of the 59 miles of river, about 12 miles is included in mill ponds where sedimentation is an active factor in reducing the sewage bacteria. In spite of this, however, the river has such a heavy fall that it is probable the entire lower portion of the river is contaminated by sewage. The rural population for the entire basin is 17.7 per square mile.

ZUMBRO RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Zumbro River drains an area bounded by the Cannon River basin on the north and the basin of Root River on the south, and located chiefly in Wabasha, Goodhue, Dodge, and Olmstead, counties in southeastern Minnesota. The North Branch of the Zumbro River rises in the southeastern part of Rice County and flows eastward; the South Branch is formed by a number of small tributaries in the southwestern part of Olmstead County and flows northward, receiving throughout its course many tributaries, the largest being the Middle Branch. In the western part of Wabasha County the two streams unite to form the Zumbro, which takes a general easterly course until it reaches the flood plain of the Mississippi, where it empties into one of the sloughs of the region. A cut-off ditch connects it directly with the river. Below the junction of the North and South branches there are no tributaries of importance.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The valleys of the North and South branches are cut 100 to 200 feet below the general level of the country and are bordered by bluffs. The valley of lower Zumbro River becomes deeper, and at the mouth of the river is 400 feet deep, and is bounded by rock cliffs, chiefly sandstone. The general width of the valley is 1 to 2 miles. The streams discharging into Zumbro Valley at the present time deposit on the flood plain more material than the Zumbro itself can carry away, and the valley is being gradually filled up. A great many large springs issue from the bluffs along various streams, and there are many springs and marshes that form the sources of the headwater streams. There are no lakes in the basin.

The region is in general a gently undulating prairie. Its extreme west end is covered with blue till, a glacial deposit consisting of a mixture of sand, clay, and gravel. Throughout the central part of the area the streams have cut through the till into the underlying limestones, sandstones, and shales of Silurian and Cambrian age. The lower section of the basin, especially below the mouth of the South Branch, is in the Driftless Area and is covered with a clay-loam soil. Very little forest remains in the basin of the Zumbro at the present time, as most of the land is under cultivation.

RAINFALL AND RUNOFF.

The mean annual rainfall increases from 28 inches in the upper part of the basin to more than 30 inches at the mouth. Of these amounts 4½ inches occur as snow. The longest rainfall record in the basin is at Wabasha, which is continuous since 1893. In that period the wettest year was 1902 when the rainfall was 39.7 inches. The driest year was 1910 when the rainfall was 13.7 inches.

Runoff records of Zumbro River have been maintained since 1909. These show the runoff to have varied from 3.76 to 4.65 inches or from 13.4 to 29.6 per cent of the rainfall.

FLOODS.

Owing to the very steep sides of the valleys, the rainfall quickly reaches the river causing sudden severe rises. The highest stage recorded occurred in April, 1888, and reached a point 25 feet higher than low water. In June, 1908, a stage 20 feet above low water was reached. These floods caused considerable damage to the towns in the valley, but as the valley itself is very narrow with little bottom land the agricultural losses were comparatively small.

REGULATION OF FLOW.

There are no reservoirs nor lakes in the basin (except one small one formed by the dam at Oronoco) to regulate the flow of the river, and the effect is seen in the sudden rises to which the Zumbro is subject. The many springs which rise in the sandstone strata along the river and tributaries are such an important source of supply that the flow of the river aside from the sudden freshets, is more uniform than that of any river in Minnesota except the Root.

DRAINAGE AREAS.

The following drainage areas have been measured in the drainage basin:

Drainage areas in Zumbro River basin.

River.	Drainage area above.	Square miles.
Zumbro	Zumbro Falls	1,120
Do	Mouth	1,390
South Branch	Rochester	277
Do	Middle Branch	364
Do	Sec. 22, T. 109 N., R. 14 W	810
Do	Mouth	821
Middle Branch	Mouth	432
North Branch	Mouth	286

GAGING STATION RECORDS.

ZUMBRO RIVER AT ZUMBRO FALLS.

Location.—At the highway bridge at Zumbro Falls, about 8 miles below the mouth of South Branch.

Records available.—June 8, 1909, to December 31, 1912.

Drainage area.—1,120 square miles.

Gage.—Chain, attached to bridge; datum unchanged since established.

Channel.—Somewhat Shifting.

Discharge measurements.—Made from the bridge.

Regulation.—The nearest dam is at Jarretts, but on account of the fall in the river the station is above its influence. The effect of the dams above Zumbro Falls is not felt at the gaging station.

Winter flow.—Owing to the presence of rapids a short distance above the station and also of springs, open water is practically continuous throughout the winter, from the rapids for a distance of several miles down stream. For this reason the daily gage readings are maintained during the winter months. A discharge measurement made in February, 1910, gave a result about 15 per cent less than that indicated by the open season curve. However, owing to the manner in which the measurement was made, it is probable that this discrepancy was largely caused by the freezing of the meter. Estimates of flow for the winter months have been made by reducing the open season rating for corresponding gage heights by 5 to 10 per cent.

Maximum flow.—The highwater of June, 1908, is marked by a spike in a telegraph pole near the railroad station at Zumbro Falls. This is at an elevation of 26.7 feet above the datum of the gage. The highwater of April, 1888, reached a stage approximately 29.7 feet, as shown by a mark not so well defined as that of the 1908 flood.

Accuracy.—Conditions at this station are good and therefore the records of flow should be reliable.

Daily discharge, in second-feet, of Zumbro River at Zumbro Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1	......	......	......	......	......	......	465	196	242	271	271	1,100
2	......	......	......	......	......	......	405	196	242	268	765	1,020
3	......	......	......	......	......	......	425	196	242	265	760	1,060
4	......	......	......	......	......	......	425	189	242	253	656	1,190
5	......	......	......	......	......	......	349	189	242	253	539	1,000
6	......	......	......	......	......	......	349	185	233	253	453	652
7	......	......	......	......	......	......	314	179	233	250	405	524
8	......	......	......	......	......	575	297	213	233	242	382	520
9	......	......	......	......	......	530	281	223	233	248	360	520
10	......	......	......	......	......	485	265	242	239	259	331	520
11	......	......	......	......	......	508	265	840	239	304	375	515
12	......	......	......	......	......	530	281	1,460	765	397	710	510
13	......	......	......	......	......	508	265	1,140	970	331	1,270	510
14	......	......	......	......	......	445	281	1,460	715	321	2,400	510
15	......	......	......	......	......	445	262	1,710	715	311	4,000	510
16	......	......	......	......	......	405	250	2,040	584	294	2,500	510
17	......	......	......	......	......	445	248	1,140	566	278	1,770	510
18	......	......	......	......	......	598	248	890	521	265	1,300	500
19	......	......	......	......	......	530	253	775	485	265	1,200	524
20	......	......	......	......	......	508	248	598	386	265	1,120	540
21	......	......	......	......	......	386	239	375	375	265	1,120	567
22	......	......	......	......	......	405	215	375	375	271	1,270	549
23	......	......	......	......	......	1,110	213	425	397	265	1,080	540
24	......	......	......	......	......	740	220	324	413	259	926	504
25	......	......	......	......	......	715	213	304	425	250	895	476
26	......	......	......	......	......	598	201	338	413	253	905	444
27	......	......	......	......	......	642	208	324	375	250	1,490	460
28	......	......	......	......	......	642	201	324	324	239	1,900	456
29	......	......	......	......	......	598	201	328	236	236	1,520	420
30	......	......	......	......	......	575	201	291	177	239	1,240	428
31	......	......	......	......	......	......	196	271	......	236	......	440
1910.												
1	435	331	269	508	297	259	183	150	179	160	171	157
2	430	342	266	485	291	253	183	164	171	160	167	164
3	425	338	296	485	297	242	181	164	164	160	167	169
4	420	318	311	469	278	245	179	150	162	160	167	158
5	415	292	412	425	278	236	173	150	167	160	167	164
6	410	305	981	405	281	242	183	150	173	160	167	158
7	405	311	2,300	405	278	233	179	150	173	160	167	164
8	420	328	2,360	401	268	233	179	150	167	152	167	136
9	412	316	2,140	371	265	231	181	150	162	150	165	158
10	405	304	1,840	367	265	231	173	150	162	150	165	158
11	412	292	1,820	367	259	231	167	153	167	153	164	147
12	374	299	1,770	360	265	228	179	160	153	153	167	147
13	349	286	2,290	353	265	220	175	164	164	153	160	150
14	345	292	2,440	335	265	218	173	164	164	150	171	153
15	342	296	1,920	349	262	215	171	167	164	150	167	153
16	345	283	1,620	335	253	210	171	183	164	150	167	157
17	345	277	1,420	345	324	215	175	236	162	148	171	160
18	342	280	1,270	335	345	215	162	231	155	148	175	157
19	342	277	1,200	338	349	208	165	231	148	160	177	157
20	359	266	1,200	338	345	194	173	210	153	164	171	152
21	359	263	1,200	331	338	203	164	187	150	167	164	157
22	345	263	1,100	331	382	201	164	183	160	167	158	158
23	345	249	992	328	405	192	164	183	160	167	165	158
24	338	252	937	311	397	196	158	179	164	158	169	157
25	311	252	840	317	363	192	150	181	155	157	164	152
26	314	249	775	331	328	192	157	167	164	158	157	150
27	318	239	695	338	314	183	153	167	164	157	158	153
28	326	247	660	331	297	183	158	167	164	165	153	157
29	338	......	611	324	278	183	158	165	167	153	150	158
30	328	......	575	304	268	185	157	167	165	157	190	158
31	328	......	534	......	265	......	153	171	......	164	......	158
1911.												
1	146	144	287	210	187	196	139	116	167	158	520	296
2	149	151	287	208	189	220	129	118	165	147	480	282
3	150	140	278	208	187	208	122	129	156	177	442	256
4	151	144	262	201	187	297	126	124	167	177	424	232
5	154	137	250	201	175	268	124	119	177	236	424	256

Daily discharge, in second-feet, of Zumbro River at Zumbro Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6	156	127	250	201	167	259	126	140	165	2,250	406	256
7	175	144	250	192	165	210	122	171	158	3,190	442	256
8	167	140	250	201	167	208	122	253	158	1,960	520	256
9	163	140	262	192	165	189	122	192	153	1,280	520	256
10	160	142	284	192	160	187	119	198	146	938	480	1,070
11	156	140	294	196	163	187	119	187	139	738	461	3,840
12	156	142	287	223	160	185	119	179	149	624	406	1,990
13	153	162	284	231	149	167	121	220	149	540	340	1,230
14	154	1,340	278	231	156	165	116	1,730	147	560	372	938
15	153	2,360	278	236	205	165	116	1,600	142	560	340	788
16	147	1,460	236	236	179	185	116	951	139	3,440	310	624
17	149	1,730	248	223	165	192	113	657	139	8,340	300	520
18	153	1,380	223	223	167	210	118	535	179	5,290	280	442
19	149	792	223	223	271	192	124	404	153	3,520	260	406
20	153	500	228	215	304	177	119	338	165	2,250	250	406
21	160	480	236	210	338	167	116	300	156	1,610	240	406
22	147	378	226	210	704	160	116	265	151	1,150	260	372
23	147	349	223	198	678	160	116	259	153	990	230	356
24	146	356	223	189	519	160	116	233	149	888	221	325
25	146	363	223	187	397	156	116	210	142	863	296	318
26	147	367	220	185	328	156	116	208	147	1,040	296	277
27	154	331	220	171	291	156	116	192	146	964	310	202
28	149	297	220	177	253	156	126	179	149	811	232	212
29	154	......	215	183	223	153	116	175	147	714	200	240
30	162	......	220	183	215	153	116	171	156	646	244	230
31	147	......	208	......	210	......	114	177	......	560	......	230
1912.												
1	......	232	232	2,320	524	424	282	200	232	186	190	......
2	......	232	232	1,850	482	442	310	210	232	186	188	......
3	......	232	232	1,380	482	442	266	190	232	183	190	......
4	......	232	232	1,160	482	389	372	210	210	172	188	......
5	......	232	244	1,160	566	372	462	210	210	179	188	......
6	......	232	232	1,430	652	340	424	221	210	176	181	......
7	......	232	232	2,180	482	310	340	190	190	170	188	......
8	......	232	232	1,760	462	282	282	442	188	181	183	......
9	......	232	232	1,260	406	282	282	340	188	170	188	......
10	......	232	232	1,050	406	282	244	256	200	179	186	......
11	......	232	232	944	372	282	325	232	186	183	186	......
12	......	232	232	840	356	256	340	232	210	200	190	......
13	......	232	221	790	340	282	406	210	190	232	221	......
14	......	232	256	892	325	325	389	221	200	232	269	......
15	......	232	232	1,700	340	356	340	221	190	232	282	......
16	......	244	244	1,430	340	340	325	200	190	221	244	......
17	......	244	282	1,050	340	325	310	221	190	210	232	......
18	......	256	892	840	325	282	269	200	200	210	221	......
19	......	256	2,590	742	696	256	250	340	210	210	232	......
20	......	256	2,120	652	5,860	269	256	340	200	200	210	......
21	......	256	1,260	696	3,180	244	310	296	210	200	210	......
22	......	256	892	2,120	1,600	232	310	282	190	200	210	......
23	......	256	790	2,060	1,380	232	340	256	190	200	210	......
24	......	269	840	1,260	1,320	244	296	232	190	190	200	......
25	......	269	944	1,050	944	232	269	221	190	190	190	......
26	......	244	840	840	742	232	250	210	186	190	190	......
27	......	232	1,480	742	742	232	250	210	181	200	190	......
28	......	256	3,760	674	630	221	232	210	181	190	200	......
29	......	256	5,200	608	524	210	221	210	176	190	190	......
30	......	......	2,880	566	482	210	200	232	179	190	186	......
31	......	......	2,250	......	442	......	210	232	......	190	......	......

Daily discharges for 1909, 1910 and 1912 computed from a well-defined rating curve. Daily discharges for 1911 computed from two fairly well-defined rating curves.

Monthly discharge of Zumbro River at Zumbro Falls.

[Drainage area, 1,120 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (8-30)	1,110	386	562	0.502	0.43	A.
July	465	196	274	.245	.28	A.
August	2,040	179	572	.511	.59	A.
September	970	177	395	.353	.39	A.
October	397	236	270	.241	.28	A.
November	4,000	271	1,130	1.01	1.13	B.
December	1,190	420	598	.534	.62	B.
1910.						
January	435	311	367	.328	.38	B.
February	342	239	287	.256	.27	B.
March	2,440	266	1,190	1.06	1.22	C.
April	508	304	367	.328	.37	A.
May	405	253	302	.270	.31	A.
June	259	183	216	.193	.22	A.
July	183	150	169	.151	.17	A.
August	236	150	172	.154	.18	A.
September	179	148	163	.146	.16	A.
October	167	148	157	.140	.16	A.
November	177	....	163	.146	.16	A.
December	169	147	156	.139	.16	A.
The year	2,440	....	309	.276	3.76	
1911.						
January	175	146	153	.137	.16	B.
February	2,360	127	512	.457	.48	B.
March	294	208	248	.221	.25	A.
April	236	171	205	.183	.20	A.
May	704	149	252	.225	.26	A.
June	297	153	188	.168	.19	A.
July	139	113	120	.107	.12	A.
August	1,730	116	346	.309	.36	A.
September	177	139	154	.138	.15	A.
October	8,340	147	1,500	1.34	1.54	B.
November	520	200	350	.312	.35	A.
December	3,840	202	573	.512	.59	B.
The year	8,340	113	384	.343	4.65	
1912.						
January	....	....	[a]245	.176	.20	C.
February	269	232	242	.174	.19	B.
March	5,200	221	993	.714	.82	A.
April	2,320	566	1,200	.863	.96	A.
May	5,860	325	846	.609	.70	A.
June	442	210	294	.212	.24	A.
July	462	200	303	.218	.25	A.
August	442	190	241	.173	.20	A.
September	232	176	198	.142	.16	A.
October	232	170	195	.140	.16	A.
November	282	181	204	.147	.16	A.

[a] Estimated.

SOUTH BRANCH ZUMBRO RIVER NEAR ZUMBRO FALLS.

Location —At the Woodville bridge, 1¼ miles above the mouth of the river, in Sec. 22, T. 109 N., R. 14 W., 6 miles below the mouth of the Middle Branch.

Records available.—June 16, 1911, to December 31, 1912.

Drainage area.—820 square miles.

Gage.—Chain, attached to bridge.

Channel. —Apparently permanent. Between the station and the mouth of the river, there is a fall of several feet which prevents backwater from the North Branch reaching the station.

Discharge measurements.—Made from the highway bridge.

Winter flow.—From December to March the river is frozen over; measurements are made to determine the winter discharge.

Accuracy.—Conditions are favorable for accurate results and the records should be good.

Daily discharge, in second-feet, of South Branch of Zumbro River near Zumbro Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1							108	80	108	97	427	174
2							100	72	105	94	418	188
3							85	68	97	124	397	174
4							97	68	105	124	376	164
5							97	68	120	111	356	160
6							80	97	111	814	372	153
7							82	88	108	2,310	389	160
8							80	97	108	1,450	393	164
9							85	97	94	884	397	178
10							80	130	94	598	368	1,020
11							65	130	88	474	331	2,860
12							80	127	94	418	303	1,620
13							88	136	88	331	276	1,020
14							65	1,450	91	315	276	745
15							85	1,290	94	327	276	724
16						130	91	745	94	1,820	233	461
17						143	82	492	88	6,820	233	384
18						150	82	351	105	3,980	229	335
19						133	80	268	88	2,660	200	331
20						127	75	218	105	1,950	181	299
21						120	72	196	105	1,380	178	279
22						111	72	174	105	1,050	188	252
23						117	72	178	100	890	192	233
24						114	75	143	100	761	192	202
25						114	75	143	91	729	181	200
26						100	65	108	94	835	181	174
27						91	70	120	88	798	156	140
28						102	80	111	85	693	114	175
29						117	78	120	85	574	140	165
30						108	78	108	85	514	181	165
31							78	111		461		160
1912.												
1			183	2,040	337	337	180	112	152	103	112	
2			183	1,580	317	337	258	145	135	103	112	
3			183	1,130	337	358	205	112	128	112	112	
4			183	955	337	337	243	135	128	96	112	
5			166	955	462	297	337	118	135	96	103	
6			148	1,190	420	278	297	115	118	112	96	
7			166	1,510	337	262	250	145	118	118	103	
8			183	1,440	297	254	13	169	484	103	96	
9			183	1,130	262	235	87	190	297	112	103	
10			183	790	262	220	69	190	484	112	96	

Daily discharge, in second-feet, of South Branch of Zumbro River near Zumbro Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
11	......	......	166	690	228	224	250	128	297	103	96	......
12	......	......	224	595	213	224	224	152	118	135	112	......
13	......	......	228	550	213	216	239	162	115	180	141	......
14	......	......	220	618	213	250	243	118	128	162	180	......
15	......	......	505	1,320	239	274	216	145	118	145	162	......
16	......	......	550	1,010	224	262	228	135	115	141	162	......
17	......	......	183	790	216	254	220	155	128	145	145	......
18	......	......	900	618	216	235	198	145	122	135	128	......
19	......	......	1,510	505	337	216	187	176	118	118	132	......
20	......	......	1,580	462	7,110	198	176	250	132	118	135	......
21	......	......	900	740	2,700	180	254	213	128	128	118	......
22	......	202	690	1,790	1,380	180	243	187	115	118	118	......
23	......	239	595	1,580	1,250	166	243	169	115	118	128	......
24	......	220	505	845	1,070	166	228	152	128	118	118	......
25	......	239	528	690	740	169	169	135	128	109	112	......
26	140	220	505	550	595	152	187	128	118	112	112	......
27	......	166	1,580	505	550	162	169	122	115	115	112	......
28	......	183	3,850	420	505	169	180	128	118	112	118	......
29	......	183	5,610	378	441	162	162	118	103	118	103	......
30	......	......	2,700	358	399	162	118	152	90	112	115	......
31	......	......	1,960	......	378	......	162	135	......	103	......	......

NOTE.—Daily discharges computed from a rating table well defined below 3,520 second-feet. Above that point the curve is liable to be in error 10 per cent at a discharge of 7,110 second-feet. Later data indicate that the maximum discharge of 6,820 second-feet on Oct. 17, 1911, may be 10 per cent too low.

Monthly discharge of South Branch of Zumbro River near Zumbro Falls.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
June (16-30)	150	91	118.	0.144	0.08	B
July	108	65	80.7	.098	.11	A
August	1,450	68	245.	.298	.34	A
September	120	85	97.4	.119	.13	A
October	6,820	94	1110.	1.35	1.56	B
November	427	114	271.	.330	.37	A
December	2,860	140	434.	.529	.61	B
1912.						
January	....	....	[a]165	.201	.23	C
February	239	....	[a]151	.184	.20	C
March	5,610	148	879	1.07	1.23	A
April	2,040	358	924	1.13	1.26	A
May	7,110	213	729	.888	1.02	A
June	358	152	231	.281	.31	A
July	337	118	214	.261	.30	A
August	250	112	150	.183	.21	A
September	484	90	158	.192	.21	A
October	180	96	120	.146	.17	A
November	180	96	120	.146	.16	A

[a] Estimated from one discharge measurement, climatological data and comparison with flow of Zumbro River at Zumbro Falls.

DEVELOPED WATER POWER.

There are four small power plants on the Zumbro and three on the South Branch. These developments are as follows:

ZUMBRO RIVER (INCLUDING THE NORTH BRANCH).

Zumbrota.—A flour mill has a timber dam at this point which creates a head of 8 feet. The dam backs the water upstream 1 mile. Flashboards are not used on the dam. A flume 30 feet long supplies water to a single turbine the details of which are unknown. About 10 horsepower is required to operate the mill which runs intermittently. There is no auxiliary steam plant as the water supply is sufficient.

Forest Mills.—The Forest Mills Elevator and Feed Mill has a timber dam which creates a head of 11 feet. This dam backs the water upstream 1 mile with an average width of 150 feet. Some distance from the dam is located the mill in which is installed a 36-inch Duplex turbine of 50 horsepower capacity. Water is supplied to the turbine by means of a cast iron pipe which heads in a canal a few feet away. The turbine is belt connected to the machinery of the feed mill which is operated intermittently. There is no auxiliary steam plant as the water supply is sufficient.

Mazeppa.—The Mazeppa Roller Mill at this point has a timber dam of a patent type. The inclined upstream face is of timber, supported by a frame work of timber on the downstream side. The abutments are of masonry. This dam creates a head of 22 feet. It backs the water 2 miles upstream and forms a pond of about 150 acres. At the left end of the dam is located the mill, in which are installed 1 22-inch Special Leffel turbine of 60 horsepower capacity, and one 14-inch Samson Leffel turbine of 24 horsepower capacity. Water is supplied to the turbines by a short iron penstock leading from the pond above the dam. The large turbine is belt connected to the machinery of the roller mill, and to a small electric generator which lights the village. The small turbine is belt connected to the machinery which runs a feed mill. The plant is operated about 15 hours per day. There is an auxiliary steam plant of 50 horsepower altho the water supply is sufficient.

Jarretts.—The Jarrett Roller mill has a loose rock dam 7 feet high which diverts water into a canal several hundred yards long leading to the mill. In this mill is installed a 48-inch Leffel turbine of 60 horsepower capacity under the available head of 11 feet. The turbine is belt connected to the mill machinery which is operated intermittently. There is no auxiliary steam plant as there is sufficient water at all times.

SOUTH BRANCH OF ZUMBRO RIVER.

Rochester.—The Rochester Milling Co. has a flour mill which utilizes an average head of 8 feet. An average of 20 horsepower is developed by one turbine. There is an auxiliary steam plant as the water supply is insufficient.

One mile below Rochester.—The Zumbro Feed mill of the Rochester Milling Co. utilizes a head of about 10 feet. By means of one turbine of 80 horsepower capacity the mill is operated.

MIDDLE BRANCH OF ZUMBRO RIVER.

Oronoco.—Oronoco mills have a timber crib dam which creates a head of about 15 feet. This dam backs the water for a distance of 2 miles with an average width of about 500 feet forming what is locally known as Lake Shady. In the flume are located two 36-inch and one 40-inch Stout Mills Temple turbines developing upon an average of about 150 horsepower. The turbines are geared to the machinery of the feed mill. There is no auxiliary steam power as the flow of the water is generally sufficient to develop the needed power at all times.

From the records of flow of Zumbro River the following table has been compiled to show the available continuous horsepower at the developed sites.

Available horsepower at developed power sites.

Developed Site.	Head in feet	Minimum Run-off.			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Zumbro River.							
Zumbrota	8	21	36	50	15	26	36
Forest Mills	11	22	37	51	22	37	51
Mazeppa	22	28	48	66	56	96	132
Jarretts	7	130	218	303	83	139	193
South Branch.							
Rochester	8	30	55	78	22	40	57
1 mile below Rochester	10	31	56	79	28	51	72
Middle Branch.							
Oronoco	15	50	91	124	68	124	169

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of Zumbro River from the mouth to the junction of the North and South branches, and up the South Branch to sec. 35, T. 108 N., R. 14 W. was made in 1911. The results of this survey are given on plates 95 to 98 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Zumbro River from mouth to sec. 35, T. 108 N., R. 14 W.

Stations.	Distance.		Elevation above sea level	Ascent between points	
	From mouth	Point to point		Total	Per mile
	Zumbro River.				
Griffiths Lake	0	....	662.8	....	....
....	1	1	670.3	7.5	7.5
....	2	1	675.0	4.7	4.7
C. M. & St. P. R. R., bridge near Kellogg	3.2	1.2	677.8	2.8	2.3
Highway bridge near Kellogg	3.7	.5	678.5	.7	1.4
....	5	1.3	681.2	2.7	2.1
....	10	5	691.3	10.1	2.2
....	14	4	701.3	10	2.5
....	15	1	704.0	2.7	2.7
Highway bridge above Dumfries	16.2	1.2	707.0	3	2.5
....	20	3.8	718.2	11.2	2.9
Highway bridge at Theilman	22.8	2.8	725.0	6.8	2.4
....	26	3.2	734.2	9.2	2.9
Highway bridge near Keegan	29.6	3.6	746.1	11.9	3.3
....	33	3.4	755.7	9.6	2.8
Highway bridge at Millville	34	1	761.3	5.6	5.6
Highway bridge at Jarretts	36.4	2.4	772.2	10.9	4.5
Dam at Jarretts, foot	36.9	.5	776.3	4.1	8.2
crest	36.9	0	783.3	7.0	....
....	38	1.1	783.8	.5	.5
Highway bridge at Hammond	39.3	1.3	790.3	6.5	5.
....	41	1.7	794.2	3.9	2.3
....	45	4	812.5	18.3	4.6
Highway bridge at Zumbro Falls	46.9	1.9	820.0	7.5	3.9
....	48	1.1	825.2	5.2	4.7
Mouth of North Branch	53.3	5.3	842.8	17.6	3.3
Highway bridge above Zumbro Falls	54.8	1.5	850.2	7.4	4.9
....	57	2.2	860.9	10.7	4.9
Dam Site (Approx.)	57.8	.8	866.0	5.1	6.4
Section line 27-34	58.2	.4	866.6	.6	1.5
Mouth of Trout Brook	59.7	1.5	873.5	6.9	4.6
Township 109-108, R. 14 W	60.3	.6	875.2	1.7	2.8
Highway bridge	61.9	1.6	882.1	6.9	4.3
Section line 11-14	63.0	1.1	889.4	7.3	6.6
Mouth of Middle Branch	64.2	1.2	898.0	8.6	7.2
Highway bridge	67.2	3	912.6	14.6	4.9
In rapids	68.4	1.2	920.0	7.4	6.2
	North Branch.				
Mouth of North Branch	0	....	842.8	....	....
Highway bridge	1	1	854.2	11.4	11.4
....	2.5	1.5	864.5	10.3	6.9
	Middle Branch.				
Mouth of Middle Branch	0	....	898.0	....	....
Head of rapids	.15	.15	904.3	6.3	42.0
....	1	.85	907.8	3.5	4.1
....	2	1	915.0	7.2	7.2
....	3.5	1.5	920.0	5.	3.3

Zumbro River flows through a narrow valley with steep slopes, and much of the bottom land is covered with timber and brush. If it were not for the Zumbro Branch of the C. M. & St. P. Ry. which runs through the valley it would be possible to erect high dams at a number of places. As the track elevation is the governing feature of any feasible developments it is not possible to develop more than 20 feet at suitable dam sites.

At Zumbro Falls.—An 18-foot dam at Zumbro Falls would form a pond about 6 miles long extending nearly to the junction of the two branches.

In sec. 17, T. 109 N., R. 13 W.—If a 20-foot dam were built at mile 42.3, 3 miles above Hammond, it would form a pond 4.5 miles long extending to Zumbro Falls. Only a small amount of land would be overflowed as the valley is very narrow in this section.

In sec. 28, T. 109 N., R. 13 W.—A 15-foot dam at mile 38.8, one-half mile below Hammond, would form a pond 3.5 miles long, reaching to the dam site in section 17. Practically no land would be overflowed as the banks are sufficiently high to prevent overflow. This dam site is just above the upper end of the Jarretts Mill pond.

In sec. 9, T. 109 N., R. 12 W.—Below Jarretts dam there is a dam site 3 miles below Millville at mile 30.5. Here a 15-foot dam would back the water 4 miles upstream, but would not overflow its banks to any extent.

The track elevation is so low, and the slope of the river so flat in the lower valley that there are no power sites of any considerable importance.

In sec. 27, T. N. 109 N., R. 14 W.—On the South Branch of Zumbro River, in T. 109 N., R. 14 W., it would be possible to erect a 65 foot dam which would back the water upstream 11 miles or more and overflow 1213 acres of land. By using the upper 15 feet for storage (see p. 308) there would be available a minimum head of 50 feet.

AVAILABLE HORSEPOWER.

Records of Zumbro River are available from 1909 to 1912, but as during the greater portion of that period the river was unusually low the estimates of flow for an ordinary low year cannot be considered as accurate as those for the lowest year.

The following table shows the available horsepower at each site described:

Undeveloped horsepower on Zumbro River.

Site.	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Zumbro Falls	18	120	200	275	196	327	450
Sec. 17, T. 109 N., R. 13 W	20	122	205	285	222	373	518
Sec. 28, T. 109 N., R. 13 W	15	122	205	285	166	280	389
Sec. 9, T. 109 N., R. 12 W	15	130	220	305	177	300	416
South Branch, Sec. 27, T. 109 N., R. 14 W	50	150[a]	300[a]	....	682	1,364	....

[a] Regulated flow.

STORAGE.

The valley of the main Zumbro is too narrow to afford reservoir sites of any considerable capacity, so that such sites can only be found on the headwater streams.

The best site in the basin and the only one of any magnitude is located on the South Branch a short distance above its mouth. The dam site is in sec. 27, T. 109 N., R. 14 W. To determine the capacity of this site the Zumbro River survey was extended up the South Branch and sufficient topography taken to show the contours above the highest feasible flowage line. The results of this survey are given on sheet No. 4 of the Zumbro River Survey. From this sheet the following table of capacities has been compiled:

Capacity of South Branch reservoir site.

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity	
			Acre-feet.	Cubic feet.
875	63.4	....	....	....
880	124	468	468	....
890	269	1,965	2,433	....
900	459	3,640	6,073	....
910	682	5,705	11,778	....
915	788	3,675	15,453	673,000,000
920	962	4,375	19,828	864,000,000
925	1,087	5,122	24,950	1,087,000,000
930	1,213	5,750	30,700	1,337,000,000

As the only available records of flow are for the period from 1909 to 1912, only the effect of storage for that period which contains the low years of 1910 and 1911 can be determined at this time.

Records of the South Branch have been maintained only during 1911 and 1912, but the runoff per square mile of the South Branch follows so closely that of the Zumbro Falls records, that the latter have been used as a basis for 1909 and 1910 flow. In determining the available flow from storage, it is necessary to take into account the loss to the stored water from evaporation. For this purpose use has been made of the evaporation records at University, N. D. and at Iowa City, Ia. Although conditions at those two points are dissimilar, the total evaporation is nearly the same, and from this fact it has been assumed that the evaporation at the South Branch reservoir site would be substantially the same.

Conditions at the dam site are feasible for the erection of a dam with a 45 or 65 foot head. A dam with a 45 foot head would have a crest length of approximately 600 feet and flood 682 acres. A dam with a head of 65 feet would have a crest length of 790 feet and flood 1213 acres. Between these two heads the area overflowed increases almost uniformly.

In this study a dam 65 feet high has been considered using the upper 15 feet of the reservoir which has a capacity of 664,000,000 cubic feet for storage. Under the most adverse conditions with a reservoir full, 6 inches of evaporation in one month, and a minimum inflow, the amount lost through evaporation would only be one-eighth of the inflow.

An inspection of the mass curve (plate IX) shows that with a reservoir one-half full on June 1, 1909, that it has been theoretically possible to regulate the flow at the dam as follows:

Possible regulation of flow at South Branch dam site.

Period.	Regulated flow in second-ft.
June 1, 1909, to September 30, 1909	290
October 1, 1909, to January 31, 1910	380
March 1, 1910, to December 31, 1911	150
January 1, 1911, to August 31, 1911	180
October 1, 1911, to February 28, 1912	300

Between October 1 to 31, 1909, February 1 to 28, 1910 and September 1 to 30, 1911, the reservoir would have been full with the water passing over the spillway.

Plate No. IX. shows also a power-percentage of time curve for the lowest period, March 1, 1910 to January 31, 1911, showing that for 72 per cent of the time, the power used would be obtained from stored water.

The conditions in this State during the latter part of 1910 and most of 1911 were so abnormal that it is a fair conclusion that the regulated flow during a normal year would be 1000 horsepower or more.

SANITARY STATISTICS.

To show the sanitary quality of the water in Zumbro River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage, have been compiled for all towns of 400 inhabitants or more, located on the river or its tributaries. These data are given in the following table in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on Zumbro River.

Town.	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems.		Rural Population of basin per square mile
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
			Zumbro River.					24.7
Kenyon	90	1,327	deep well	no	35,000	river	no	....
Zumbrota	69	1,138	deep well	no	25,000	river	no	....
Mazeppa	59	471	deep well	no	1,000	river	no	....
Mouth S. Branch	53	....	....	....	....	....	....	....
Zumbro Falls	47	208	well	no	....	none	....	....
			South Branch Zumbro River.					
Rochester	29	7,844	shallow wells	(natural sand filter)	600,000	river	no	....
Mouth Middle Fork	11	....	....	....	....	....	....	....
			Middle Branch Zumbro River.					
Dodge Center	50	957	deep well	no	....	none	....	....
Kasson	30	932	well	....	45,000	tributary	no	....
Mouth W. Middle Fork	7	....	....	....	....	....	....	....
			North Middle Branch Zumbro River.					
Pine Island	10	834	well	no	81,000	none	....	....

From the preceding table it appears that above the South Branch the river receives untreated sewage from Kenyon, Zumbrota, and Mazeppa, representing a population of 2940. As the river has a heavy fall in this stretch, it is evident that sewage pollution will be found throughout this stretch.

At the mouth of the South Branch is received the drainage from 821 square miles, which carries the untreated sewage from Rochester, and Kasson, representing a population of 8800.

Between the South Branch and the mouth of the river, a distance of 53 miles, no additional urban sewage is received, but as the river has an average fall of 3.4 feet per mile below the South Branch, it is probable that sewage pollution will be found at the mouth of the river.

The rural population of the entire basin is 24.7 per square mile.

ROOT RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Root River which joins the Mississippi about 3 miles below La Crosse, drains an area including the extreme southeastern portion of Minnesota and a very small area, not exceeding a few square miles, in northeastern Iowa. The North Fork, which is the principal branch, rises in the southeastern part of Dodge County and flows in a general easterly course, being joined by the Middle Fork a few miles below Chatfield and by the South Fork near Lanesboro. Rush Creek enters the main stream near Rushford, and Money Creek and South Root River near Houston.

The North Fork flows to its junction with the Middle Fork through a cultivated valley one-half mile in average width and from 50 to 100 feet below the general surface level. Below the Middle Fork, nearly to the mouth of the South Fork near Lanesboro, the valley is narrow and gorgelike, being cut 200 feet or more below the general level. The little bottom land there is in this section is under cultivation. Below the junction with the South Fork the Root flows through a narrow, steep-sided valley, in average width a quarter of a mile, until it reaches Peterson, below which, for the remainder of the course of the stream, the valley spreads out to an average width of three-quarters of a mile, and the bordering bluffs rise 300 to 500 feet above the bottom land. Nearly all the bottom land is under cultivation.

The fall of the North Fork is heavy from the head of the stream to its junction with the South Fork, below which the slope gradually decreases until it practically disappears a short distance above the mouth. The immediate banks of the river are 5 to 15 feet high.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The region drained is an undulating plateau whose uplands range in altitude from 1,100 to 1,300 feet above sea level. In the upper portion of the basin the Root and its fanlike tributaries flow over glacial drift, but farther down they occupy rock-cut valleys which become deeper as the streams are descended.

The upper portion of the drainage basin is covered with a drift sheet of till, a mixture of sand, clay, and gravel, but the greater portion of the basin lies in the "Driftless Area" and is covered with a soil of clay loam or "loess-loam." Upon cutting through the drift sheet the rivers flow through the limestones of the Silurian system, and the sandstones and limestones of the Cambrian system. The sandstones are all strong water bearing bodies and to them are due the many springs which are found along the bluffs.

By far the greater part of the area drained by the Root is under cultivation, the forested areas being chiefly on the sides of the bluffs.

RAINFALL AND RUNOFF.

The mean annual rainfall is about 32 inches, the highest for any basin in Minnesota. Of this amount 5 inches occur as snow. The longest record for the basin is at Grand Meadow. Since 1886 the wettest year was 1909 when the rainfall was 45.4 inches. The driest year was 1910 with a precipitation of 16.9 inches.

Runoff records of Root River have been maintained since 1909. These show the runoff to vary from 4.10 to 5.34 inches or from 12.8 to 27.7 per cent of the rainfall.

FLOODS.

Owing to the very steep sides of the valleys, the rainfall quickly reaches the river. The result of this rapid runoff is that the bottom lands are inundated to such an extent that a considerable portion of them is not under cultivation. One of the severest floods occurred in June 1908, although no data are available to show the height of the water at that time.

REGULATION OF FLOW.

The absence of lakes and reservoirs is shown in the sudden rises to which Root River is subject. The many springs which rise in the sandstone strata in the bluffs are such an important source of supply that aside from the sudden rises, Root River has the most uniform flow of any stream in the State. The importance of the underground sources was especially noticeable during the extremely dry year of 1910 when the flow diminished proportionately less than that of any other river.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Root River basin.

River.	Drainage area above.	Square miles.
North Fork Root	Sec. 8, T. 104 N., R. 11 W	290
Do	Middle Fork	300
Do	Gaging station near Lanesboro	647
Middle Fork	Mouth	212
South Fork	Mouth	268
Root	Gaging station near Houston (above South Root River)	1,560
Do	Mouth	1,660
Rush Creek	Mouth	111
Money Creek	Mouth	83

GAGING STATION RECORDS.

ROOT RIVER NEAR HOUSTON.

Location.—At highway bridge 1 mile east of Houston, in Sec. 34, T. 104 N., R. 6 W., and 1 mile above the mouth of South Root River, ordinarily an insufficient stream but during heavy rains overflowing its banks badly, and flooding a considerable area.

Records available.—May 28, 1909, to December 31, 1912.

Drainage area.—1,560 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Shifting, scouring out during floods and gradually filling in afterward; nearly permanent at low stages.

Discharge measurements.—Made from the bridge.

Winter flow.—From December to March discharge measurements are made through the ice to determine the approximate winter flow.

Regulation.—There is no dam below the station and the nearest dam above is at Rushford. As the flow is ample at all times for the power generated at that point it is not held back during certain portions of the day and thus the dam has no influence on the gage heights at Houston.

Accuracy.—The shifting channel renders it necessary to make more frequent measurements than at other stations and the results based on them can probably not be considered better than fair or, possibly good except for low stages, when the channel changes but little.

Daily discharge, in second-feet, of Root River near Houston.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1						575	730	371	440	440	554	
2						575	615	385	432	440	583	
3						557	547	365	470	435	575	
4						682	505	375	465	450	583	
5						755	490	365	442	430	651	
6						970	475	365	439	425	591	
7						849	475	365	430	425	540	
8						730	451	355	425	425	526	
9						682	460	365	425	425	505	
10						660	547	365	455	440	487	
11						651	475	1,780	425	440	615	
12						615	460	1,410	550	450	637	
13						583	440	1,260	505	450	850	
14						568	420	5,600	655	440	1,930	
15						540	420	2,500	840	440	3,800	
16						533	420	1,900	780	435	4,050	
17						557	400	1,290	760	457	1,930	
18						547	400	1,050	710	435	1,410	
19						523	395	1,000	625	432	1,150	
20						490	385	930	600	435	1,040	
21						490	385	715	475	443	1,000	
22						490	395	650	530	440	1,070	
23						475	385	614	505	420	1,200	
24						505	379	600	500	432	1,020	
25						547	375	605	480	432	920	
26						512	375	565	465	432	880	
27						765	379	534	465	425	1,650	
28					615	745	385	512	458	425	1,840	
29					615	705	379	482	458	420	1,150	
30					607	942	379	465	450	425	1,000	
31					583		375	460		430		
1910.												
1			430	686	458	448	338	315	462	350	345	
2			430	659	458	448	342	300	405	340	348	
3			450	641	452	427	335	305	375	355	355	
4			460	641	448	427	330	290	360	337	340	
5			500	740	448	420	335	290	1,270	348	340	
6			1,000	641	438	424	320	290	1,500	337	348	
7			2,500	605	434	417	330	285	731	348	335	
8			2,500	573	434	405	325	305	573	330	348	
9			2,000	573	434	402	325	305	490	322	340	
10		464	1,800	557	417	402	320	305	441	335	340	
11			1,600	557	414	405	335	298	414	332	340	
12			1,380	533	414	393	322	305	408	330	340	
13			1,560	529	414	393	322	340	387	330	332	
14			1,900	525	414	390	325	390	384	330	348	
15			1,790	525	402	387	330	366	375	330	355	
16			1,450	529	417	384	322	355	355	330	348	
17			1,180	525	504	384	350	375	340	340	340	
18			1,080	549	472	375	338	441	358	340	335	
19			1,020	525	486	366	320	396	355	332	340	
20			1,020	518	483	360	315	375	350	340	340	
21			1,000	518	545	360	310	350	348	350	355	
22			985	508	1,270	372	325	360	340	345	348	
23			945	497	686	360	310	335	348	348	330	
24			879	490	623	358	322	335	366	350	355	
25			853	508	585	363	310	335	387	348	348	
26			789	508	557	360	320	335	378	340	348	
27			760	494	525	363	305	335	402	335	350	
28			734	486	508	375	305	315	363	348	348	
29			703	486	483	348	308	305	360	340	335	
30			730	476	483	348	300	355	355	335	315	
31			700		462		295	525		332		

Daily discharge, in second-feet, of Root River near Houston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1			550	347	407	430	314	314	492	479	666	
2			570	320	447	418	309	307	479	425	651	
3			550	347	389	418	287	287	461	690	621	
4			458	332	365	496	289	314	453	1,040	601	
5			422	377	362	472	323	327	445	957	590	
6			422	368	350	469	298	380	456	1,360	604	
7			422	350	347	435	287	585	443	2,900	618	
8			390	347	342	405	287	772	440	3,110	648	
9			405	335	342	402	289	485	430	1,560	663	
10			405	350	337	385	289	446	425	1,130	666	
11			422	338	335	375	275	430	415	937	648	
12			405	347	313	368	277	418	410	824	618	
13			390	368	310	368	277	2,240	403	756	497	
14	310		390	377	328	368	271	6,120	386	724		
15		4,000	345	389	365	344	291	5,740	380	705		
16		3,090	345	377	333	356	287	2,900	370	1,160		
17		2,680	345	368	328	380	267	1,660	370	3,330		
18		1,570	345	370	318	368	277	1,260	1,190	5,320		
19		1,500	330	383	312	356	285	1,050	828	3,140		
20		1,010	360	374	347	351	287	902	587	1,960		
21		750	360	377	389	344	287	820	530	1,540		
22		685	345	365	1,200	327	271	903	482	1,280		
23		685	330	353	809	318	285	860	453	1,100		
24		700	330	362	717	330	277	724	440	973		
25		648	330	362	612	320	285	666	425	929		
26		612	330	335	537	320	277	627	413	860		
27		620	375	335	509	311	279	587	391	846		
28		530	360	345	477	320	283	553	393	796		
29			360	342	451	309	289	547	405	763		
30			360	335	415	309	296	506	413	724		
31			340		408		271	506		696		
1912.												
1				5,960	632	739	430	456	430	405	405	
2				4,270	598	1,280	509	430	405	405	405	
3				2,660	598	930	537	430	405	380	405	
4				2,050	667	813	509	430	405	380	405	
5				1,980	776	739	456	405	405	380	405	
6				2,050	632	667	430	456	456	380	405	
7				2,500	598	632	456	930	405	380	405	
8				2,420	566	598	405	509	405	380	405	
9				1,660	537	566	509	456	380	380	405	
10				1,330	537	537	4,870	456	456	380	380	
11				1,180	537	537	2,840	482	430	380	405	
12				1,050	509	537	1,180	430	405	509	405	
13				1,010	509	537	1,010	430	380	537	456	
14				1,140	509	537	970	430	405	509	430	
15				1,140	509	537	813	405	430	482	456	
16				1,440	482	537	703	405	405	456	456	
17				1,140	482	509	632	430	405	430	430	
18				970	456	482	598	430	430	430	405	
19				890	482	482	566	456	456	405	405	
20				813	4,510	456	776	456	456	430	405	
21				776	1,330	456	851	482	430	430	405	
22				776	851	456	703	456	430	430	430	
23				1,380	2,420	456	813	430	405	405	405	
24				1,380	4,630	430	667	430	405	405	405	
25				1,010	2,120	430	566	430	405	405	405	
26			776	851	1,330	405	537	405	405	405	405	
27			776	776	1,100	405	509	405	405	405	405	
28			4,040	739	970	405	509	380	405	405	356	
29			6,590	703	1,050	405	482	380	380	405	380	
30			7,090	667	813	456	456	456	380	405	380	
31			5,960		739		456	430		405		

Daily discharges for 1909, 1910 and 1912 computed from a well defined rating curve. Daily discharges for 1911 computed from two fairly well-defined rating curves, one of which was applied indirectly prior to May 22.

Monthly discharge of Root River near Houston.

[Drainage area, 1,560 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June	970	475	627	0.402	0.45	A
July	730	375	442	.283	.33	B
August	5,600	355	933	.598	.69	B
September	840	425	522	.335	.37	B
October	457	420	435	.279	.32	B
November	4,050	487	1,160	.744	.83	C
December			[a]600	.385	.44	C
1910.						
January			[a]500	.321	.37	B
February			[a]450	.288	.30	B
March	2,500	430	1,130	.724	.83	C
April	740	476	553	.354	.40	B
May	1,270	402	502	.322	.37	A
June	448	348	389	.249	.28	A
July	350	295	322	.206	.24	A
August	525	285	339	.217	.25	A
September	1,500	340	466	.299	.33	A
October	355	322	339	.217	.25	A
November	355	315	343	.220	.25	A
December			[a]310	.199	.23	B
The year	2,500		470	.301	4.10	
1911.						
January			[a]310	.199	.23	C
February	4,000	300	841	.539	.56	C
March	570	330	390	.250	.29	B
April	389	320	356	.228	.25	B
May	1,200	310	436	.279	.32	B
June	496	309	372	.238	.27	B
July	323	267	286	.183	.21	B
August	6,120	287	1,100	.706	.81	B
September	1,190	370	474	.304	.34	A
October	5,320	425	1,390	.891	1.03	B
November	666	450	535	.343	.38	C
December			[a]875	.561	.65	C
The year	6,120		614	.394	5.34	
1912.						
January			[b]485	.311	.36	
February			[b]400	.256	.28	
March	7,090		[b]1,250	.801	.92	
April	5,960	667	1,560	1.00	1.12	A
May	4,630	456	1,050	.673	.78	A
June	1,280	405	565	.362	.40	A
July	4,870	405	831	.533	.61	A
August	930	380	451	.289	.33	A
September	456	380	413	.265	.30	A
October	537	380	417	.267	.31	A
November	456	356	408	.262	.29	A

[a] Estimated from one discharge measurement and gage heights to water surface.

[b] Estimated from climatological records and open water relation between the flow at Lanesboro and Houston.

NORTH FORK OF ROOT RIVER NEAR LANESBORO.

Location.—At the first highway bridge 1 mile above the junction of the North and South Forks, in Sec. 6, T. 103 N., R. 9 W., in Fillmore County; 2 miles north of Lanesboro, and about 5 miles below a small creek that enters from the west.

Records available.—January 30, 1910, to December 31, 1912.

Drainage area.—647 square miles.

Gage.—Chain; datum unchanged since established.

Channel.—Permanent prior to 1912, when a shift developed. As there is more than 10 feet fall between the station and the mouth of the South Fork, there is no danger of backwater from that stream. One thousand feet back from the right bank there is an old channel through which the river formerly flowed. At a stage of 6 feet the flow commences through this old channel. At extreme flood stage the right bank is overflowed for a width of one-fourth mile.

Discharge measurements.—Made from the bridge. At extreme flood stages measurements can be made from the railroad bridge just above the junction with the South Fork.

Winter flow.—From December to March the river is frozen over; measurements are made to determine the winter discharge.

Accuracy.—Conditions at this station are favorable for accurate results and therefore the estimates should be reliable.

Daily discharge, in second-feet, of North Fork of Root River near Lanesboro.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1				924	167	196	134	128	199	189	160	
2				924	167	185	134	134	189	181	160	
3				850	203	185	141	134	171	167	164	
4				850	203	196	137	141	171	154	164	
5				779	167	185	137	141	1,040	147	160	
6				711	185	174	137	141	476	141	164	
7				711	203	174	141	150	306	137	154	
8				647	167	171	134	160	276	134	154	
9			2,040	587	203	181	134	171	234	134	164	
10			1,940	587	203	185	134	185	181	131	164	
11			1,940	587	203	174	134	185	171	131	160	
12			1,080	647	167	171	141	167	167	122	154	
13			1,940	647	167	167	137	167	171	122	171	
14			1,940	647	185	160	134	203	181	128	171	
15			1,830	647	167	154	134	181	185	131	171	
16			1,620	647	203	150	137	189	181	128	164	
17			1,680	587	242	141	141	199	181	128	164	
18			1,080	587	242	141	137	203	171	141	167	
19			1,000	587	242	134	134	211	171	141	171	
20			924	530	242	141	141	203	181	141	174	
21			924	530	242	137	141	196	185	141	181	
22			924	530	284	150	141	196	189	150	196	
23			425	587	284	150	141	203	181	154	196	
24			425	530	250	150	134	189	174	154	174	
25			376	425	263	150	134	185	181	160	174	
26			376	425	242	150	134	174	185	160	167	
27			425	376	234	150	128	167	189	150	167	
28			425	376	222	147	122	167	196	150	160	
29			476	329	219	137	119	196	189	160	160	
30			476	284	203	134	119	207	189	150	160	
31			425		199		119	203		160		

Daily discharge, in second-feet, of North Fork of Root River near Lanesboro—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1			203	110	116	128	66	119	147	167	329	238
2			195	110	141	141	66	77	147	219	302	235
3			185	104	134	160	66	88	147	617	284	210
4			175	99	119	211	66	119	147	814	263	185
5			170	99	128	242	77	110	160	745	263	175
6			165	99	128	203	72	119	160	2,840	280	196
7			162	110	119	160	66	503	154	3,890	338	203
8			159	99	119	167	75	199	164	1,670	376	196
9			156	99	110	141	63	196	150	887	376	210
10			153	174	110	141	63	147	134	617	376	2,350
11			150	185	104	128	90	134	128	519	367	3,160
12			147	185	99	110	54	122	128	425	329	1,430
13			144	160	99	110	63	9,380	128	400	171	711
14			141	160	110	99	38	8,660	128	376	203	450
15			138	160	99	99	68	2,240	134	376	284	385
16			135	141	82	110	68	962	119	1,250	276	348
17			132	141	99	141	54	718	119	4,320	352	210
18			129	141	99	119	59	456	814	2,990	284	306
19		456	126	141	82	131	68	367	334	1,480	263	263
20		425	123	128	99	128	59	320	211	1,020	276	284
21		396	120	128	834	99	56	284	203	772	203	250
22		371	117	128	679	80	54	3,430	185	635	210	222
23		338	114	119	503	77	56	293	174	530	284	222
24		311	111	110	329	90	59	242	189	476	210	222
25		302	108	90	222	82	59	222	171	476	235	234
26		284	105	90	211	99	54	211	141	425	235	250
27		267	102	110	185	77	56	185	131	415	210	240
28		259	99	110	167	75	66	211	134	405	210	220
29			96	110	160	82	59	174	196	376	222	210
30			93	119	141	72	54	174	167	348	235	200
31			90		128		59	147		329		200
1912												
1				3,400	284	386	196	157	164	144	141	
2				2,040	250	541	226	144	150	150	141	
3				1,250	329	461	222	157	131	150	141	
4				1,080	306	386	246	164	144	141	141	
5				1,160	284	362	211	178	263	137	141	
6				1,340	284	306	215	192	185	141	131	
7				1,830	250	263	230	192	157	141	131	
8				1,430	238	222	192	185	157	141	125	
9				850	222	215	199	164	141	131	131	
10				617	222	211	1,310	157	141	131	131	
11				587	222	192	514	157	125	141	131	
12				558	211	192	487	157	125	185	154	
13				530	211	211	410	144	164	316	185	
14				558	199	230	435	125	171	230	171	
15				1,040	203	207	362	125	174	192	174	
16		154		850	199	192	293	150	150	178	174	
17				558	196	192	230	157	164	164	174	
18				476	196	185	246	185	199	164	189	
19				400	203	185	199	207	246	174	199	
20				376	2,040	185	230	222	222	174	250	
21				376	352	185	367	238	171	189	222	
22				779	329	185	280	250	174	196	199	
23				1,620	5,090	185	280	222	144	157	174	
24	160			779	2,520	164	230	160	125	141	164	
25				530	970	164	192	131	150	141	160	
26			376	425	629	157	222	125	141	141	160	
27			587	400	514	157	164	125	144	141	154	
28			2,480	352	487	157	164	125	150	141	141	
29			7,640	329	461	157	192	131	150	141	141	
30			5,200	329	362	157	192	185	131	141	125	
31			4,140		316		157	174		141		

Daily discharge computed from a rating table well defined below 4,000 second-feet. A new table was used subsequent to May 26, 1912.

Discharge estimated March 1 to 31, 1911, because of errors in observed gage heights.

Monthly discharge of North Fork of Root River near Lanesboro.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1910.						
February			[a]150	0.232	0.24	D
March	2,040	150	829	1.28	1.48	C
April	924	284	202	.930	1.04	B
May	284	167	212	.328	.38	B
June	196	134	161	.249	.28	B
July	141	119	134	.207	.24	B
August	203	128	177	.274	.32	B
September	1,040	167	229	.354	.40	C
October	189	122	146	.226	.26	C
November	196	154	167	.258	.29	C
1911.						
February (19-28)	456	259	341	.527	.20	C
March	203	90	137	.212	.24	D
April	185	90	125	.193	.22	A
May	834	82	186	.287	.33	A
June	242	72	123	.190	.21	A
July	90	38	62.4	.096	.11	A
August	9,380	77	987	1.53	1.76	A
September	814	119	181	.280	.31	A
October	4,320	167	994	1.54	1.78	A
November	376	171	275	.425	.47	A
December	3,160	175	459	.709	.82	B
1912.						
January			[b]180	.278	.32	C
February			[b]150	.232	.25	C
March	7,640		[b]820	1.27	1.46	C
April	3,400	329	895	1.38	1.54	A
May	5,090	196	599	.926	1.07	B
June	541	157	233	.360	.40	B
July	1,310	157	293	.453	.52	B
August	250	125	167	.258	.30	A
September	263	125	162	.251	.28	B
October	316	131	161	.249	.29	B
November	250	125	160	.247	.28	B

[a] Estimated.
[b] Estimated from discharge measurements, climatological records and gage heights to water surface.

DEVELOPED WATER POWER.

There are five power plants on Root River, and two on the South Fork.

ROOT RIVER (INCLUDING NORTH FORK).

Stewartville.—The Cussons Milling Co. has a flour and feed mill, which utilizes a head of 13 feet. Two turbines develop an average of 60 horsepower used in running the mill.

Simpson.—A flour mill at this point is operated by water power. It is probable that not more than 50 horsepower is developed.

Eight miles above Chatfield.—The Orion Flour Mill, which is near the line between Pleasant Grove and Orion townships, has a rock-and-brush dam, 3 feet high, which backs the water upstream 1 mile. From the pond above the dam, a canal 1000 feet long carries water to the mill. By means of this canal, a head of 8 feet is created. A 48-inch Leffel turbine of 40 horsepower capacity having a hand governor, is belt-connected to the mill machinery. There is also a 32-inch Leffel turbine in the mill. During the fall and winter months the plant is operated from 16 to 18 hours per day. There is no auxiliary steam plant as the water supply is usually sufficient.

Two miles southeast of Chatfield.—The Chatfield Electric Light and Power Co. has a power plant just above the Middle Fork. An 8-foot rubble rock dam topped with 2 feet of concrete backs the water upstream 1 mile. During the winter months 20-inch flashboards are used to increase the pondage. The tail race has been cut through a knoll 1000 feet across into the river below the Middle Fork. This gives a head of 15 feet. A short under flume supplies water to a pair of 24-inch S. Morgan Smith horizontal turbines of 72 horsepower capacity each. These are controlled by a Woodward automatic governor. They are connected to a 55 KW Fort Wayne alternating current generator of 2200 volts. The plant is operated 5 hours per day during the summer and 12 hours during the winter months. There is an auxiliary steam plant of 130 horsepower capacity.

Rushford.—The Rushford Power Co. has a power plant 1 mile southeast of Rushford. One mile up the river there is a 5-foot dam having a timber section 40 feet long and the remainder, masonry; no flashboards are used on the dam. From the pond above the dam a canal leads to the power plant where an operating head of 12 feet is available. Set vertically in draft tubes in concrete frames are two 45-inch Samson Leffel turbines of 149 horsepower capacity each, and an old 56-inch turbine of 75 horsepower capacity. Each 45-inch turbine is belt-connected to a 75 KW Bullock, 3-phase, alternating current generator of 2300 volts. One unit is used to furnish light and power to Rushford, while the other is held in reserve. The 56-inch wheel is belt connected to the machinery of the flour, and saw mill nearby. The Samson wheels are controlled by a Woodward automatic governor while the older turbine has a hand governor. The plant is operated continuously six days per week. There is no auxiliary steam plant as the water supply is sufficient.

SOUTH FORK OF ROOT RIVER.

Preston.—A flour mill utilizes a head of 8 feet. One turbine develops an average of 40 horsepower.

Lanesboro.—The village of Lanesboro owns a dam which creates a head of 28 feet utilized by two power plants. The pond area is 6 acres; no flashboards are used as the water supply is sufficient.

The Electric light station has a 23-inch Samson Leffel turbine of 158 horsepower capacity which has no governor. The turbine is set vertically in a draft tube which is set in a concrete case opening into the forebay. The turbine is direct connected to a 60 KW Triumph direct current generator of 2200 volts. The plant is operated from 6 to 12 hours per night. There is no auxiliary steam plant.

The Lanesboro Roller Mill leases water from the city to run a turbine that is like that in the electric light station, and installed in a similar manner. The two plants are within 100 yards of each other. The turbine is belt connected to the mill machinery which is operated not to exceed 10 hours per day. There is no auxiliary steam plant.

From the records of flow of Root River the following table has been compiled to show the available continuous horsepower at the developed sites (as there are no records on the South Fork the estimate of flow cannot be considered as accurate as that on the main river and North Fork.)

Available horsepower at developed power sites.

Developed site.	Head in feet.	Minimum Run-off.			Horsepower (80% Efficiency).		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Root River.							
Stewartville	13	11	24	30	13	28	35
Simpson							
8 miles above Chatfield	8	16	36	45	12	26	33
2 miles southeast of Chatfield	15	26	58	73	35	79	100
Rushford	12	134	295	375	146	322	418
South Fork.							
Preston	8	16	36	45	12	26	33
Lanesboro	28	24	54	67	61	137	170

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of Root River from its mouth to Orion Mill on the North Fork, 8 miles above Chatfield, was made in 1910. The results of this survey are given on plates 63 to 67, inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Root River from mouth to Orion Mill.

Stations.	Distance.		Elevation above sea level.	Ascent between Points.	
	From Mouth.	Point to Point.		Total.	Per mile.
Mississippi River	0.0	....	631	....	....
C. M. & St. P. Ry. bridge	3.9	3.9	634	3.0	0.8
Bridge at Hokah	8.7	4.8	641	7.0	1.5
....	12.0	3.3	647.5	6.5	2.0
C. M. & St. P. Ry. bridge	16.3	4.3	653	5.5	1.3
Bridge at Mound Prairie	18.8	2.5	657	4.0	1.6
Silver Creek	22.9	4.1	662.5	5.5	1.3
South Root River	27.1	4.2	669.5	7.0	1.7
Bridge above Houston	30.1	3.0	677	7.5	2.5
C. M. & St. P. Ry. bridge	33.9	3.8	686	9.0	2.4
....	38.0	4.1	695.5	9.5	2.3
Lower end of Rushford mill race	44.0	6.0	710	14.5	2.4
Bridge at Rushford	45.0	1.0	713	3.0	3.0
Rushford dam, foot	47.3	2.3	719.5	6.5	2.8
Rushford dam, crest	47.3	0.0	725	5.5	....
Upper end pond Rushford dam	48.4	1.1	725	0.0	0.0
....	51.2	2.8	730	5.0	1.8
....	54.0	2.8	739	9.0	3.2
....	56.0	2.0	744	5.0	2.5
Bridge at Whalen	62.4	6.4	769	25.0	3.9
South Fork of Root River	65.7	3.3	784	15.0	4.5
....	70.0	4.3	813	29.0	6.7
Money Creek	76.9	6.9	856	43.0	6.2
Trout Creek	80.9	4.0	873	17.0	4.2
....	86.0	5.1	894.5	21.5	4.2
Highway bridge	90.6	4.6	913	18.5	4.0
Lower end Chatfield mill race	93.6	3.0	925	12.0	4.0
Chatfield dam, foot	94.8	1.2	931	6.0	5.0
Chatfield dam, crest	94.8	0.0	939	8.0	....
Upper end pond Chatfield dam	95.6	.8	939	0.0	0.0
Bridge near Chatfield	98.4	2.8	953	14.0	5.0
Highway bridge	103.2	4.8	989	36.0	7.5
Lower end Orion mill race	107.2	4.0	1,018	29.0	7.2
Orion Mill dam, foot	107.6	.4	1,021.5	3.5	8.8
Orion Mill dam, crest	107.6	0.0	1,026	4.5	....

The heaviest fall and topography best suited to power development are found on the North Fork and for a few miles below the junction of the North and South Forks. Below that point the slope of the river becomes less and the banks comparatively low. The valley becomes so wide that it is not feasible to develop comparatively high heads by building a dam across the entire valley. Although the fall continues fairly heavy above the upper limits of the survey, the flow of the river is too small to permit of extensive power development.

The accompanying sheets of the Root River Survey show the following power sites:

In sec. 8, T. 104 N., R. 11 W.—A 20-foot dam at mile 96.8, 1½ miles below the Chatfield bridge would have a crest length of 600 feet. It would back the water 3 miles upstream and overflow 268 acres of cultivated land.

In sec. 35, T. 104 N., R. 10 W.—In this portion, the river flows through a very narrow valley with steep sides making possible a high head development. A dam 100 feet above the water surface at mile 70.8, 5½ miles above the junction with the South Fork would have a crest length of 600 feet, and would have a foundation in the limestones and sandstones of the Cambrian series. It would from a pond 21 miles long and would overflow about 1600 acres.

In sec. 1, T. 103 N., R. 10 W.—If an 18-foot dam were erected at mile 68.1, 2½ miles above the mouth of the South Fork, it would back the water 2½ miles upstream, nearly to the dam site in section 35. As the banks are high, not more than 25 acres of land would be overflowed.

In sec. 4, T. 103 N., R. 9 W.—At mile 59.9, 1½ miles below Whalen, a 28-foot dam having a crest length of 400 feet would form a pond 6½ miles long, reaching a point on the North Fork three-fourths mile above its junction with the South Fork. About 230 acres of land, largely under cultivation, would be overflowed.

In sec. 35, T. 104 N., R. 9 W.—A 17-foot dam at mile 55.5, 4 miles above Peterson, would back the water nearly 5 miles upstream, and would overflow 125 acres of land.

In the lower river there are a number of possible developments of low head but these are too small to be considered here.

AVAILABLE HORSEPOWER.

Records of Root River are available from 1909 to 1912. On these records are based the estimates of horsepower in the following table:

Undeveloped horsepower on Root River.

Site.	Head in feet.	Minimum Run-off.				Horsepower (80% Efficiency).	
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Sec. 8, T. 104 N., R. 11 W.	20	26	58	73	47	105	133
Sec. 35, T. 104 N., R. 10 W.	[a]70	220	370	....	1,400	2,355	....
Sec. 1, T. 103 N., R. 10 W.	18	62	136	168	101	223	275
Sec. 4, T. 103 N., R. 9 W.	28	94	207	263	239	527	669
Sec. 35, T. 104 N., R. 9 W.	17	94	207	263	145	320	406

[a] See description of storage site below.

STORAGE.

Below the junction of the North and South Forks the topography of Root River Valley is unsuited for reservoir sites as the valley is too wide to be dammed. On the North Fork however, the valley is narrow and has steep sides affording a better opportunity for dam sites.

From a point 5½ miles above the South Fork and for a distance of more than 30 miles upstream, the valley of the North Fork is narrow offering a good reservoir site. The dam site where a 100 foot dam can be erected is in sec. 35, T. 104 N., R. 10 W., at mile 70.8 above the mouth of Root River. From the survey of Root River (plates 66 and 67) which included this portion, the following capacities for the reservoir formed by the 100 foot dam, have been compiled.

Capacity of North Fork reservoir.

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity.	
			Acre-feet	Cubic-feet
820	14	....	....	....
830	78	460	460	....
840	303	1,900	2,360	....
850	378	3,400	5,700	....
860	522	4,500	10,200	....
870	867	6,940	17,200	....
880	1,100	9,840	27,040	....
890	1,375	12,380	39,420	1,717,000,000
900	1,671	15,230	54,650	2,381,000,000
910	1,920	17,960	72,610	3,163,000,000
920	2,214	20,670	93,280	4,063,000,000

As the only available records of flow of Root River are for the period from 1909 to 1912, only the effect of storage for that period which contain the very low years of 1910 and 1911 can be determined at this time. Although the lower valley is subject to severe floods owing to the quick spilling drainage area, no serious floods occurred during the period under consideration so it is impossible to give any definite data regarding the effect of the reservoir upon flood prevention.

In computing the loss to the stored water from evaporation, use was made of the records of evaporation at Grand Forks, N. D. and Iowa City, Ia., which show substantial agreement in total annual evaporation.

If the upper 30 feet of the reservoir were used for storage, and the lower 70 feet for power head, there would be a storage capacity of 2.4 billion cubic feet. The evaporation loss would be lessened, as during a great portion of the time the water surface would be below the top, with a corresponding lessened area of water surface.

A mass curve has been prepared (plate X) showing the net amount available for storage after evaporation losses had been deducted. With a storage capacity of 2.4 billion, it is seen that the reservoir would have been capable of sustaining a continuous discharge of 220 second-feet during the extreme dry period extending from March 1, 1910 to August 1, 1911, without reducing the power head below 70 feet. During this period had the plant been in operation, power would have been derived from stored water for

75 per cent of the time. During the latter half of 1909 which may be considered an ordinary low year, the same available storage would have sustained a continuous flow of 370 second-feet. In the period July 1, 1911 to March 1, 1912, an available storage of 2 billion cubic feet would have sustained a continuous flow of 470 second-feet.

In the table of available horsepower on p. 321 the estimates of power at this site, have been based on the assumption that a 100 foot dam would be built giving 2.4 billion cubic feet of storage, and a power head of not less than 70 feet.

SANITARY STATISTICS.

To show the sanitary quality of the water in Root River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage, have been compiled for all towns of 400 inhabitants or more, located on the river or its tributaries. These data are given in the following table in order of location beginning near the source:

Municipal water supply and sewage disposal of towns on Root River and tributaries.

Town.	Distance above mouth	Population 1910.	Water Works System.			Sewerage System.		Rural population in basin per square mile.
			Source of Supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
			Root River.					22.1
Stewartville	131	794	well	no	10,000	river	no	
Chatfield	98	1,226	deep well	no	25,000	none	none	
Middle Fork	94							
South Fork	66							
Whalen	62	1,121	well	no[a]		none		
Peterson	52	266	none			none		
Rushford	45	1,011	artesian well	no	25,000	Rush Creek	no	
Houston	29	100	artesian well			none		
Hokah	9	400						
			South Fork Root River.					
Preston	16	1,193	spring	no	60,000	none		
Lanesboro	2	1,200	spring	no		none		
			Middle Fork Root River.					
Mouth Deer Creek	15							
Spring Valley	27	1,817	spring	no	30,000	tributary	no	
			Deer Creek.					
Grand Meadow	25	552	well	no		no		

[a] Used for fire protection only

From the preceding table it is seen that above the junction with the South Fork, the river receives untreated sewage from Stewartville. The average fall above the South Fork is 5.8 feet per mile, which insures the distribution of sewage from Stewartville throughout this stretch of river. At no place on the entire river is the water used for municipal purposes.

At the mouth of the South Fork, is received the drainage from 268 miles which carries no urban sewage.

Between the South Fork and the mouth, a distance of 66 miles, the river receives raw sewage from Rushford, with a population of 1011. The average fall of the river below the South Fork is 2.3 feet per mile. From this, it is evident that sewage pollution from Rushford will extend to the mouth.

The rural population for the entire basin is 22.1 per square mile.

CEDAR RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The drainage area of Cedar River lying in Minnesota, which is the only portion considered in this description, is located in Mower, Dodge, Steele, and Freeborn counties. Cedar River is formed by the junction of several streams in the southwestern part of Dodge County. Its general course is southward through Minnesota. The river flows through a gorgelike valley, although very much less than the valleys of the streams to the eastward, as the river has not cut through the overlying glacial drift. The chief tributaries are Dobbin, Turtle, Rose, Orchard and Woodbury creeks.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The entire area is covered with a drift sheet of blue-till, a mixture of sand, clay and gravel. Upon this till are found deposits of sand and gravel. These deposits being porous are the mouths of water reservoirs which penetrate the drift sheet, and give rise to the springs which are found along the streams. Along the Cedar River are found a few outcrops of cretaceous sandstones, and Devonian limestones, shales and sandstones. The northern portion of the basin is underlain by cretaceous rocks, while in the southern portion are found rocks of the Devonian and Silurian systems. The general feature of the drainage basin is a moderately elevated prairie with no rock outcrop except as noted above. Elevations range from 1150 to 1350 feet above sea level.

The absence of lakes in the basin prevents the natural regulation of the river as is shown by the sudden freshets to which it is subjected. The area is prairie except for trees along the various streams.

RAINFALL AND RUNOFF.

The mean annual rainfall increases from 28 inches in the upper part of the area to about 31 inches at the state line as determined from the lines of equal rainfall for the southern portion of the state.

Of these amounts 4½ inches occur as snow. The nearest long time record is that at Grand Meadow which is continuous since 1886. During that period the wettest year was 1909 with a rainfall of 45.4 inches. The driest year was 1910 with a rainfall of 16.9.

Runoff records of Cedar River have been maintained since 1909. These show the runoff to have varied from 3.56 to 4.36 inches or from 9.9 to 22.0 per cent of the rainfall.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Cedar River basin.

River.	Drainage area above.	Square miles.
Cedar	Gaging station near Austin	425
Do	State line	602
Shell Rock	Lake Albert Lea outlet	129
Do	State line	176

GAGING STATION RECORDS.

CEDAR RIVER NEAR AUSTIN.

Location.—Just below the dam of the Red Cedar Mill, 2 miles below Austin, in Sec. 15, T. 102 N., R. 18 W.

Records available.—May 29, 1909, to December 31, 1912.

Drainage area.—425 square miles.

Gage.—From May 29, 1909, to April 30, 1912, staff gage located in tailrace. May 1, 1912, to December 31, 1912, chain gage located on bridge a short distance below power house. No relation between the two gages. As the chain gage has not been rated, no estimates are available.

Channel.—Somewhat shifting.

Discharge measurements.—Made from bridge to which the chain gage is fastened, and by wading.

Winter flow.—The relation between gage height and discharge is affected by ice, although the river remained open in the vicinity of the gage. The discharge during the frozen period of the year has been based on the result of discharge measurements.

Regulation.—Immediately above the station is the water power plant known as Red Cedar mill. During the low water season the water is drawn down below the crest of the dam by the end of the ten or twelve hour run, and after the turbine is closed the water is held back for several hours before it has risen sufficiently to flow over the crest. Consequently, the stage of the river changes considerably during each twenty-four hours. In order to get a mean gage height the gage is read five times daily, as follows: Before the turbine is started in the morning, one hour after starting, at noon, just before shutting down at night, and one-half hour later.

Accuracy.—During the summer of 1911 grass grew in the channel to such an extent that it caused backwater in varying amount at the gage as shown by discharge measurement. Therefore, the low water records of 1911 cannot be considered better than fair.

Daily discharge, in second-feet, of Cedar River near Austin.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1						163	181	36	76	70	122	632
2						146	155	73	70	70	502	632
3						146	111	62	76	40	443	849
4						289	84	46	70	48	302	926
5						309	92	47	48	52	209	424
6						309	111	18	76	58	144	352
7						322	96	37	70	63	132	318
8						302	92	15	63	63	76	254
9						362	58	34	70	63	92	138
10						302	111	40	52	63	76	162
11						251	58	49	58	92	239	138
12						184	70	70	48	84	774	117
13						132	38	155	84	122	1,540	138
14						302	75	1,880	144	84	5,230	138
15						459	47	2,830	155	76	3,740	128
16						248	40	1,930	155	76	2,230	117
17						248	43	1,380	122	63	1,320	117
18						195	40	1,070	111	84	900	108
19						144	48	702	48	63	632	98
20						84	58	474	63	92	565	150
21						132	38	335	70	92	678	98
22						84	46	206	63	102	678	117
23						92	43	195	92	102	523	161
24						84	43	144	92	48	523	98
25						144	46	103	84	70	443	68
26						168	43	122	58	111	750	68
27						600	44	102	76	76	2,890	98
28						678	41	100	70	44	2,120	161
29					96	462	40	51	70	48	1,270	161
30					103	309	37	75	70	48	774	108
31					245		43	79		34		108
1910.												
1	169	95	75	165	63	73	56	59	59	49	63	16
2	40	106	82	150	70	64	61	49	59	28	59	82
3	132	104	102	119	68	61	28	66	56	61	54	48
4	115	82	102	146	71	64	30	52	28	52	52	16
5	128	88	192	128	55	23	56	39	54	52	56	50
6	132	52	380	126	63	49	58	59	63	51	19	16
7	125	102	890	119	63	62	52	20	56	52	53	64
8	125	92	1,360	117	61	61	38	52	60	52	52	53
9	95	75	1,400	96	60	48	52	52	59	21	53	14
10	113	82	1,110	62	76	56	46	23	54	63	56	48
11	109	85	1,120	86	63	71	47	54	26	52	59	16
12	104	93	1,160	86	54	37	61	54	60	37	18	50
13	100	60	2,070	89	61	63	64	54	56	54	19	40
14	81	96	1,760	89	56	59	63	22	52	53	54	49
15	100	95	1,240	89	28	59	73	53	50	52	54	14
16	82	92	869	89	70	59	47	59	52	23	26	50
17	121	85	664	71	107	59	38	55	52	63	61	48
18	95	76	544	107	66	56	54	52	22	56	53	16
19	88	84	557	96	76	30	47	53	58	61	53	53
20	92	65	578	84	86	52	89	56	54	52	22	55
21	92	88	561	89	89	56	59	36	52	56	89	14
22	90	72	482	94	87	39	58	53	54	52	84	18
23	79	88	394	66	76	40	54	56	54	28	22	55
24	88	75	369	64	96	44	33	56	54	61	32	52
25	88	57	325	105	78	46	54	55	22	37	96	18
26	93	71	299	82	37	44	54	54	53	59	82	28
27	87	50	245	72	72	49	50	55	53	52	20	54
28	85	76	218	76	66	48	50	34	55	49	53	53
29	85		201	79	62	64	26	59	54	50	52	46
30	62		195	78	53	59	44	59	51	46	20	15
31	96		160		73		30	52		61		55
1911.												
1	7	40	75	44	66	105	30	32	47	8	227	109
2	77	53	65	7	60	141	0	31	38	61	212	24
3	75	42	63	48	55	108	38	27	6	55	73	24
4	70	45	58	46	50	110	0	30	46	132	184	85
5	66	1	39	60	48	126	39	22	6	132	45	24

Daily discharge, in second-feet, of Cedar River near Austin—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6	39	59	65	55	50	79	38	5	46	637	148	25
7	36	42	63	54	23	59	5	56	61	1,010	195	86
8	33	42	65	58	59	52	39	51	5	565	195	126
9	29	44	73	31	51	49	5	54	5	315	192	160
10	55	0	73	63	44	47	52	105	8	212	173	578
11	54	51	53	50	46	22	26	98	67	148	206	1,680
12	43	7	54	64	42	37	39	63	35	111	44	774
13	42	40	78	84	45	50	30	2,000	29	113	171	451
14	50	380	68	86	21	41	1	3,200	6	128	144	299
15	0	965	57	81	51	38	38	835	6	261	187	283
16	55	715	49	57	51	42	3	330	61	3,180	113	173
17	46	685	50	72	49	44	38	159	6	3,880	86	105
18	45	640	55	63	45	19	29	104	57	1,680	111	158
19	40	290	28	55	46	45	0	60	58	951	49	139
20	37	223	58	55	58	43	34	41	7	669	107	115
21	46	142	58	55	81	37	1	84	58	416	73	84
22	0	98	51	52	260	41	36	101	6	318	79	94
23	51	98	46	26	217	38	1	82	8	283	209	98
24	46	98	44	60	145	41	20	50	11	261	28	59
25	40	75	33	50	107	20	22	5	84	254	62	76
26	42	52	0	44	75	51	22	45	71	245	26	105
27	45	81	51	47	68	41	37	5	8	236	107	89
28	44	65	49	47	39	35	25	49	8	201	26	79
29	2		53	48	61	31	22	45	8	171	24	78
30	52		46	24	34	32	0	45	66	165	25	79
31	44		41		69		32	22		198		46
1912.												
1	63	9	11	1,660	154							
2	132	76	64	1,200								
3	111	52	6	770								
4	102	12	58	565								
5	26	70	53	565								
6	35	63	48	770								
7	44	12	5	1,200								
8	111	70	53	727								
9	122	58	53	408								
10	84	44	7.5	332								
11	92	16	48	295								
12	70	70	53	259								
13	132	63	48	295								
14	34	18	6	1,150								
15	111	76	48	1,250								
16	144	16	44	645								
17	111	77	7.5	408								
18	76	13	70	332								
19	52	48	210	242								
20	70	64	351	166								
21	11	35	351	525								
22	31	58	225	1,880								
23	58	48	194	1,150								
24	52	53	154	486								
25	40	11	166	295								
26	34	53	180	259								
27	34	58	1,350	259								
28	10	7.5	4,180	154								
29	34	58	3,720	194								
30	48		2,150	180								
31	52		1,880									

Daily discharge for 1909 and 1910 computed from a well-defined rating curve. Daily discharge for 1911 computed from a fairly well-defined rating curve that was applied indirectly because of shift.

Monthly discharge of Cedar River near Austin.

[Drainage area, 425 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June	678	84	255	0.600	0.67	B
July	181	37	66.8	.157	.18	A
August	2,830	15	402	.946	1.09	B
September	155	48	80.1	.188	.21	B
October	122	34	71.0	.167	.19	A
November	5,230	76	997	2.35	2.62	A
December	926	68	232	.546	.63	B
1910.						
January	169	40	99.7	.235	27	B
February	106	50	81.6	.192	20	B
March	2,070	75	636	1.50	1.73	B
April	165	64	97.3	.229	.26	A
May	107	28	67.9	.160	.18	A
June	73	23	53.2	.125	.14	B
July	73	26	50.7	.119	.14	B
August	66	20	50.1	.118	.14	B
September	63	22	51.1	.120	.13	B
October	63	23	49.5	.116	.13	B
November	96	18	49.5	.116	.13	B
December	82	14	39.2	.092	.11	C
The year	2,070	14	110	.260	3.56	
1911.						
January	77	0	42.3	.100	.12	B
February	965	0	181	.426	.44	B
March	78	0	53.6	.126	.15	B
April	86	7	52.9	.124	.14	B
May	260	21	68.3	.161	.19	B
June	141	19	54.1	.127	.14	C
July	52	0	22.6	.053	.06	D
August	3,200	5	253	.595	.69	D
September	84	5	30.9	.073	.08	C
October	3,880	8	548	1.29	1.49	B
November	227	24	117	.275	.31	B
December	1,680	24	203	.478	.55	B
The year	3,880	0	136	.320	4.36	
1912.						
January	144	10	68.6	.161	.19	C
February	77	7.5	45.1	.106	.11	C
March	4,180	5	509	1.20	1.38	B
April	1,880	154	621	1.46	1.63	B

DEVELOPED WATER POWER.

There are three developed water powers on Cedar River as follows:

Ramsey.—(No data.)

Austin.—The Peerless Roller Mill has a dam that creates a head of 9 feet which is increased to 10 feet by the use of 12-inch flashboards. At the left end of the dam is located the mill in which is installed a 35-inch Samson Leffel turbine of 70 horsepower capacity, which is regulated by a hand governor. Water is supplied to the turbine by a wooden flume 30 feet long. There is an auxiliary steam plant of 75 horsepower. As the water supply is not sufficient to run the mill electric power generated at the Red Cedar Mill is also used. The plant is operated continuously.

Two Miles Below Austin.—The Red Cedar mill, which is operated by the owner of the Peerless Roller mill, has a timber dam which creates a head of 13 feet at normal stage. The water is backed 2 miles upstream. Flashboards are used almost continuously, and during low stages the water is drawn down as much as 2 feet below the crest at the end of the 11 hours run. One turbine having a capacity of 125 horsepower is controlled by a Woodward automatic governor. It is bevel-geared to a horizontal shaft which is belt connected to a 300 KW National Electric 2-phase alternating current generator of 2,200 volts. The current is transmitted to Austin for use in running the roller mill at that point.

From the records of flow of Cedar River the following table has been compiled showing the available continuous horsepower at the developed sites.

Available horsepower at developed power sites.

Developed site.	Head in feet.	Minimum Run-off.		Horsepower (80% Efficiency).	
		Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Ramsey					
Austin	10	20	34	18	31
2 Miles below Austin	13	23	39	27	46

SANITARY STATISTICS.

To show the sanitary quality of the water in Cedar River and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on Cedar River and its tributaries. The only town in this class is Austin with a population of 6,960. Its source of supply is springs, from which 500,000 to 700,000 gallons per day are pumped. The untreated sewage is emptied into the river.

The rural population of the basin is 20.6 per square mile.

DES MOINES RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The area drained by Des Moines River in Minnesota lies in the southwestern part, chiefly in Murray, Cottonwood, Nobles and Jackson counties. Des Moines River rises in the northern part of Murray County and flows southeast to Lake Shetek. Just below the mouth of Lake Shetek it is joined by Beaver Creek which is the most important tributary to the upper river with the possible exception of Heron Lake outlet. From this point its course is generally southeast to the Cottonwood-Jackson county line where the river turns abruptly to the northeast for about 10 miles when it again turns abruptly and continues its southeasterly course to the State line. Beside Beaver Creek and Heron Lake outlet there are no important tributaries.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The Des Moines throughout its course flows in a well defined valley eroded for the most part in the glacial drift which covers the entire drainage basin. The depth of the valley increases from 50 to 150 feet with a width of one-third to two-thirds miles between the top of the bluffs along the river.

The drainage basin is covered with a drift sheet of blue till which contains deposits of gravel and sand. The largest deposits of this nature are found on the southwestern border where the land rises to a height of several hundred feet above the remainder of the basin. These deposits of sand and gravel are the open mouths of water reservoirs which penetrate the drift sheet and give rise to the many springs which are the source of the headwaters of the Des Moines. So deep is the covering of drift that there are no rock outcrops in the basin. This drift is underlain by the sandstones, limestones and shales of cretaceous formation. The range of elevations is from 1,100 to 1,750 feet above sea level.

The entire area is within the prairie region and the only timber is found on the borders of the lakes which are abundant within the basin and along the larger streams. A very large percentage of the drainage area is under cultivation.

RAINFALL.

The mean annual rainfall increases from 25 inches in the upper portion of the basin to more than 28 inches at the State line. Of these amounts 3½ inches occur as snow. The longest record in this part of the State is that at Worthington which extends back to 1892. In that period the wettest year was 1896 with a rainfall of 36.5 inches, and the driest, 1910, with a rainfall of 14.5 inches.

REGULATION OF FLOW.

There are no reservoirs in the basin, but the many lakes, some having an area of several square miles, are natural regulators of the flow, as shown by the absence of severe floods. This natural regulation is shown very well when a comparison is made between the Des Moines and Cedar rivers. The latter having the same general character of drainage area but without lakes is subject to severe freshets.

DRAINAGE WORK.

Much of the upland area is so flat that artificial drainage is necessary. The following table shows the extent of this work.

Drainage work in Des Moines River basin.

County.	Miles of Ditch.	Acreage Benefited.
Jackson	109	16,000
Murray	30	4,000
Nobles	20	4,000

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Des Moines River basin.

River.	Drainage area above.	Square miles.
Des Moines	Lake Shetek outlet	144
Do	Heron Lake outlet (including Heron Lake)	912
Do	Gaging station at Jackson	1,160
Do	State line	1,220
Oksida Creek	Mouth	110
Heron Lake outlet	Mouth	427

GAGING STATION RECORDS.

DES MOINES RIVER AT JACKSON.

Location.—At highway bridge one-half mile below the dam in Jackson, 100 yards above the nearest tributary, a small stream entering from the west.

Records available.—May 31, 1909, to November 30, 1912.

Drainage area.—1,160 square miles.

Gage.—Vertical staff; datum unchanged since established.

Channel.—Permanent prior to 1912, when a shift occurred.

Discharge measurements.—Made from bridge.

Regulation.—At the dam one-half mile above the station is a power plant which develops 35 horsepower under a head of 6½ feet. The plant operates only six hours a day on the average, but so far the morning and evening gage heights do not show any appreciable change in the stage of the river owing to water being held back in the low-water season after the turbines have been shut down.

Winter flow.—Observations are discontinued from December to March because of ice.

Accuracy.—Conditions are favorable for good results and the records of flow should therefore be reliable.

Daily discharge, in second-feet, of Des Moines River at Jackson.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1						1,070	1,500	616	95	48	55	
2						1,040	1,490	556	92	46	66	
3						1,050	1,510	492	106	44	71	
4						1,090	1,560	468	103	39	63	
5						1,130	1,600	435	98	38	68	
6						1,160	1,620	400	95	40	54	
7						1,140	1,630	411	88	42	59	
8						1,120	1,610	370	88	43	43	
9						1,080	1,550	370	82	43	42	
10						1,090	1,590	349	77	44	48	
11						1,060	1,560	349	68	54	55	
12						1,050	1,570	360	82	70	61	
13						1,080	1,540	345	81	49	68	
14						1,190	1,510	328	87	49	127	
15						1,140	1,470	312	85	50	121	
16						1,050	1,450	308	83	46	88	
17						1,010	1,420	285	76	43	88	
18						928	1,420	278	70	44	88	
19						847	1,410	243	68	44	109	
20						795	1,360	234	63	43	72	
21						808	1,290	220	70	43	127	
22						808	1,230	203	70	44	147	
23						941	1,140	198	68	47	147	
24						1,130	1,100	186	64	48	109	
25						1,080	1,020	182	59	44	102	
26						1,070	963	158	55	63	132	
27						1,220	914	155	55	64	196	
28						1,480	829	157	54	57	223	
29						1,690	787	139	50	44	127	
30						1,630	704	118	50	57	180	
31					1,020		678	106		54		
1910.												
1				311	145	53	39	29	27	32	29	
2				299	138	42	48	29	27	27	35	
3				286	138	43	36	27	26	30	35	
4				284	122	48	36	27	27	26	34	
5				265	122	37	35	27	27	26	32	
6				243	121	34	35	27	27	29	27	
7				215	116	32	33	27	26	28	27	
8				224	109	35	31	27	25	26	31	
9				222	108	47	32	27	29	26	26	
10				209	94	112	31	28	29	26	25	
11			777	200	96	147	35	27	24	25	35	
12			909	189	95	132	37	27	27	27	32	
13			941	180	96	101	32	28	31	36	34	
14			1,070	172	87	88	32	29	27	33	30	
15			1,000	174	82	56	38	28	27	27	29	
16			766	162	71	63	36	29	32	26	27	
17			678	169	82	55	34	29	31	30	27	
18			694	164	90	58	32	29	31	26	26	
19			642	130	83	48	31	29	26	23	26	
20			616	175	71	46	32	28	24	25	27	
21			588	172	75	46	34	27	25	25	30	
22			570	179	66	41	34	27	25	30	32	
23			532	158	57	40	34	27	23	33	27	
24			505	145	56	40	32	27	25	29	35	
25			468	145	59	36	38	27	25	29	32	
26			439	186	51	44	31	27	29	30	31	
27			417	193	57	62	29	27	31	30	31	
28			395	179	53	46	28	27	32	31	34	
29			374	175	50	46	29	27	30	29	30	
30			353	162	43	39	29	26	29	26	31	
31			332		46		29	26		25		
1911.												
1				48	46	34	20	23	36	44	90	**35**
2				43	42	40	20	30	36	44	70	**35**
3				42	38	36	21	29	35	45	75	**35**
4				38	36	33	22	26	31	47	67	**40**
5				46	31	32	22	[illegible]	40	63	66	**40**

Daily discharge, in second feet, of Des Moines River at Jackson—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6				45	37	27	21	29	47	267	72	40
7				46	36	27	20	56	50	226	83	45
8				46	36	27	21	46	48	253	78	45
9				46	36	27	20	37	43	216	78	55
10				50	31	26	19	116	42	207	80	82
11				38	29	25	18	63	45	207	85	71
12				36	29	24	18	46	43	207	116	60
13			47	38	29	23	19	46	42	198	73	60
14			50	42	29	22	19	58	40	189	56	59
15			62	48	29	22	19	54	38	172	53	57
16			48	45	30	21	18	43	39	172	48	66
17			53	48	31	22	18	53	44	189	55	63
18			46	39	32	20	19	48	73	180	50	82
19			53	38	36	20	34	60	82	172	47	59
20			50	48	29	20	29	45	102	172	48	56
21			53	48	29	20	32	42	92	155	48	55
22			53	46	30	20	30	40	73	155	50	54
23			45	39	32	20	27	39	60	139	102	70
24			42	41	40	20	23	40	50	155	85	65
25			40	38	41	21	23	38	48	124	56	60
26			41	31	36	23	25	44	47	124	53	60
27			42	31	32	22	25	41	51	116	47	55
28			40	30	32	22	23	37	47	109	40	45
29			36	36	31	22	23	36	45	102	35	35
30			37	34	30	20	22	36	45	82	35	30
31			44		31		23	36		98		30
1912.												
1				362	214	80	5	4.2	9	5	4.8	
2				385	195	66	4.9	4.2	14	5	14	
3				479	195	54	8.2	4.2	14	4.8	14	
4				362	186	66	18	4.2	13	4.5	9.0	
5				296	186	60	18	4.5	9	4.6	9.9	
6				296	195	54	11	4.6	8.2	4.6	9.9	
7				275	195	48	14	5.8	7	4.5	9.9	
8				275	176	42	18	176	7	4.5	8.6	
9				254	167	36	9.9	54	7	9.9	8.2	
10				254	158	18	16	30	7	48	8.6	
11				244	167	42	18	18	7	30	9.0	
12				234	149	30	14	18	7	24	14	
13				254	140	30	7.4	14	7	18	16	
14				296	140	30	5.8	11	7	16	18	
15				296	140	36	4.8	9.9	5.8	13	14	
16				275	132	36	4.8	8.6	5	18	14	
17				254	123	24	4.8	9	5.4	54	14	
18				234	123	30	4.8	9	7	30	11	
19				234	123	24	8.2	94	7	17	14	
20				214	116	18	14	42	7	11	14	
21				362	116	18	9	36	6.6	8.6	9.0	
22				362	108	18	6.6	18	7	7.0	9.0	
23				317	108	18	5.8	16	5.8	7.0	9.0	
24				275	94	18	4.8	11	4.9	5.8	14	
25				254	101	8.2	4.5	9	5.4	5.0	8.2	
26				275	94	16	4.4	8.2	5.4	5.4	18	
27				254	80	14	4.2	6.6	5.8	5.0	30	
28				244	101	7	4.2	5.4	5.8	5.0	18	
29				234	87	5.8	4.2	5	7.4	5.0	16	
30				214	80	5	4.5	8.2	7.4	4.9	16	
31					80		4.5	8.6		4.8		

NOTE.—These discharges are based on a well-defined rating curve. Discharges for Nov. 28 to Dec. 9 and Dec. 23 to 31, 1911, estimated because of ice.

Monthly discharge of Des Moines River at Jackson.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June	1,690	795	1,100	0.948	1.06	B
July	1,630	678	1,320	1.14	1.31	B
August	616	106	301	.259	.30	A
September	106	50	76.1	.066	.07	A
October	70	38	49.7	.041	.05	B
November	223	42	97.9	.084	.09	B
1910.						
March (11-31)	1,070	332	622	.536	.42	B
April	311	130	199	.172	.19	A
May	145	43	86.4	.074	.09	A
June	147	32	57.2	.049	.05	A
July	48	28	33.6	.029	.03	B
August	29	26	27.5	.024	.03	B
September	32	23	27.5	.024	.03	B
October	36	23	28.1	.024	.03	B
November	35	26	30.2	.026	.03	B
1911.						
March (13-31)	62	36	46.4	.040	.03	A
April	50	30	41.5	.036	.04	A
May	46	29	33.4	.029	.03	A
June	40	20	24.6	.021	.02	A
July	34	18	22.4	.019	.02	A
August	116	23	44.0	.038	.04	A
September	102	31	50.5	.044	.05	A
October	267	44	149	.128	.15	A
November	116	35	64.7	.056	.06	B
December	82	....	53.0	.046	.05	C
1912.						
April	479	214	285	.246	.27	B
May	214	80	138	.119	.14	B
June	80	5	31.7	.027	.03	B
July	18	4.2	8.59	.0074	.009	C
August	176	4.2	21.2	.018	.02	C
September	14	4.9	7.40	.0064	.007	C
October	54	4.5	12.6	.011	.01	C
November	30	4.8	12.7	.011	.01	C

DEVELOPED WATER POWER.

There are three power developments on Des Moines River as follows:

Near Junction of Beaver Creek and the Outlet of Lake Shetek.—A flour mill at this point has a dam which creates a head of 8 feet. In the mill is installed a 27-inch McCormick turbine of 30 horsepower capacity. This is belt connected to the mill machinery. There is an auxiliary steam plant.

Windom.—The Windom Roller mill has a dam which creates a head of 9 feet. In the mill is a 72-inch turbine which develops 100 horsepower used in running the mill.

Jackson.—A flour mill at Jackson has a timber crib dam which creates a head of 6½ feet. Flashboards are not used on the dam.

At the right end of the dam is the mill in which are installed a 48-inch Leffel turbine of 21 horsepower capacity, and a 42-inch Flenniken turbine of 15 horsepower capacity. Water is supplied to the turbines by a flume. The turbines are belt connected to the mill machinery which is operated 6 hours per day. There is no auxiliary steam plant.

As there are no winter records of the Des Moines, and as in normal years it is probable that the minimum flow occurs during that period, the estimated flow of the Des Moines for an ordinary low year cannot be considered more than approximate. The following table shows the available continuous horsepower at the developed sites:

Available horsepower at developed power sites.

Developed site.	Head in feet.	Minimum Run-off.		Horsepower (80% Efficiency.)	
		Lowest month.	Lowest month average low year.	Lowest month.	Lowest month average low year.
Near Lake Shetek outlet	8	8	15	6	11
Windom	9	20	37	16	30
Jackson	6.5	22	41	13	24

SANITARY STATISTICS.

To show the sanitary quality of the water in Des Moines River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on the river or its tributaries. These data are given in the following table in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on Des Moines River and tributaries.

Towns.	Distance above State line.	Population 1910.	Water Works System.			Sewerage System.		Rural population of basin per square mile.
			Source of Supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
			Des Moines River.					16.7
Slayton	100	850	deep well	no	....	tributary	no	....
Heron Lake outlet	60	....	....	....	....	....	....	....
Windom	40	1,749	wells	no	....	Des Moines	no	....
Jackson	15	1,907	well	no	60,000	Des Moines	no	....
			Heron Lake Outlet.					
Worthington	40[a]	2,385	deep wells	no	100,000	Okabena Cr.	no.	....
Heron Lake	13[a]	803	none	....	....	none	....	....

[a] Distance above mouth.

From the preceding table it is seen that the river water is not used for municipal purposes. Before reaching the State line the Des Moines receives the untreated sewage from Slayton, Windom, Jackson and Worthington, representing a population of 6,900. The rural population is 16.7 per square mile.

ROCK RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The area drained by Rock River lies in the southwestern part of Minnesota and the northwestern part of Iowa. Rock River rises in a high table land in the northern part of Pipestone County known as the Coteau des Prairies and takes a generally southerly course, emptying into Big Sioux River a few miles north of Calliope, Iowa. Its principal tributaries in Minnesota are Champepadan, and Kanaranzi creeks at the State line.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The area is gently undulating and is covered with a deposit of glacial drift varying in thickness from 50 to 300 feet and upward. Through this drift, Rock River has cut a wide, shallow valley, while its tributaries have cut narrower and more gorgelike valleys. These valleys contain extensive alluvial deposits. The glacial drift is underlain chiefly by Sioux quartzite with some granite rock in the eastern portion of the basin where the drift sheet is thin. Little or no water is found in it, but in the thicker portions ground water is found in abundance. The deposits of sand and gravel give up their water freely and are not easily affected by drought.

The drainage basin is situated within the prairie region with the result that no timber is found except along the rivers. The land is all under cultivation.

RAINFALL.

The mean annual rainfall increases from 24 inches in the upper portion of the basin to 27 inches at the State line. The only record in the basin is that at Luverne which extends from 1894 to 1907. During that period the wettest year was 1896 with a rainfall of 37.7 inches. The driest year was 1910 with a rainfall of about 14.4 inches as determined from records at Pipestone and Worthington.

FLOODS.

Owing to an absence of lakes and swamp areas in the basin, with their regulating effect, the river is subject to severe floods which overflow the valley to a width of ¼ to 1 mile, throughout its entire length.

DRAINAGE AREAS.

The following drainage areas have been measured in this basin:

Drainage areas in Rock River basin.

River.	Drainage area above.	Square miles.
Rock	Gaging station at Luverne	440
Do	State line	550
Kanaranzi Creek	State line	161

GAGING STATION RECORDS.

ROCK RIVER AT LUVERNE.

Location.—At the Rock Island Railroad bridge at Luverne, 3½ miles above the mouth of Elk Creek.

Records available.—August 23, 1911, to December 31, 1912.

Drainage area.—440 square miles.

Gage.—Vertical staff.

Channel.—Probably permanent, owing to the small rapids just below the station, but severe floods will cause a change.

Discharge measurements.—Made from the railroad bridge at flood stage, from the highway bridge at medium stage, and at a wading section in low water.

Regulation.—The flow of the river is not artificially controlled above Luverne, as there are no dams except a low rock dam a short distance above the station, which does not regulate the flow but simply raises the water level about 2 feet.

Winter flow.—From December to March the river is frozen over at the station and measurements are made through the ice to determine the winter discharge.

Daily discharge, in second-feet, of Rock River at Luverne.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1									13	32	81	
2									13	32	75	
3									13	32	69	
4									211	40	79	
5									130	58	71	
6									81	976	75	
7									40	1,080	81	
8									32	911	88	
9									32	667	95	
10									203	456	84	
11									246	303	75	
12									180	211	48	
13									88	246	69	
14									58	346	58	
15									48	246	53	
16									32	283	48	
17									32	547	44	
18									109	667	42	
19									151	618	40	
20									165	456	40	
21									151	346	40	
22									81	246	40	
23								16	58	195	32	
24								16	40	180		
25								16	40	158		

Daily discharge, in second-feet, of Rock River at Luverne—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
26	......	......	......	......	......	......	......	16	32	148	......	......
27	......	......	......	......	......	......	......	16	32	137	......	......
28	......	......	......	......	......	......	......	16	32	130	......	......
29	......	......	......	......	......	......	......	16	25	123	......	......
30	......	......	......	......	......	......	......	16	25	112	......	......
31	......	......	......	......	......	......	......	13	......	109	......	......
1912.												
1	......	......	104	306	92	40	12	8.8	32	14	10	......
2	......	......	92	245	86	32	10	8.8	40	14	10	......
3	......	......	59	167	64	32	11	8.4	26	14	10	......
4	......	......	59	142	69	28	13	8.4	25	14	10	......
5	......	......	59	111	134	28	19	8.4	19	12	10	......
6	......	......	49	98	134	25	11	8.4	14	11	10	......
7	......	......	49	86	118	22	10	8.4	14	10	11	......
8	......	......	32	80	104	22	11	8.8	11	10	11	......
9	......	......	32	74	80	19	11	8.8	12	10	11	......
10	......	......	25	69	80	19	12	8.4	10	10	10	......
11	......	......	25	64	98	19	10	8.4	10	14	10	......
12	......	......	25	59	111	22	10	9.6	9.6	16	11	......
13	......	......	32	36	134	25	10	9.6	8.4	22	12	......
14	......	......	25	74	104	25	9.6	9.6	8.4	19	12	......
15	......	......	25	98	86	28	8.4	9.6	8.4	16	11	......
16	......	......	19	134	74	25	8.4	9.6	9.6	14	11	......
17	......	......	19	98	74	25	8.4	10	9.6	14	10	......
18	......	59	92	86	59	22	8.4	10	10	13	10	......
19	......	167	104	74	54	19	10	25	10	12	11	......
20	......	134	69	64	64	19	11	59	9.6	14	11	......
21	......	285	40	80	167	22	13	92	8.4	14	11	......
22	......	350	32	98	104	19	13	69	10	13	11	......
23	......	328	32	126	80	18	11	40	10	13	12	......
24	......	328	40	111	59	16	12	25	9.6	12	10	......
25	......	265	92	86	54	16	12	20	8.4	12	10	......
26	......	205	118	104	59	14	10	19	19	11	10	......
27	......	167	111	134	49	12	12	16	19	11	10	......
28	......	134	158	167	49	12	12	14	15	10	10	......
29	......	134	265	185	44	12	10	14	15	10	10	......
30	......	......	372	118	44	12	10	15	16	10	10	......
31	......	......	350	......	40	......	8.4	26	......	10	......	......

NOTE.—Daily discharges computed from a rating table well defined for 1911 and fairly well defined for 1912.

Monthly discharge of Rock River at Luverne.

[Drainage area, 440 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
August (23-31)	16	13	15.7	0.036	0.019	B
September	246	13	79.8	.181	.20	B
October	1,080	32	326	.741	.85	B
November	95	......	53.6	.122	.14	C
December	......	......	23	.052	.06	D
1912.						
January	......	......	2.0	.0046	.005	......
February	350	......	91.7	.208	.22	C
March	372	19	84.0	.191	.22	B
April	306	36	112.0	.255	.28	B
May	167	40	82.8	.188	.22	B
June	40	12	21.6	.049	.05	C
July	19	8.4	10.9	.025	.03	C
August	92	8.4	19.2	.044	.05	C
September	40	8.4	14.2	.032	.04	C
October	22	10	12.9	.029	.03	C
November	12	10	10.5	.024	.03	C

NOTE.—Discharge from November 25, 1911, to February 18, 1912, estimated from observer's notes, climatological records and one discharge measurement.

SANITARY STATISTICS.

To determine the sanitary quality of the water in Rock River and the extent to which it is used for municipal purposes, data showing the source of municipal supply, and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on the river. These data are given in the following table:

Municipal water supply and sewage disposal of towns on Rock River.

Town.	Distance above State line.	Population 1910.	Water Works System.			Sewerage System.		Rural population of basin per square mile.
			Source of Supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
Luverne	15	2,540	Shallow wells	no	150,000	river	no	15.6

From the preceding table it appears that above Luverne, the river receives no urban sewage. At that point untreated sewage from a population of 2,540 enters the river, and as the river has considerable fall, pollution from that source will extend to the State line. The rural population of the basin is 15.6 per square mile.

River water is not used for municipal purposes.

UNDEVELOPED WATER POWER ON MINOR STREAMS TRIBUTARY TO MISSISSIPPI RIVER.

There are a number of smaller streams tributary to the Mississippi for which no records of flow are available, but where there are sufficient elevations to give an approximate idea of the fall. The data for these streams are presented herewith—arranged in descending order.

LEECH LAKE RIVER.

The following table of elevations and distances along Leech Lake River has been compiled from various sources.

Elevations and distances along Leech Lake River from mouth to Leech Lake.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to Point.		Total.	Per mile.
Mississippi River	0		1,285		
Mud Lake outlet	3	3	1,287	2	0.7
Range line 27-28	15	12	1,291	4	.3
Foot of Leech Lake dam	18	3	1,293	2	.7
Crest of Leech Lake dam	18	0	1,298	5	
Leech Lake	20	2	1,298	0	0.0

BOY RIVER.

The following table of elevations and distances along Boy River has been compiled from various sources:

Elevations and distances along Boy River from mouth to Tenmile Lake.

Point.	Distance in miles.		Elevation in feet above sea level	Ascent in feet between points.	
	Above mouth.	Point to Point.		Total.	Per mile.
Leech Lake	0	....	1,299	....	....
Boy Lake outlet	7	7	1,299	0	....
Ingnadona Lake outlet	16	9	1,311	12	1.3
Rice Lake outlet	21	5	1,311	0	....
Girl Lake outlet	25	4	1,327	16	4.0
Woman Lake outlet	29	4	1,327	0	....
Whitefish Lake outlet	42	13	1,363	36	2.8
Fourteen Mile Lake outlet	47	5	1,380	17	3.4
Ten Mile Lake outlet	51	4	1,381	1	.2

PRAIRIE RIVER.

To determine the power and storage available on Prairie River a survey extending from the mouth to the outlet of Crooked Lake was made in 1911. The results of this survey are given on plates 52 to 54 inclusive of the atlas, and from them the following table of elevations and distances has been compiled:

Elevations and distances along Prairie River from mouth to outlet of Crooked Lake.

Station.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	From Mouth.	Point to Point.		Total.	Per mile.
Mississippi River	0	....	1,246.5	....	....
Great Northern Ry	1.0	1.0	1,247	0.5	0.5
....	1.8	.8	1,254	7	.9
Township line, T. 55-56 (foot of rapids)	6.0	4.2	1,256	2	.5
Outlet lower Prairie Lake	6.6	.6	1,278.5	22.5	37.5
Inlet lower Prairie Lake	7.6	1.0	1,278.5	0	....
Crest of logging dam (Upper Prairie Lake)	7.7	.1	1,287.5	9	90.0
Inlet upper Prairie Lake	11.0	3.3	1,287.5	0	....
Clearwater Creek	15.9	4.9	1,291.5	4	.8
T. 56 N., R. 25 W—T. 57 N., R. 24 W.	18.4	2.5	1,295.5	4	1.6
Sec. 32-33, T. 57 N., R. 24 W	22.8	4.4	1,297	1.5	.3
Outlet of Lawrence Lake	27.3	4.5	1,300.9	3.9	.9
Inlet of Lawrence Lake	30.7	3.4	1,300.9	0	....
Outlet of Crooked Lake	32.6	1.9	1,301.5	.6	.3

A study of the foregoing table and the topographic sheets shows one important power site as follows:

A 17-foot dam at the outlet of the lower Prairie Lake at mile 6.3 (elevation 1273) would raise the water level in the lower lake

11 feet, and in the upper lake 2.4 feet, completely submerging the existing fall between the two, which is utilized by a logging dam. The area of the pond at elevation 1290 would be 1,038 acres. Very little land would be overflowed by the 17-foot dam, but if a dam of greater height were built, a considerable area of cultivated land on the upper lake would be overflowed. An additional head of 16 feet could be obtained by a canal and pipe line a few hundred feet long below the dam. This would give a total available head of 33 feet.

STREAM GAGING RECORDS.

The following miscellaneous discharge measurements have been made on Prairie River just below Lower Prairie Lake.

Discharge measurements of Prairie River below lower Prairie Lake.

Date.	Hydrographer.	Gage Height.	Discharge.
		Feet.	Sec.-ft.
1909.			
June 8	J. C. Hoyt		187
Do 29	G. A. Gray	9.68	509
August 4	do	8.35	120
Do 25	do	10.55	1,220
October 2	do	9.05	293
1911.			
August 20	G. L. Rosing	8.17	96

PINE RIVER.

The following table of elevations and distances has been compiled from various sources:

Elevations and distances along Pine River from mouth to Jack Pine Lakes.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to Point.		Total.	Per mile.
Mississippi River	0		1,180		
Little Pine River	5	5	1,185	5	1.0
Pine Lake, outlet	12	7	1,200	15	2.1
Pine River dam, foot	15	3	1,220	20	6.7
Pine River dam, crest	15	0	1,236	16	
Whitefish Lake, inlet	24	9	1,236	0	0.0
Norway Lake	33	9	1,284	48	5.3
Lake Hattie	40	7	1,308	24	3.4
Rice Lake	46	6	1,310	2	.3
Pine Mountain Lake, outlet	48	2	1,324	14	7.0
Pine Mountain Lake, inlet	51	3	1,324	0	0.0
Jack Pine Lakes	60	9	1,394	70	7.8

HUDSON BAY DRAINAGE AREAS.

RED RIVER BASIN.

SOURCE, COURSE AND TRIBUTARIES.

Red River rises in Minnesota, its most remote source being a small lake near the southwest corner of Clearwater County, about 13 miles west of Lake Itasca, at an elevation of about 1,550 feet above sea level. From this lake it flows southward 60 miles (measured in a direct line) through a succession of small lakes to Ottertail Lake (elevation 1,320 feet); thence westward 100 miles to Breckenridge, Minn., and Wahpeton, N. D. (elevation 943 feet); from this point it runs northward 395 miles to the International Boundary and approximately 150 miles further to the southern end of Lake Winnipeg. This body of water is about 250 miles long, and from its north end Nelson River flows northeastward 400 miles to Hudson Bay.

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

The principal tributaries of Red River from the east, or Minnesota side are Pelican, Buffalo, Wild Rice, Red Lake, Snake, Tamarack, Two Rivers, and Roseau rivers. From the west or North Dakota side, Bois des Sioux, Wild Rice, Sheyenne, Goose, Park and Pembina rivers. The Bois des Sioux forms the Minnesota—North Dakota boundary throughout its length, but is of little importance otherwise, as it is merely a prairie stream with very small flow except during a few weeks in the spring.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

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

Although the main branch of Red River is Ottertail River, the term Red River Valley is applied to the valley of the Bois des Sioux rather than to that of the Ottertail and extends from Lake Traverse northward to Lake Winnipeg. This valley is a plain from 30 to 50 miles wide and 315 miles long. As the elevation of Lake Traverse is 970 feet and that of Lake Winnipeg 710 feet, the fall of the valley in the entire distance is 260 feet or considerably less than 1 foot per mile. Lake Traverse is 15 miles long and from 1 to $1\frac{1}{2}$ miles wide and is shallow, being for the most part less than 10 feet in depth; it is bordered on either side by bluffs rising from 100 to 150 feet above the lake level. Those bluffs continue on each side of Browns Valley to Bigstone Lake, where they have the same height. During the glacial epoch Red River Valley was occupied by an immense lake, now called Lake Agassiz, which had its outlet through Browns Valley into Bigstone Lake and through the present Minnesota Valley. At the present time there is water connection between the two lakes during periods of very high water, as the watershed between the two is a marsh that is only 3 feet above Lake Traverse and 11 feet above Bigstone Lake.

In addition to the gentle northward slope of the valley, there is a gentle slope toward the center from each side. In this axial depression Red River has cut a channel 20 to 60 feet deep. Between the drainage lines of the tributaries which cross the valley at right angles to the river, there are areas from 5 to 15 miles wide that have no water courses.

The entire area is covered with a sheet of blue till, consisting of a mixture of sand, clay and gravel. The portion of the basin formerly occupied by Lake Agassiz is covered with a deposit of lacustrine clay. The basin is underlain by Cretaceous rocks. In one of these rocks, the Dakota sandstone, is found the source of the artesian water in North and South Dakota. In the lower portion of the valley, especially in Kittson County, salt water is found not only in the gravel beds of the glacial drift, but also on the underlying rock; much of the surface water is also permeated by salt.

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

East of a north-south line drawn about 50 miles east of the main Red River the whole country is heavily timbered; west of such a line it is open prairie, treeless except along the streams. A further description of the eastern portion of the basin is given in the description of the areas drained by Wild Rice and Red Lake rivers.

RAINFALL AND RUNOFF.

The mean annual rainfall of the Red River drainage area increases uniformly from west to east, being 15 to 18 inches at the western boundary, 19 to 24 inches at stations in the middle of the valley, and 24 to 26 inches at the eastern boundary. About 75 per cent of the total rainfall occurs in the six months from April 1 to September 30. The longest rainfall record in the valley is that at Pembina, N. D., which extends back to 1872. Since that time the year of heaviest rainfall was 1878 when the rainfall was 34 inches. The driest year was 1910, when the rainfall varied from 10 to 16 inches in different portions of the valley.

Owing to the larger rainfall on the eastern side of the area, the runoff per square mile is much greater than in the western portion. Continuous runoff records have been maintained on Red River since 1900. During this period, the runoff has varied from 1.44 to 6.42 inches or from 5.9 to 23.1 per cent of the rainfall, in the portion of the area above Fergus Falls; and from 0.41 to 2.51 inches or 1.8 to 11.3 per cent of the rainfall at Grand Forks. In the first instance the runoff is from an area that is largely timbered while in the latter instance the records represent the flow from both the timbered area on the east and the prairie region on the west. The runoff above Fergus Falls is from an area of many lakes, while the percentage of lake area in the latter case is very small.

The following table shows the annual variation between rainfall and runoff:

Relation between rainfall and runoff.

Station.	Year.	Rainfall.	Run-off.	Per cent.
Ottertail above Fergus Falls	1900	27.00	2.15	8.0
	1901	25.14	2.62	9.9
	1902	23.70	3.25	13.7
	1903	26.35	2.94	11.2
	1904	22.94	3.99	17.4
	1905	31.14	5.25	16.8
	1906	33.62	6.42	19.1
	1907	21.93	5.07	23.1
	1908	26.48	3.92	14.8
	1909	29.37	3.81	13.0
	1910	13.94	2.08	14.9
	1911	24.36	1.44	5.9
Red at Grand Forks	1903	23.04	1.63	7.1
	1906	26.58	2.51	9.4
	1907	19.61	2.02	10.3
	1908	22.14	1.68	7.5
	1909	25.56	1.42	5.6
	1910	11.35	1.28	11.3
	1911	22.56	.41	1.8

FLOODS.

Red River owing to its tortuous course, gentle slope, and northward discharge is subject to severe floods in the spring of the year when the ice breaks up. As the upper portion of the drainage area is the most southerly, the upper reaches of the river usually break up several days or weeks earlier than the lower, which lies in a colder region. Not only is the water from the melting snow from the upper portion of the basin held back by the ice in the lower portion, but this causes the runoff from both the upper and lower portions of the average area to reach the lower portion of the channel at the same time greatly overtaxing its capacity and causing the river to inundate a large portion of the adjacent valley. If the same amount of water were released over the whole basin in a single day (as may occur in the summer months during a heavy widespread storm) the water from the nearest portion of the basin would reach the mouth of the river long before that from the more remote portions and the rise would be less violent though more prolonged.

The following table [a] shows the maximum stage of Red River at Grand Forks for each year since 1882. Prior to 1902 the records were obtained from the U. S. Engineer gage, but since that time from that of the U. S. Geological Survey gage. All readings have been referred to the latter datum.

Maximum stage of Red River at Grand Forks.

Year.	Date of opening.	Date.	Maximum stage of River.	Year.	Date of opening.	Date.	Maximum stage of River.
1882...	....	April 18....	48.0	1898...	April 15....	April 14....	15.0
1883...	....	April 26....	42.2	1899...	April 19....	April 17....	20.9
1884...	....	April 16....	31.1	1900...	April 14....	October 13	16.5
1885...	....	April 17....	23.1	1901...	April 9....	April 7....	26.3
1886...	....	April 13....	20.0	1902...	April 7....	March 31	26.0
1887...	....	April 16....	16.1	1903...	April 13....	April 11....	28.0
1888...	....	April 19....	29.5	1904...	April 18....	April 27....	40.6
1889...	....	April 1....	12.0	1905...	April 7....	May 16....	26.0
1890...	April 14....	April 15....	10.6	1906...	April 9....	April 18....	36.0
1891...	April 16....	April 13....	17.7	1907...	April 8....	April 7....	40.0
1892...	....	April 17....	33.4	1908...	April 12....	April 11....	32.8
1893...	....	April 24....	45.5	1909...	April 20....	April 8....	21.5
1894...	April 13....	April 24....	26.9	1910...	March 22	March 22	30.7
1895...	April 15....	April 6....	9.9	1911...		June 12....	10.65
1896...	April 18....	May 30....	32.0	1912...		April 9....	12.7
1897...	April 10....	April 10....	50.2				

(The average summer stage is from 6 to 8 feet on the gage.)

From the foregoing table it will be seen that in 31 years the maximum stage for all but 4 years has occurred during the spring breakup. The flood of April, 1897, is the highest on record, although it is stated that the flood of 1850 reached a stage corresponding to 60 feet on the present gage.

[a] "The Red River of the North," by Elwyn F. Chandler.

NAVIGATION.

Red River is navigable from Grand Forks down to Winnipeg. Theoretically it is navigable from Grand Forks up to Breckenridge except during low water, but in recent years there has been no traffic except in the lower 25 miles of this stretch, and many fixed bridges have been built, practically closing it to navigation.

Prior to the building of the railroads, Red River was the great highway of the valley, but river transportation could not compete with the railroads and it gradually declined, until a few years ago when it was revived. In 1907 the Red River Transportation Company which operates above and below Grand Forks for a distance of 30 or 40 miles in each direction, carried 225,000 bushels of grain, and in 1909 800,000 bushels.

For 30 years the Federal Government has been at work improving Red River for navigation chiefly by dredging, and by removing snags and boulders. The chief aim has been to provide a channel 60 feet wide, and 4 feet deep at low water from Grand Forks to the International Boundary.[a]

REGULATION OF FLOW.

The head waters of the tributaries from the Minnesota side are regulated naturally to a certain extent by lakes and swamps, and artificially by means of logging dams. The portion of the runoff thus controlled is so small as compared with the total runoff that it is probable the effect on the flow of Red River below the mouth of the Boise des Sioux is slight. There are no dams on Red River itself, but on the Ottertail there are a number of logging dams above Otterail Lake which control the flow in the upper section. The natural regulation afforded by Ottertail Lake which is below all such dams, destroys any effect on the flow of the lower river that might be caused by the operation of the logging dams.

Below Ottertail Lake there are a number of power dams, but the pondage above these dams is so small that the effect of the slight storage thus afforded on Red River itself, is negligible.

DRAINAGE WORK.

To show the present status of drainage work in the Minnesota portion of the Red River Valley the following table has been compiled from the Report of the State Drainage Commission. The counties are arranged in descending order beginning at Lake Traverse:

[a]Taken chiefly from "The Red River of the North," by Elwyn F. Chandler.

Drainage work in Red River basin.

County.	Original area of swamp lands.	Benefited by drainage, acres.
Traverse	42,000	100,000
Grant	33,000	53,600
Wilkin	50,000	221,000
Ottertail	162,000	31,500
Clay	230,000	280,200
Becker	50,000	4,200
Norman	50,000	185,500
Mahnomen	50,000	0
Polk	174,000	1,052,000
Clearwater	72,000	24,200
Red Lake	202,000	902,500
Marshall	258,000	925,100
Kittson	184,000	332,500
Roseau	534,000	399,700

In most of the counties it will be noted that the acreage benefited exceeds the original swamp area. It is therefore evident that much of the land benefited was not classed as swamp land. Also it should be understood that "land benefited" does not necessarily mean "land reclaimed" as many of the drainage systems included above have simply the main outlet ditch completed. Before the land will be reclaimed it will be necessary to construct additional laterals.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Red River basin.

River.	Drainage area above.	Square miles.
Ottertail	Pine Lake outlet	690
Do	Ottertail Lake outlet	1,160
Do	Gaging station sec. 19, T. 133 N., R. 42 W	1,310
Do	Fergus Falls	1,360
Do	Sec. 6, T. 132 N., R. 43 W	1,800
Do	Mouth Bois des Sioux River	2,080
Red	Fargo	6,020
Do	Grand Forks	25,000
Do	International Boundary	34,300
Toad	Mouth	111
Dead Lake outlet	Mouth	111
Battle Lake outlet	Mouth	171
Pelican	Lake Lizzie outlet	310
Do	Gaging station in sec. 18 (Fergus Falls township)	433
Do	Mouth	450
Bois des Sioux	Lake Traverse outlet	1,110
Do	Mouth	1,740
Mustinka	South Branch	225
Do	Mouth	814
South Branch Mustinka	Mouth	129
West Branch Mustinka	Mouth	286
Rabbit	Mouth	282
Buffalo	South Branch	573
Do	Mouth	1,400
South Branch Buffalo	Mouth	621
Marsh	Mouth	297
Sand Hill	Mouth	535
Snake	Mouth	1,040
Middle River	Mouth	397
Tamarack	Mouth	578
Two Rivers	Mouth	1,020
North Branch Two Rivers	Mouth	198

Drainage areas in Red River basin—Continued.

River.	Drainage area above.	Square miles.
South Branch Two Rivers	Gaging station at Hallock	776
Do	Mouth	813
Roseau	Roseau Lake outlet	979
Roseau	International Boundary	1,350
West Branch Roseau	Gaging station sec. 7, T. 161 N., R. 39 W	265
North Branch	Mouth	290
Wild Rice (North Dakota)	Mouth	[a]1,400
Sheyenne	Mouth	[a]7,000
Elm	Mouth	[a] 610
Goose	Mouth	[a]1,450
Forest	Mouth	[a] 890
Park	Mouth	[a]1,010
Pembina	Mouth	[a]3,440

[a] "The Red River of the North," by Elwyn F. Chandler.

GAGING STATION RECORDS.

OTTERTAIL RIVER AT OTTERTAIL LAKE OUTLET.

Location.—At the outlet of Ottertail Lake in Sec. 4, T. 133 N., R. 40 W. There is no tributary of importance between the lake and the station at Three-mile Bridge. This station was maintained by the U. S. Engineer Corps.

Records available.—May 1, 1899, to May 14, 1904; compiled from unpublished data in the United States Engineer Office at St. Paul.

Drainage area.—1,160 square miles.

Gage.—No data. This was of relatively little importance as discharge measurements were made daily and the estimates based almost directly on these.

Discharge measurements.—Made from bridge and by wading.

Winter flow.—The river is frozen over during the winter months but measurements were made to determine the winter flow.

Daily discharge, in second-feet, of Ottertail River at Ottertail Lake outlet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1					250	295	679	450	450	300	300	300
2					250	338	675	400	400	325	300	325
3					250	332	718	400	350	300	275	325
4					250	345	742	400	380	300	280	250
5					250	329	716	375	400	320	275	350
6					250	374	702	400	400	350	260	300
7					253	370	759	360	400	325	260	300
8					247	415	712	700	425	300	325	275
9					218	408	831	600	450	250	375	300
10					205	414	735	500	475	275	350	300
11					212	526	740	400	425	300	350	300
12					229	526	746	400	425	300	350	300
13					220	565	740	450	400	275	350	375
14					201	646	662	430	375	250	325	300
15					214	655	673	425	400	225	325	300
16					230	555	630	400	380	275	350	300
17					209	561	645	475	380	275	325	275
18					223	652	667	500	375	300	325	300
19					236	651	685	600	360	275	350	300
20					236	635	640	600	350	275	350	300

Daily discharge, in second-feet, of Ottertail River at Ottertail Lake Outlet—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
21	......	......	......	......	236	655	625	600	375	275	360	300
22	......	......	......	......	238	684	574	550	350	300	360	300
23	......	......	......	......	246	710	568	475	400	275	325	300
24	......	......	......	......	241	719	600	525	420	275	350	300
25	......	......	......	......	247	702	611	500	375	275	325	300
26	......	......	......	......	246	697	604	450	375	260	325	300
27	......	......	......	......	237	734	576	475	325	280	350	300
28	......	......	......	......	240	754	516	475	350	300	350	300
29	......	......	......	......	258	698	502	500	350	275	350	300
30	......	......	......	......	255	714	453	460	325	275	325	300
31	......	......	......	......	293	......	407	450	......	300	......	300
1900.												
1	......	......	235	187	220	163	112	78	143	176	213	206
2	......	......	235	188	214	156	117	88	150	177	211	210
3	......	......	235	181	200	159	110	92	157	175	212	213
4	......	......	235	195	171	162	114	92	144	172	215	213
5	......	......	235	201	226	164	129	105	144	177	218	217
6	......	......	235	193	213	152	117	118	142	175	219	208
7	......	......	235	193	199	149	121	100	136	178	219	201
8	......	......	235	221	202	147	117	100	140	181	215	211
9	......	......	235	223	199	134	113	148	138	193	213	208
10	......	......	235	219	197	135	106	137	136	189	214	206
11	......	......	235	208	190	136	109	160	150	192	212	202
12	......	......	235	207	211	132	103	146	137	184	211	195
13	......	......	235	215	203	136	106	132	140	200	209	206
14	......	......	235	206	195	132	103	133	146	200	212	194
15	......	......	235	204	181	138	106	135	161	201	174	199
16	......	......	235	203	182	132	109	138	163	188	214	203
17	......	......	235	227	180	133	105	135	165	193	212	206
18	......	......	235	189	193	133	106	135	166	198	200	190
19	......	......	235	178	183	127	106	139	159	193	95	199
20	......	......	171	202	183	131	94	142	165	197	166	201
21	......	......	191	212	183	120	91	148	166	200	200	194
22	......	......	191	203	181	123	96	153	164	203	196	189
23	......	......	191	194	178	119	100	146	163	194	201	171
24	......	......	191	192	187	118	89	155	163	206	216	168
25	......	......	191	199	172	117	91	155	167	208	213	189
26	......	......	212	202	182	119	94	150	165	202	211	199
27	......	......	193	216	176	122	71	144	173	204	204	191
28	......	......	188	222	170	110	75	142	176	203	221	191
29	......	......	188	218	172	114	74	153	169	203	222	191
30	......	......	188	214	171	107	72	153	170	219	211	186
31	......	......	187	......	165	......	75	152	......	216	......	181
1901.												
1	180	159	126	184	164	223	243	412	365	202	186	176
2	181	155	123	181	176	224	244	446	362	204	184	147
3	198	155	124	174	174	226	243	427	360	203	182	171
4	197	154	126	184	180	226	286	430	360	202	180	164
5	182	152	131	187	180	222	329	432	350	203	172	160
6	186	151	136	176	181	227	315	417	345	205	192	178
7	181	149	134	181	190	221	333	387	330	207	216	174
8	175	154	132	185	181	220	351	378	325	204	238	180
9	180	151	134	191	195	222	360	358	319	207	240	186
10	171	149	137	204	193	225	326	415	289	198	240	169
11	167	147	140	199	184	220	347	412	266	195	239	177
12	177	146	142	207	187	205	337	409	308	211	240	158
13	174	142	143	209	189	211	323	414	315	208	221	158
14	171	148	141	207	188	224	339	421	310	204	223	141
15	170	134	143	205	186	221	355	408	309	192	196	144
16	170	130	138	220	203	223	375	468	309	200	211	147
17	169	131	139	222	218	224	350	419	269	192	191	131
18	168	131	140	223	213	227	397	402	250	188	171	145
19	168	132	150	214	215	227	385	385	251	181	228	145
20	167	141	146	219	217	233	365	392	252	182	240	175
21	166	132	157	222	216	232	375	374	238	183	226	190
22	175	140	160	224	217	234	385	390	234	176	206	175
23	166	136	160	215	230	239	369	369	230	166	206	160
24	164	136	160	210	219	244	359	363	257	161	208	170
25	169	136	161	221	217	250	358	359	226	174	212	165

Daily discharge, in second-feet, of Ottertail River at Ottertail Lake Outlet—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
26	171	127	166	215	215	231	365	355	222	172	207	159
27	170	130	160	227	214	247	407	348	210	167	213	159
28	169	126	179	191	219	234	414	371	205	162	218	175
29	157	......	178	155	226	250	421	376	205	174	223	164
30	153	......	172	156	227	259	416	358	206	164	205	162
31	152	......	178	......	220	......	400	367	......	180	......	151
1902.												
1	149	146	149	171	198	564	594	459	313	219	228	219
2	147	147	147	175	192	573	578	434	312	224	222	224
3	146	147	146	160	194	577	582	426	297	222	216	138
4	152	144	157	164	194	596	572	417	287	212	227	206
5	164	144	163	172	194	579	561	413	273	212	224	208
6	175	144	161	170	233	668	552	404	279	212	227	212
7	166	138	169	169	217	658	543	409	270	217	216	199
8	178	135	157	170	218	651	580	385	262	226	223	185
9	175	136	163	175	228	644	564	378	266	220	200	188
10	184	137	169	143	223	674	552	376	253	216	178	185
11	185	154	166	68	232	729	524	363	254	218	220	172
12	169	124	182	16	241	688	523	343	249	217	193	182
13	153	144	160	100	372	695	515	356	242	215	238	179
14	156	146	156	145	346	671	506	355	242	196	228	187
15	169	144	158	145	341	655	515	369	242	206	236	195
16	160	145	162	139	377	660	545	342	244	208	236	188
17	179	146	162	134	380	640	522	345	234	211	236	189
18	165	145	166	137	411	628	513	348	247	210	234	206
19	173	145	167	128	442	651	522	327	236	205	232	192
20	181	145	175	132	416	635	504	329	238	200	217	196
21	164	145	175	135	434	627	486	324	231	196	222	197
22	169	147	176	142	445	620	489	317	225	208	234	187
23	162	148	175	139	439	619	488	309	230	204	232	183
24	153	146	174	120	464	609	472	305	231	215	230	111
25	150	154	186	129	462	616	472	301	224	213	233	140
26	147	148	181	138	460	617	480	317	235	210	56	169
27	145	135	165	180	446	585	468	316	230	210	167	163
28	143	141	174	184	428	589	455	304	231	222	219	164
29	136	......	165	188	524	584	453	281	232	211	219	164
30	149	......	169	192	566	579	468	302	233	216	219	157
31	135	......	172	......	556	......	446	310	......	215	......	148
1903.												
1	152	102	101	205	321	394	298	189	177	264	375	337
2	156	111	113	226	342	387	290	193	187	267	381	322
3	161	98	123	226	339	373	293	197	180	296	381	339
4	158	107	129	226	336	366	280	196	180	299	382	303
5	154	102	136	232	342	378	280	192	177	302	375	332
6	145	104	147	239	344	362	267	197	175	319	379	334
7	100	103	133	251	322	372	255	197	180	313	368	336
8	101	105	139	250	330	381	273	191	180	321	381	328
9	104	106	144	260	368	365	269	189	189	324	393	324
10	98	107	150	247	345	354	267	186	210	325	373	334
11	95	104	159	275	354	353	260	184	205	323	374	313
12	92	44	163	279	363	349	261	176	213	322	373	304
13	112	120	159	282	359	355	262	170	216	335	350	296
14	94	106	161	282	366	360	256	174	219	331	360	288
15	91	111	165	285	349	363	243	171	226	354	171	298
16	56	116	169	293	341	354	231	169	237	346	82	308
17	125	103	170	286	355	346	224	167	230	340	83	301
18	121	101	174	282	360	352	210	182	226	361	259	300
19	116	97	172	322	401	347	217	180	222	341	294	309
20	95	95	194	330	414	347	189	174	223	366	279	298
21	119	94	192	330	420	348	204	173	224	354	281	288
22	109	95	197	335	413	348	203	176	235	353	319	283
23	100	97	201	337	404	332	202	175	248	360	324	288
24	96	101	195	336	408	327	186	175	234	364	321	280
25	100	104	203	337	413	325	180	167	249	365	328	279
26	104	105	189	323	403	312	205	174	237	368	325	270
27	116	107	199	309	404	302	229	170	250	364	322	275
28	105	89	199	343	394	306	221	181	246	363	340	280
29	102		202	336	405	310	199	176	242	360	340	270
30	99		204	327	394	308	207	172	259	369	357	276
31	93		202		390		195	167	......	371	......	262

Daily discharge, in second-feet, of Ottertail River at Ottertail Lake Outlet—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	261	216	193	213	434							
2	257	223	194	224	435							
3	253	200	110	232	434							
4	252	200	179	240	445							
5	247	208	184	239	463							
6	254	206	191	240	482							
7	240	206	198	246	516							
8	243	207	186	285	528							
9	246	208	201	285	539							
10	240	200	190	292	548							
11	233	205	201	300	547							
12	244	200	200	301	533							
13	240	188	198	305	571							
14	225	185	196	312	567							
15	239	183	196	328								
16	235	179	201	323								
17	238	193	205	339								
18	241	195	196	343								
19	236	199	202	348								
20	236	195	209	348								
21	236	195	217	351								
22	234	191	202	351								
23	196	190	208	364								
24	196	190	208	380								
25	197	179	211	396								
26	219	187	215	409								
27	214	173	211	411								
28	211	181	207	402								
29	211	189	215	424								
30	220		222	432								
31	210		210									

Monthly discharge of Ottertail River at Ottertail Lake outlet.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.				Run-off. (depth in inches on drainage area.)
	Maximum.	Minimum.	Mean.	Per square mile.	
1899.					
May	293	201	238	0.205	0.24
June	754	295	555	.478	.53
July	831	407	649	.559	.64
August	700	360	481	.415	.48
September	475	325	393	.339	.38
October	350	225	291	.251	.29
November	375	260	328	.283	.32
December	375	250	302	.260	.30
1900.					
January			235	.203	.23
February			235	.203	.21
March	235	171	218	.188	.22
April	227	178	204	.176	.20
May	226	165	190	.164	.19
June	164	107	134	.116	.13
July	129	71	97.9	.084	.097
August	160	78	132	.114	.13
September	176	136	155	.134	.15
October	219	172	193	.166	.19
November	222	95	205	.177	.20
December	217	168	198	.171	.20
The year	235	71	183	.158	2.15

Monthly discharge of Ottertail River at Ottertail Lake Outlet—Continued

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)
	Maximum.	Minimum.	Mean.	Per square mile.	
1901.					
January	198	152	172	0.148	0.17
February	159	126	142	.122	.13
March	179	123	147	.127	.15
April	227	155	200	.172	.19
May	230	164	201	.173	.20
June	259	205	229	.197	.22
July	421	243	351	.303	.35
August	468	348	395	.341	.39
September	365	205	283	.244	.27
October	211	161	189	.163	.19
November	240	171	210	.181	.20
December	190	131	163	.141	.16
The year	468	123	224	.193	2.62
1902.					
January	185	135	161	.139	.16
February	154	124	144	.124	.13
March	186	146	166	.143	.16
April	196	16	145	.125	.14
May	566	192	351	.303	.35
June	729	573	629	.542	.60
July	594	446	518	.447	.52
August	459	281	354	.305	.35
September	313	224	251	.216	.24
October	226	196	212	.183	.21
November	238	56	215	.185	.21
December	224	111	182	.157	.18
The year	729	16	277	.239	3.25
1903.					
January	161	56	112	.097	.11
February	120	44	101	.087	.091
March	204	101	167	.144	.17
April	343	205	286	.247	.28
May	420	321	371	.320	.37
June	394	302	349	.301	.34
July	298	180	237	.204	.24
August	197	167	180	.155	.18
September	259	175	216	.186	.21
October	371	264	337	.291	.34
November	393	82	322	.278	.31
December	339	262	302	.260	.30
The year	420	44	248	.214	2.94
1904.					
January	261	196	232	.200	.23
February	223	173	196	.169	.18
March	222	110	199	.172	.20
April	432	213	322	.278	.31
May (1-14)	567	435	503	.434	.23

OTTERTAIL RIVER NEAR FERGUS FALLS.

Location.—Three-mile bridge, 3½ miles northeast of Fergus Falls, between Secs. 18 and 19, T. 133 N., R. 42 W., several miles above the outlet of Wall Lake, and 20 miles below Ottertail Lake, through which the river flows.

Records available.—May 9, 1904, to December 31, 1912. A gaging station was maintained from May 1, 1899, to May 14, 1904, by the United States Engineer Corps at the outlet of Ottertail Lake, where the drainage area is about 12 per cent less than at the Geological Survey station, with no important tributaries intervening. The observations at Fergus

Falls in connection with those at the outlet of Ottertail Lake furnish a 14-year record of flow of the river below Ottertail Lake.

Drainage area.—1,310 square miles.

Gage.—Chain attached to the bridge; datum unchanged since establishment.

Channel.—Permanent.

Discharge measurements.—Discharge measurements are made from the bridge except at extreme low stages, when they are made at a wading section.

Winter flow.—The river is frozen over from December to March and measurements are made to determine the winter flow.

Regulation.—Ottertail Lake, about 22 square miles in area, forms a natural reservoir, regulating the flow of the river to such an extent that the recorded range of stage has not exceeded 2 feet. On the upper part of the river are a number of dams used in driving logs to the saw mill at Frazee, where the lowest dam is built. The next dam below Frazee is at Maine, several miles below Ottertail Lake, about Sec. 35, T. 134 N., R. 41 W. During the low water season the closing of the turbine gates at Maine may have an effect on the flow immediately below the dam, but small lakes through which the river flows before reaching the gaging station tend to equalize the flow at the latter plants, but owing to the fall of the river their influence is not observable at the gage.

Accuracy.—Excellent, except during 1911 when changes in chain length may cause some error in determination of discharge.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1						609	735	418	335	320	335	
2						609	692	400	350	320	335	
3						692	692	400	350	320	335	
4						735	650	400	350	320	335	
5						778	650	400	350	320	335	
6						778	609	400	350	320	335	
7						735	568	400	335	320	335	
8						735	534	400	335	320	320	
9					534	692	534	383	335	320	320	
10					534	650	534	383	335	320	320	
11					500	650	534	383	335	320	320	
12					478	650	500	366	335	320	320	
13					500	650	500	366	335	320	320	
14					534	692	500	366	320	320	320	
15					534	692	478	366	320	335	320	
16					534	692	456	366	320	335	320	
17					500	609	456	350	320	335	320	
18					500	609	500	350	320	335	320	
19					534	609	500	350	320	335	320	
20					534	568	478	350	320	335	320	
21					568	568	478	350	320	320	320	
22					609	568	456	350	320	320	320	
23					609	1,080	437	350	320	320	335	
24					650	820	437	335	320	320	335	
25					650	778	437	335	320	320	335	
26					609	735	418	335	320	335	335	
27					609	735	418	335	320	335	335	
28					609	692	437	335	320	335	335	
29					609	735	437	335	320	335	335	
30					609	735	418	335	320	335	335	
31					650		418	335		335		

Daily discharge, in second-feet, of Ottertail River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1				255	315	526	665	726	789	665	552	
2				255	315	526	665	726	789	665	552	
3				255	449	580	696	726	758	665	552	
4				274	449	580	726	726	758	665	552	
5				274	449	607	758	855	758	665	552	
6				274	449	607	758	855	758	665	552	
7				294	449	607	789	855	726	665	552	
8				294	449	607	758	855	726	665	552	
9				294	449	607	758	855	726	665	552	
10				236	449	607	726	822	726	636	552	
11			357	236	607	580	726	822	726	636	552	
12			402	236	607	580	726	789	726	607	552	
13			402	274	607	607	726	726	758	607	552	
14			402	274	607	607	726	726	758	607	552	
15			380	315	607	607	726	758	758	607	552	
16			380	315	607	607	726	758	758	607	552	
17			402	315	580	619	726	789	75[illegible]	607	552	
18			402	315	580	607	726	789	822	580	552	
19			402	315	580	607	696	789	822	580	552	
20			402	315	552	607	696	789	822	580	552	
21			380	315	552	607	696	789	789	580	552	
22			357	315	552	607	789	789	789	580	552	
23			315	315	526	636	665	789	758	580	552	
24			274	315	526	665	665	758	758	580	552	
25			274	315	526	665	665	758	726	580	552	
26			274	315	526	665	696	758	726	580	552	
27			274	315	526	665	696	758	696	580	552	
28			274	315	526	665	726	758	696	580	552	
29			274	315	526	665	726	758	665	580	552	
30			255	315	526	665	726	758	665	580	552	
31			255		526		726	758		580		
1906.												
1				476	665	822	1,020	822	758	665	665	
2				476	696	855	1,020	822	758	665	665	
3				476	726	855	1,020	822	758	665	665	
4				476	726	855	1,020	822	758	665	665	
5				476	726	855	1,020	789	758	665	665	
6				476	726	921	1,020	789	758	665	636	
7				402	726	921	1,020	789	758	665	636	
8				402	726	954	1,020	758	758	665	636	
9				449	758	987	1,020	758	758	665	607	
10				449	758	987	987	726	758	665	607	
11				499	758	987	954	726	726	665	607	
12				499	758	987	954	726	726	665	607	
13				499	758	987	954	726	726	665	607	
14				499	789	987	954	726	726	665	607	
15				499	789	987	954	696	726	665	636	
16				499	789	987	954	696	726	665	636	
17				499	789	987	921	696	726	665	665	
18				499	789	987	921	696	726	665	665	
19				499	789	987	921	696	726	665	665	
20				499	789	987	855	665	726	665	665	
21				526	789	987	855	665	758	696	665	
22				526	789	987	855	665	726	726	665	
23				526	789	987	855	696	726	726	665	
24				552	789	987	855	726	696	726	665	
25				552	822	1,020	855	758	696	696	665	
26				607	822	1,020	855	758	696	696	665	
27				636	822	1,020	855	758	696	665	665	
28				636	822	1,020	855	758	665	665	665	
29				636	822	1,020	855	758	665	665	665	
30				665	822	1,020	855	758	665	665	665	
31					822		822	758		665		
1907.												
1				789	726	665	665	426	294	336	336	
2				726	726	665	665	426	294	336	336	
3				726	726	665	665	402	274	336	336	
4				726	726	636	636	402	274	336	315	
5				665	726	636	636	402	274	336	315	

Daily discharge, in second-feet, of Ottertail River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
6				636	726	636	636	402	274	336	315	
7				636	726	636	636	402	274	336	315	
8				636	726	636	607	402	274	357	315	
9				607	726	636	607	380	274	357	315	
10				607	726	636	607	380	274	357	315	
11				580	726	665	580	380	274	357	315	
12				580	726	665	580	380	274	357	336	
13				580	726	696	580	380	336	357	336	
14				580	696	726	580	357	336	357	336	
15				580	696	726	580	357	336	357	357	
16				607	696	726	552	357	336	336	357	
17				607	696	758	552	357	315	336	357	
18				607	696	758	552	357	315	336	357	
19				636	696	758	580	357	315	336	357	
20				636	696	726	580	336	315	336	336	
21				636	726	726	552	336	315	336	336	
22				636	726	726	552	315	315	336	336	
23				665	726	726	552	315	315	315	336	
24				665	696	726	526	315	315	315	336	
25				696	696	726	499	315	315	315	336	
26				696	696	696	474	315	315	315	336	
27				696	696	696	474	315	315	315	336	
28				696	696	696	449	315	315	315	357	
29				696	696	696	449	315	315	336	357	
30				726	665	696	449	315	315	336	357	
31					665		449	315		336		
1908.												
1				340	357	580	855	552	380	336	274	
2				340	357	580	855	552	380	336	274	
3				340	357	607	822	552	380	336	274	
4				340	357	636	822	526	380	336	274	
5				357	357	665	789	526	380	315	274	
6				357	357	665	789	526	380	315	274	
7				357	357	696	758	499	357	315	274	
8				315	357	726	758	499	357	315	274	
9				315	357	758	758	499	357	315	274	
10				294	357	822	726	499	357	315	274	
11				294	357	822	726	474	357	315	274	
12				294	380	921	726	474	357	315	274	
13				294	380	921	696	474	357	294	274	
14				294	402	921	696	449	357	294	274	
15				294	402	921	696	449	357	294	274	
16				274	426	888	665	449	357	294	255	
17				274	426	888	665	449	357	294	255	
18				274	426	888	665	426	357	294	255	
19				274	426	855	636	426	357	294	255	
20				274	449	855	636	426	357	294	255	
21				274	449	855	636	402	357	274	255	
22				274	449	855	607	402	357	274	255	
23				294	449	888	607	402	357	274	255	
24				294	474	888	607	402	357	294	255	
25				315	474	888	607	402	357	294	255	
26				336	499	888	607	402	357	294	236	
27				336	499	888	580	402	357	294	236	
28				336	499	888	580	380	357	294	236	
29				357	499	888	580	380	357	274	236	
30				357	552	855	552	380	357	274	236	
31					552		552	380		274		
1909.												
1				526	402	526	402	315	499	552	474	380
2				526	402	526	402	315	499	552	449	380
3				510	402	552	402	315	499	552	449	380
4				499	426	552	380	294	499	552	449	380
5				499	426	552	380	294	499	552	449	
6				499	426	526	380	294	526	552	449	
7				474	449	526	357	336	526	552	449	
8				474	449	526	357	336	526	552	449	
9				449	449	499	357	336	552	552	449	
10				426	449	499	357	336	552	552	449	

Daily discharge, in second-feet, of Ottertail River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
11				426	449	499	357	336	552	552	426	
12				402	449	499	357	315	552	526	426	
13				402	449	499	357	315	552	526	426	440
14				380	449	499	336	315	552	499	426	
15				357	449	499	336	336	580	499	426	
16				336	449	499	315	336	580	499	426	
17				315	449	499	315	357	580	499	426	
18				315	474	499	315	357	580	499	426	
19				315	474	499	336	380	580	499	426	
20				315	474	499	336	402	580	499	426	
21				315	474	474	336	402	580	474	426	
22				315	474	474	315	426	580	474	402	
23				336	474	474	315	449	580	474	402	
24				336	474	449	315	449	552	474	402	
25				336	499	449	315	449	552	474	402	
26				357	499	449	315	474	552	474	402	
27				357	499	426	315	474	552	474	402	
28			552	380	499	426	315	474	552	474	402	
29			552	380	499	426	315	474	552	474	380	
30			526	402	499	426	315	474	552	474	380	
31			526		526		315	474		474		
1910.												
1			200	402	449	357	236	98	43	28	85	68
2			200	402	449	357	236	85	52	28	85	74
3			200	402	449	336	236	85	43	28	85	74
4			200	402	449	336	218	85	36	22	98	74
5			200	402	449	336	218	85	36	22	111	
6			200	426	449	336	201	85	36	22	111	
7			200	426	449	336	201	85	36	22	85	
8			200	426	449	315	184	85	28	28	85	
9			200	426	449	315	184	85	22	36	85	
10			200	426	449	315	184	85	22	36	85	
11			200	426	449	315	184	74	22	36	85	
12			200	426	426	315	168	74	22	36	85	
13			200	426	426	315	168	74	16	28	85	
14			426	426	426	315	168	74	28	36	85	
15			402	449	426	315	168	62	28	36	85	
16			357	449	402	294	168	62	28	28	74	
17			357	449	402	294	168	62	28	28	74	
18			336	449	402	274	168	62	28	28	74	
19			336	449	402	274	153	62	28	43	74	
20			336	449	402	274	153	74	28	43	74	
21		219	336	449	402	274	138	74	28	52	74	
22			336	449	402	255	138	52	43	52	74	
23			315	449	402	255	138	52	43	74	74	85
24			315	449	402	255	124	36	28	85	74	
25			315	449	402	255	124	36	52	85	62	
26			315	449	380	255	111	36	62	98	62	
27			315	449	380	236	111	36	28	98	62	
28			336	449	380	236	98	36	28	85	62	
29			336	449	380	236	98	36	28	85	62	
30			380	449	380	236	98	36	28	85	62	
31			380		357		98	36		85		
1911.												
1				218	218	218	124	98	111	138	168	
2				201	218	218	111	111	98	153	153	
3				184	218	218	124	124	111	153	168	
4				201	236	218	124	124	98	168	153	
5				184	218	218	124	124	111	153	153	
6				184	218	201	124	111	124	153	153	
7				184	201	201	111	124	111	168	153	
8				201	201	201	124	124	124	153	153	
9				218	218	201	124	138	111	168	138	
10				218	218	201	124	138	124	168	153	
11				255	218	184	111	153	124	168		
12				255	218	184	98	153	111	184		
13				255	218	168	111	138	138	168		
14				255	218	168	98	153	124	184		
15				236	218	168	98	138	138	168		

Daily discharge, in second-feet, of Ottertail River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
16				236	218	168	98	138	138	168		
17				255	236	153	98	138	124	184		
18				255	236	153	98	124	138	168		
19				274	236	153	98	138	138	184		
20				236	236	153	98	124	153	168		
21				236	236	138	111	138	138	168		
22				218	236	138	111	138	138	168		
23				218	218	138	98	111	124	153		
24				255	218	124	111	124	138	168		
25				236	218	124	98	111	124	153		
26			168	236	218	124	98	124	138	153		
27			201	236	218	124	98	124	153	168		
28			201	236	218	138	98	98	138	153		
29			218	255	218	138	98	111	153	168		
30			236	236	218	124	98	98	138	153		
31			236		218		111	111		153		
1912.												
1					236	336	274	184	168	201	201	
2					236	336	315	184	201	201	201	
3					274	336	294	218	201	201	201	
4					315	336	255	184	201	201	201	
5					336	336	294	255	201	201	184	
6				201	315	336	294	218	201	201	184	
7				201	315	336	255	274	201	184	184	
8				184	294	336	402	255	201	184	201	
9				168	294	336	380	274	201	201	168	
10				138	255	294	315	236	168	168	201	
11				168	294	315	336	236	218	201	201	
12				153	294	315	315	236	218	201	201	
13				153	274	315	274	255	218	201	201	
14				168	274	315	315	255	218	201	201	
15				168	274	336	294	236	218	201	201	
16				184	274	336	294	236	218	184	201	
17				184	274	336	255	236	201	184	201	
18				201	274	336	294	236	201	184	201	
19				201	274	336	274	218	184	184	201	
20				168	201	294	236	184	153	184	168	
21				201	294	336	274	201	184	184	218	
22				201	294	336	274	201	184	184	218	
23				201	294	336	218	184	201	184	218	
24				218	294	336	255	184	201	201	218	
25	60			236	274	315	255	184	236	201	218	
26				236	274	315	255	184	236	201	201	
27				236	315	315	218	184	218	201	201	
28				236	315	315	255	184	218	201	236	
29				236	315	315	236	184	218	201	201	
30				201	274	274	201	201	218	168	200	
31					294		218	201		201		

Note.—Daily discharges computed from an excellent rating curve.

Monthly discharge of Ottertail River near Fergus Falls.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1904.						
May (9-31)	650	478	565	0.431	0.37	A
June	1,080	568	696	.531	.59	A
July	735	418	513	.392	.45	A
August	418	335	365	.279	.32	A
September	350	320	329	.251	.28	A
October	335	320	326	.249	.29	A
November	335	320	328	.250	.28	A
1905.						
March (11-31)	402	255	340	.260	.20	B
April	315	236	292	.223	.25	A
May	607	315	516	.394	.45	A
June	665	526	613	.468	.52	A
July	789	665	719	.549	.63	A
August	855	726	778	.594	.68	A
September	822	665	750	.573	.64	A
October	665	580	614	.469	.54	A
November	552	552	552	.421	.47	A
1906.						
April	665	402	517	.395	.44	A
May	822	665	772	.589	.68	A
June	1,020	822	965	.737	.82	A
July	1,020	822	932	.711	.82	A
August	822	665	742	.566	.65	A
September	758	665	727	.555	.62	A
October	726	665	674	.515	.59	A
November	665	607	649	.495	.55	A
1907.						
April	789	580	652	.498	.56	A
May	726	665	709	.541	.62	A
June	758	636	692	.528	.59	A
July	665	449	565	.431	.50	A
August	426	315	359	.274	.32	A
September	336	274	303	.231	.26	A
October	357	315	337	.257	.30	A
November	357	315	336	.256	.29	A
December			[a]300	.230	.27	C
1908.						
January			[a]260	.198	.23	C
February			[a]230	.176	.19	C
March			[a]200	.153	.18	C
April	357		312	.238	.27	A
May	552	357	421	.321	.37	A
June	921	580	813	.621	.69	A
July	855	552	686	.524	.60	A
August	552	380	454	.347	.40	A
September	380	357	362	.276	.31	A
October	336	274	301	.230	.27	A
November	274	236	261	.199	.22	A
December			[a]220	.168	.19	C
The year	921		377	.288	3.92	
1909.						
April	526	315	399	.305	.34	A
May	526	402	460	.351	.40	A
June	552	426	492	.376	.42	A
July	402	315	343	.262	.30	A
August	474	294	375	.286	.33	A
September	580	499	549	.419	.47	A
October	552	474	511	.390	.45	A
November	474	380	426	.325	.36	A
December			[a]390	.298	.34	C

[a] Estimated from a few discharge measurements.

Monthly discharge of Ottertail River near Fergus Falls—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1910.						
January			a325	0.248	0.27	C
February			a240	.168	.17	C
March	426	200	285	.218	.25	B
April	449	402	434	.331	.37	A
May	449	357	417	.318	.37	A
June	357	236	294	.224	.25	A
July	236	98	163	.124	.14	A
August	98	36	64.8	.049	.06	A
September	52	16	32.6	.025	.03	A
October	98	22	48.3	.037	.04	A
November	111	62	79.0	.060	.07	A
December			a 80.0	.061	.07	C
The year	449	16	205	.156	2.09	
1911.						
January			80.0	.061	.07	B
February			85.0	.065	.07	B
March			125	.095	.11	C
April	274	184	229	.175	.20	A
May	236	201	221	.169	.19	A
June	218	124	169	.129	.14	A
July	124	98	108	.082	.09	A
August	153	98	126	.096	.11	A
September	153	98	128	.098	.11	A
October	184	138	164	.125	.14	A
November	168		128	.098	.11	B
December			110	.084	.10	B
The year	274		140	.107	1.44	
1912.						
January			80	.061	.07	C
February			70	.053	.06	B
March			70	.053	.06	C
April	236	138	181	.138	.15	B
May	336	201	284	.217	.25	A
June	336	274	325	.248	.28	A
July	402	201	278	.212	.24	A
August	274	184	216	.165	.19	A
September	236	153	204	.156	.17	A
October	201	168	193	.147	.17	A
November	236	168	201	.153	.17	A

a Estimated from a few discharge measurements.

NOTE.—From January 1 to March 25, 1911; from November 12, 1911, to April 5, 1912, the discharge was estimated from a few discharge measurements, observer's records, and climatological records.

RED RIVER NEAR FERGUS FALLS.

Location.—At Dewey Bridge in Sec. 6, T. 132 N., R. 43 W., 3½ miles west of Fergus Falls. The nearest tributary is Pelican River which enters 1 mile above.

Records available.—June 19, 1909, to March 31, 1910.

Drainage area.—1,800 square miles.

Gage.—Vertical staff.

Discharge measurements.—Made from the bridge.

Channel.—The section was slightly within the influence of the Dayton Hollow Dam, 4 miles below, and wherever the dam was open, the station control was changed. For this reason the station was discontinued.

Accuracy.—As the station was not completely rated no estimates of discharge have been made. The base data are given herewith.

Discharge measurements of Red River near Fergus Falls.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Dis-charge.
		Feet.	Sq. ft.	Feet.	Sec.-ft.
1909.					
July 12	E. F. Chandler	124	320	6.28	499
August 4	do	123	284	6.01	404
Sept. 3	do	124	390	6.98	676
October 3	do	124	365	6.79	724

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

(Observer, M. Dewey.)

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							6.52	6.08	6.99	6.82	6.31	6.80
2							6.34	6.09	6.99	6.76	6.29	5.81
3							6.22	6.04	7.00	6.74	6.28	5.92
4							6.11	6.05	6.86	6.71	6.26	
5							6.12	6.02	6.91	6.71	6.29	
6							6.14	6.10	6.98	6.66	6.25	
7							6.06	6.61	7.01	6.64	6.27	
8							6.06	6.34	7.01	6.59	6.21	
9							6.08	6.27	7.03	6.66	6.22	
10							6.10	6.34	7.02	6.86	5.74	
11							6.15	6.42	7.01	6.39	5.88	
12							6.31	6.58	7.01	6.60	5.96	
13							6.37	6.65	7.03	6.52	5.95	
14							6.24	6.65	6.91	6.54	6.91	
15							6.16	6.56	7.02	6.51	8.58	
16							6.14	6.58	7.07	6.44	8.66	
17							6.03	6.56	7.00	6.54	8.58	
18							6.01	6.52	7.06	6.43	8.26	
19						6.13	6.07	6.54	7.08	6.42	8.16	
20						6.21	6.01	6.52	7.09	6.49	8.16	
21						6.22	6.46	6.64	7.02	6.46	8.16	
22						6.18	6.80	6.68	7.08	6.39	8.19	
23						6.18	6.55	6.84	7.06	6.42	8.25	
24						6.18	6.48	7.02	7.65	6.35	8.31	
25						6.29	6.58	6.89	7.04	6.39	8.31	
26						6.19	6.54	7.09	6.96	6.33	8.06	
27						6.16	6.30	7.07	6.90	6.32	7.82	
28						6.01	6.26	7.01	6.86	6.34	7.33	
29						6.12	6.20	6.94	6.84	6.29	7.48	
30						6.25	6.12	6.96	6.82	6.34	7.54	
31							5.99	6.98		6.31		

Daily gage height, in feet, of Red River near Fergus Falls, Minn., for 1910.

Day.	Jan.	Feb.	Mar.
1			7.29
2			
3		7.12	
4			
5			
6			
7			
8			
9		7.22	7.35
10			

Day.	Jan.	Feb.	Mar.
11			
12	6.99		
13			
14			
15		6.99	
16			7.40
17			7.48
18			6.17
19	6.91		5.90
20			5.65

Day.	Jan.	Feb.	Mar.
21			5.48
22		7.21	5.51
23			5.47
24			5.42
25			5.44
26	7.12		5.48
27			5.51
28			5.42
29			5.45
30			5.51
31			5.46

NOTE.—Ice from Jan. 1 to March 15. The average thickness of ice during this period was 1.60 feet.

RED RIVER AT FARGO, N. DAK.

Location.—At the highway bridge connecting Front Street, Fargo, N. Dak., with Moorhead, Minn., 10 miles above the mouth of Sheyenne River.

Records available.—May 27, 1901, to December 31, 1912.

Drainage area.—6,020 square miles.

Gage.—Vertical staff attached to the breakwater for the center pier of the Front Street bridge, and is read from the bridge or the river banks by the aid of a field glass. Datum unchanged since establishment.

Channel.—Clay and silt; slightly shifting.

Discharge measurements.—From the Front Street bridge and the Northern Pacific Railway bridge.

Regulation.—There is a low dam of steel sheet-piling a few rods below the footbridge at Fargo Waterworks, one-half mile above the gage. This dam, a tight overflow-weir without sluices, was built in August, 1910, for the purpose of maintaining a sufficient depth of water for the intake pipe of the waterworks, and raises the water about 5 feet at lowest stage.

Winter flow.—The relation of gage height to discharge is affected by ice from about the middle of November to the first of April, and during this time observations are discontinued. At the spring break-up, on account of the comparatively sluggish current and the fact that the river flows northward into a colder district, a pronounced backwater effect is usually caused by ice jams and partial ice jams.

Accuracy.—Because of the inaccessibility of the gage, the relatively poor conditions for making accurate discharge measurements and the slightly shifting channel, the records are not considered better than good.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	......	......	616	700	463	760	790	488	369	283	325	189
2	......	......	616	671	439	730	760	488	369	283	325	189
3	......	......	616	590	463	730	760	513	369	283	304	......
4	......	......	616	513	463	760	790	538	369	283	304	......
5	......	......	616	463	439	850	820	564	369	283	283	......
6	......	......	616	439	463	880	820	564	369	283	283	......
7	......	......	616	439	513	940	850	538	369	283	263	......
8	......	......	616	439	564	970	850	513	347	283	263	......
9	......	......	564	439	590	1,000	820	513	347	263	225	......
10	......	......	513	513	643	1,035	790	488	347	263	207	......
11	......	......	513	488	643	1,035	730	488	325	263	189	......
12	......	......	538	513	643	1,035	730	488	325	263	189	......
13	......	......	616	488	643	1,000	730	488	325	244	172	......
14	......	......	643	488	643	1,000	730	488	325	244	172	......
15	......	......	700	488	616	970	730	488	325	244	225	......
16	......	......	940	488	488	940	730	488	325	225	283	......
17	......	......	1,105	488	564	910	700	463	325	225	325	......
18	......	......	1,105	463	700	910	671	439	394	225	392	......
19	......	......	850	439	790	910	643	415	304	225	392	......
20	......	......	730	415	940	910	616	439	304	225	392	......
21	......	......	700	392	1,000	910	616	439	304	225	392	......
22	......	......	730	392	1,140	910	590	415	304	207	392	......
23	......	......	760	392	1,175	910	590	415	304	225	392	......
24	......	......	790	392	1,105	910	564	415	304	244	392	......
25	......	347	820	415	1,105	910	564	415	304	283	392	......

Daily discharge, in second-feet, of Red River at Fargo, N. Dak.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
26		488	850	415	1,140	910	538	392	304	325	369	
27		538	940	439	1,000	880	513	392	304	369	347	
28		616	940	439	880	850	488	392	304	392	304	
29			1,000	415	880	850	463	415	304	392	244	
30			850	415	820	820	488	392	283	369	189	
31			730		760		488	369		325		
1903.												
1				1,970	590	538	392	263	304	325	463	
2				2,210	590	538	415	263	304	325	463	
3				2,290	564	513	415	263	304	347	463	
4				2,370	564	513	415	263	304	347	463	
5				2,410	564	513	415	283	304	369	463	
6				2,450	564	513	439	283	304	392	463	
7				2,090	564	488	439	283	283	439	463	
8				1,700	538	488	439	283	283	463	463	
9				1,770	538	463	415	283	263	488	463	
10				1,810	538	439	415	283	263	513	463	
11				2,010	538	439	392	283	263	538	463	
12				1,700	538	439	392	283	283	564	463	
13				1,210	538	439	392	283	304	564	463	
14				1,000	538	463	369	283	325	538	463	
15				880	564	463	369	283	347	538	463	
16				730	564	488	369	283	347	513	439	
17				730	538	488	347	283	347	488	439	
18				700	513	463	347	263	369	513	439	
19				700	538	439	347	263	369	513	439	
20				700	538	439	325	263	369	513	439	
21				643	564	439	325	263	369	513	463	
22				671	590	439	325	263	369	488	488	
23				671	643	439	325	244	347	488	513	
24				671	643	439	325	225	347	488	538	
25				671	616	415	325	225	325	488	590	
26				643	616	415	304	225	304	488	590	
27			225	643	616	415	304	225	304	488		
28			513	616	590	415	304	225	304	488		
29			1,000	590	564	415	304	263	304	463		
30			1,525	564	538	392	283	304	304	463		
31			1,560		538		283	325		463		
1904.												
1				1,386	1,650	907	2,354	636	378	444	466	
2				1,281	1,350	907	2,060	610	400	444	466	
3				1,386	1,215	907	1,852	585	400	466	466	
4				1,458	1,119	966	1,650	585	444	489	466	
5				1,534	1,119	996	1,496	560	489	489	444	
6				1,534	1,088	996	1,386	560	512	489	444	
7				1,610	1,088	996	1,315	560	512	489	444	
8				1,811	1,088	996	1,315	560	512	489	444	
9				1,534	1,119	1,026	1,215	536	512	489	444	
10				1,572	1,151	1,119	1,183	536	489	489	444	
11				1,730	1,151	1,119	1,151	512	489	489	444	
12				2,018	1,151	1,119	1,183	512	489	512	444	
13				2,480	1,119	1,088	1,215	512	466	489	444	
14				3,296	1,151	1,057	1,215	512	466	489	444	
15				4,272	1,151	996	1,151	512	444	489	444	
16				4,890	996	966	1,119	512	444	489	444	
17				5,289	966	936	1,088	512	444	512	444	
18				5,670	936	907	1,026	512	444	512	444	
19				6,036	907	878	966	512	444	512	444	
20				6,089	878	878	936	489	444	489	444	
21				5,878	878	850	936	489	444	489	444	
22				5,514	878	822	822	466	444	489	444	
23				5,150	878	822	795	466	444	489	444	
24				4,635	878	1,119	741	444	444	489	444	
25				4,230	907	1,458	688	444	444	512	444	
26				3,733	907	2,186	688	444	444	512	444	
27				3,390	907	2,700	688	422	422	489	378	
28				2,920	907	2,832	662	400	422	489	315	
29				2,354	936	2,832	662	400	422	489	231	
30				1,976	936	2,656	636	378	422	466	273	
31					936		636	378		466		

Daily discharge, in second-feet, of Red River at Fargo, N. Dak.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1				730	392	820	970	1,070	1,000	880	671	
2				513	392	820	940	1,035	1,000	850	671	
3				590	415	790	910	1,035	970	850	700	
4				564	463	790	880	1,000	970	850	700	
5				513	513	850	940	1,000	970	820	700	
6				513	590	910	970	1,000	940	760	700	
7				538	643	940	1,000	970	940	760	700	
8				564	700	1,000	1,035	940	940	730	671	
9				564	760	970	1,070	970	940	700	671	
10				538	850	940	1,105	940	910	700	643	
11				513	1,105	940	1,105	910	910	700	643	
12				513	1,490	910	1,105	940	910	730	616	
13				488	2,210	940	1,140	970	880	760	616	
14				463	3,130	970	1,105	1,070	850	760	616	
15				439	3,690	970	1,105	1,105	790	760	616	
16				439	4,090	970	1,070	1,140	790	760	643	
17				439	4,250	970	1,070	1,315	790	760	616	
18				439	4,010	940	1,070	1,525	790	760	616	
19				439	3,570	910	1,070	1,490	820	760	616	
20				439	2,770	940	1,035	1,420	880	760	616	
21				439	2,290	970	1,070	1,385	880	760	616	
22				415	1,850	970	1,035	1,350	910	760	616	
23				415	1,595	970	1,000	1,280	940	760	616	
24				415	1,525	1,000	1,000	1,280	940	730	616	
25				415	1,350	1,000	1,000	1,210	940	700	616	
26				415	1,280	970	1,000	1,175	940	700	616	
27				415	1,175	970	940	1,175	940	700	643	
28				415	1,105	970	1,000	1,140	940	700	616	
29				415	1,000	1,000	1,070	1,105	910	700	590	
30				392	850	1,000	1,070	1,070	910	700		
31					820		1,105	1,035		671		
1906.												
1				1,869	1,260	1,910	1,720	1,260	1,330	1,130	1,160	
2				2,100	1,290	1,830	1,720	1,330	1,260	1,100	1,160	
3				2,180	1,330	1,790	1,830	1,430	1,200	1,070	1,160	
4				2,220	1,360	1,720	1,870	1,390	1,160	1,040	1,130	
5				2,220	1,390	1,680	1,910	1,430	1,130	1,010	1,130	
6				2,310	1,430	1,640	1,910	1,460	1,100	978	1,100	
7				2,470	1,430	1,680	1,910	1,430	1,040	978	1,100	
8				2,800	1,430	1,680	1,870	1,390	978	949	1,070	
9				3,050	1,390	1,720	1,830	1,360	978	920	1,040	
10				2,800	1,360	1,720	1,760	1,330	978	863	1,010	
11				2,140	1,330	1,760	1,720	1,290	1,010	863	1,010	
12				1,760	1,360	1,720	1,640	1,260	978	863	1,010	
13				1,790	1,260	1,680	1,570	1,230	949	835	1,010	
14				2,220	1,230	1,640	1,570	1,200	949	835	978	
15				2,510	1,200	1,640	1,570	1,160	949	835	978	
16				2,640	1,830	1,640	1,500	1,130	949	781	808	
17				2,800	2,430	1,610	1,460	1,100	949	835	920	
18				2,840	2,350	1,640	1,460	1,160	949	835	863	
19				2,640	2,140	1,640	1,460	1,230	949	835	808	
20				2,310	1,910	1,640	1,430	1,230	978	781	775	
21				1,990	1,790	1,640	1,390	1,230	978	781	775	
22				1,290	1,720	1,610	1,360	1,260	1,040	781	775	
23				1,570	1,680	1,610	1,330	1,230	1,100	808	775	
24				1,460	1,640	1,570	1,330	1,230	1,130	935	775	
25				1,360	1,610	1,570	1,290	1,260	1,230	863	775	
26				1,290	1,680	1,640	1,260	1,260	1,230	978	775	
27				1,260	1,950	1,640	1,260	1,260	1,230	1,040	800	
28				1,230	1,830	1,640	1,260	1,290	1,200	1,130	800	
29				1,230	1,910	1,720	1,260	1,330	1,160	1,160	808	
30				1,230	1,950	1,720	1,260	1,390	1,160	1,160	978	
31					1,990		1,260	1,390		1,160		
1907.												
1					1,640	1,370	1,370	691	425	447	403	403
2					1,610	1,340	1,340	665	403	447	425	381
3					1,610	1,300	1,340	665	403	447	425	339
4					1,580	1,270	1,300	639	403	469	447	318
5					1,540	1,240	1,270	639	403	515	447	298

Daily discharge, in second-feet, of Red River at Fargo, N. Dak.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
6					1,510	1,240	1,240	613	403	515	469	318
7					1,510	1,200	1,200	613	381	515	447	318
8					1,510	1,170	1,170	639	381	515	447	339
9					1,470	1,170	1,140	665	381	515	447	360
10					1,440	1,200	1,140	665	381	492	447	403
11					1,410	1,440	1,140	639	381	492	469	
12					1,370	2,100	1,100	639	381	515	298	
13					1,370	3,100	1,070	613	360	469	220	
14					1,340	3,660	1,040	613	360	469	220	
15					1,370	4,140	1,010	639	387	447	239	
16					1,340	4,380	976	639	403	447	278	
17					1,300	4,420	945	613	425	425	318	
18					1,300	4,260	915	588	425	425	360	
19					1,270	3,900	885	563	447	447	403	
20					1,270	3,420	856	539	447	447	447	
21					1,240	2,900	885	515	469	447	469	
22					1,240	2,440	885	492	492	425	447	
23					1,240	2,140	856	492	515	425	425	
24					1,240	1,850	856	469	515	425	403	
25					1,200	1,750	827	469	492	425	425	
26					1,200	1,680	827	447	492	425	447	
27					1,240	1,58C	799	447	492	425	425	
28					1,270	1,510	771	425	492	425	447	
29					1,300	1,440	744	425	469	425	447	
30					1,300	1,410	717	425	447	425	403	
31					1,340		691	425		403		
1908.												
1					717	885	1,850	945	539	469	403	
2					691	915	1,780	915	539	492	403	
3					665	945	1,710	915	539	492	403	
4					639	915	1,640	885	539	469	391	
5					639	885	1,610	856	539	447	403	
6					613	915	1,580	799	539	425	425	
7				1,920	613	945	1,540	799	515	425	425	
8				1,920	613	976	1,510	771	492	403	403	
9				1,890	588	1,040	1,440	771	469	403	381	
10				1,920	588	1,610	1,370	744	447	403	381	
11				1,710	588	2,140	1,370	744	425	403	381	
12				1,340	563	2,480	1,340	744	425	403	360	
13				1,040	563	2,600	1,270	744	425	403		
14				799	563	2,480	1,200	744	425	425		
15				717	563	2,440	1,140	717	425	403		
16				665	563	2,330	1,070	691	425	381		
17				639	563	2,330	1,100	691	425	381		
18				613	613	2,290	1,140	665	403	403		
19				588	639	2,220	1,140	665	403	403		
20				588	665	2,070	1,100	665	425	403		
21				588	717	1,920	1,070	639	447	403		
22				588	1,010	1,780	1,040	613	469	403		
23				563	827	1,750	1,040	588	447	403		
24				563	744	1,710	976	563	447	381		
25				588	744	1,710	945	539	447	381		
26				613	799	1,820	945	515	447	381		
27				639	827	1,890	1,100	515	447	381		
28				639	827	1,920	1,070	515	447	403		
29				665	915	1,920	1,070	539	447	425		
30				717	885	1,920	1,040	539	447	425		
31					885		976	539		425		
1909.												
1				1,150	825	1,540	664	589	770	770	664	
2				1,060	825	1,580	614	565	743	797	664	
3				1,000	853	1,610	450	565	743	797	664	
4				970	882	1,610	565	565	770	797	664	
5				1,030	825	1,580	690	565	743	797	664	
6				1,030	797	1,470	690	565	716	797	664	
7				1,000	882	1,380	743	589	743	797	664	
8				1,000	911	1,340	690	565	690	797	664	
9				1,000	911	1,340	664	589	716	797	639	
10				940	882	1,310	541	589	743	797	639	

Daily discharge, in second-feet, of Red River at Fargo, N. Dak.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
11	......	......	......	940	882	1,280	518	690	770	797	639	......
12	......	......	......	911	853	1,220	565	853	770	797	639	......
13	......	......	......	853	882	1,220	565	743	770	825	639	......
14	......	......	250	882	882	1,180	565	639	770	825	639	......
15	......	......	250	940	882	1,000	589	639	770	797	541	......
16	......	......	250	1,090	853	970	565	743	770	770	520	......
17	......	......	250	1,120	853	970	589	825	770	743	520	......
18	......	......	232	1,030	882	940	589	853	770	743	520	......
19	......	......	232	970	853	911	565	825	770	770	520	......
20	......	......	250	940	882	911	589	743	797	770	520	......
21	......	......	268	882	882	882	589	639	825	770	500	......
22	......	......	250	882	853	853	614	639	825	743	500	......
23	......	......	250	882	882	825	589	639	853	743	500	......
24	......	......	305	853	911	797	589	541	853	743	500	......
25	......	......	407	853	940	797	614	690	853	716	500	......
26	......	......	518	853	970	770	639	716	853	690	500	......
27	......	......	970	825	970	743	664	797	853	690	500	......
28	......	......	1,090	770	1,000	770	664	825	970	690	495	......
29	......	......	1,180	853	1,060	797	664	853	970	690	518	......
30	......	......	1,220	911	1,780	797	639	797	770	690	428	......
31	......	......	1,250	......	1,510	......	614	797	......	664	......	......
1910.												
1	......	......	270	1,470	1,280	635	356	131	51	60	36	......
2	......	......	270	1,470	1,250	608	332	131	51	60	51	......
3	......	......	270	1,400	1,250	582	309	131	51	51	60	......
4	......	......	270	1,400	1,220	582	309	131	43	51	60	......
5	......	......	290	1,400	1,190	556	309	90	43	51	43	......
6	......	......	520	1,400	1,190	582	309	102	51	51	43	......
7	......	......	790	1,370	1,160	582	286	116	51	51	51	......
8	......	......	850	1,310	1,160	582	286	116	43	51	60	......
9	......	......	820	1,280	1,120	556	264	116	43	51	......	......
10	......	......	820	1,280	1,120	556	221	102	43	51	......	......
11	......	......	1,070	1,250	1,090	556	201	102	43	51	......	......
12	......	......	1,300	1,500	1,090	530	201	90	43	51	......	......
13	......	......	1,850	1,470	1,090	530	201	102	43	51	......	......
14	......	......	2,700	1,440	1,090	530	201	102	43	55	......	......
15	......	......	3,300	1,440	969	504	201	102	51	55	......	......
16	......	......	3,800	1,440	911	478	242	60	51	60	......	......
17	......	......	4,000	1,280	882	504	242	60	51	60	......	......
18	......	......	4,300	1,120	882	530	221	60	43	60	......	......
19	......	......	4,500	1,120	882	453	221	69	43	60	......	......
20	......	......	4,700	1,120	853	428	201	51	43	90	......	......
21	......	......	4,600	1,160	824	404	182	60	43	79	......	......
22	......	......	4,400	1,250	824	404	164	69	51	102	......	......
23	......	......	4,100	1,850	824	404	182	43	43	69	......	......
24	......	......	3,100	1,960	797	380	182	60	43	79	......	......
25	......	......	2,440	1,920	770	380	164	69	43	79	......	......
26	......	......	2,670	1,780	770	380	147	69	51	60	......	......
27	......	......	1,890	1,600	743	380	147	43	60	79	......	......
28	......	......	1,780	1,530	689	380	147	69	60	43	......	......
29	......	......	1,710	1,440	689	380	131	79	60	30	......	......
30	......	......	1,600	1,310	689	380	131	69	60	30	......	......
31	......	......	1,530	......	662	......	131	51	......	36	......	......
1911.												
1	......	......	......	356	286	242	131	131	131	201	......	......
2	......	......	......	356	286	264	131	131	131	182	......	......
3	......	......	......	356	286	309	131	131	131	164	......	......
4	......	......	......	380	309	428	116	116	116	147	......	......
5	......	......	......	380	309	428	102	147	116	147	......	......
6	......	......	......	309	286	428	116	164	116	309	......	......
7	......	......	......	309	286	404	116	201	116	332	......	......
8	......	......	......	309	264	380	116	221	147	356	......	......
9	......	......	......	309	264	356	116	201	164	242	......	......
10	......	......	......	428	286	356	116	221	147	264	......	......
11	......	......	......	608	286	242	90	221	116	264	......	......
12	......	......	......	504	309	264	90	221	147	242	......	......
13	......	......	......	474	309	264	90	221	147	221	......	......
14	......	......	......	428	286	264	90	221	164	221	......	......
15	......	......	......	428	309	264	79	201	182	242	......	......

Daily discharge, in second-feet, of Red River at Fargo, N. Dak.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
16				428	309	242	79	182	164	242		
17			356	428	309	221	90	182	182	242		
18			380	380	309	201	90	182	221	242		
19			404	380	309	182	79	164	182	264		
20			428	332	309	164	79	147	182	264		
21			453	356	309	164	79	131	182	264		
22			453	380	286	164	79	147	147	264		
23			428	332	286	116	79	147	164	264		
24			453	332	286	116	90	147	182	264		
25			453	332	242	116	90	147	182	264		
26			478	332	242	131	90	131	182	264		
27			556	309	242	116	116	131	182	264		
28			404	286	242	116	102	147	182	264		
29			309	286	242	131	116	147	201	250		
30			309	286	242	131	131	147	201	230		
31			309		242		131	131		210		
1912.												
1				461	405	640	490	328	211	352	285	
2				490	433	610	461	306	211	328	265	
3				550	433	550	461	265	246	328	285	
4				670	433	520	461	265	246	306	285	
5				760	520	490	461	246	265	285	306	
6				790	640	490	490	211	246	265	285	
7				914	852	490	490	211	228	265	246	
8				1,070	914	461	461	246	246	285	228	
9				1,010	1,010	461	490	265	228	285	246	
10				760	1,070	490	490	246	228	285	246	
11				640	1,070	490	550	265	211	265	265	
12				580	1,070	490	610	306	194	265	265	
13				520	1,100	520	640	378	194	265	246	
14				461	1,130	520	670	580	211	265	228	
15				461	1,070	490	580	550	194	285	211	
16				433	1,040	461	490	490	194	285	194	
17				405	945	461	490	490	178	285	178	
18				461	883	490	520	490	178	265	178	
19				520	760	490	520	490	194	246	178	
20				580	670	490	490	490	211	246	194	
21				520	610	520	461	352	228	265	194	
22				461	580	640	461	306	228	265	194	
23				433	580	610	433	265	246	265	194	
24				405	580	580	405	246	265	265	178	
25				405	580	580	378	228	265	246	162	
26				405	580	550	405	211	285	246	132	
27				378	580	550	378	194	306	246	118	
28				405	580	520	352	194	306	246	132	
29				433	610	520	352	194	328	246	132	
30				433	610	520	328	211	328	265	132	
31					610		328	211		265		

Daily discharges computed from a number of well-defined rating curves.

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

[Drainage area, 6,020 square miles.]

Month.	Discharge in second-feet				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1902.						
March	1,100	513	737	0.122	0.14	
April	700	392	469	.078	.09	
May	1,180	439	733	.122	.14	
June	1,040	730	904	.150	.17	
July	850	463	676	.112	.13	
August	564	369	463	.077	.09	
September	369	283	328	.054	.06	
October	392	207	275	.046	.05	
November	392	172	298	.050	.06	
1903.						
April	2,450	564	1,260	.209	.23	
May	643	513	566	.094	.11	
June	538	392	460	.076	.08	
July	439	283	363	.060	.07	
August	325	225	268	.045	.05	
September	369	263	317	.053	.06	
October	564	325	471	.078	.09	
November (1-26)	590	439	474	.079	.08	
1904.						
April	6,090	1,280	3,220	.535	.60	
May	1,650	878	1,040	.173	.20	
June	2,830	822	1,270	.211	.24	
July	2,350	636	1,120	.186	.21	
August	636	378	502	.083	.10	
September	512	378	452	.075	.08	
October	512	444	488	.081	.09	
November	466	231	428	.071	.08	
1905.						
April	730	392	480	.080	.09	A
May	4,250	392	1,640	.274	.31	A
June	1,000	790	937	.156	.17	A
July	1,140	880	1,030	.172	.20	A
August	1,520	910	1,130	.188	.22	A
September	1,000	790	908	.151	.17	A
October	880	671	751	.125	.14	A
November (1-29)	700	590	641	.107	.12	A
1906.						
April	3,050	1,230	2,050	.341	.38	B
May	2,430	1,200	1,630	.271	.31	A
June	1,910	1,570	1,680	.279	.31	A
July	1,910	1,260	1,550	.257	.30	A
August	1,460	1,100	1,290	.214	.25	A
September	1,330	949	1,070	.178	.20	A
October	1,160	781	940	.156	.18	A
November	1,160	775	942	.156	.17	C
1907.						
March (18-31)			[a]2,970	.493	.26	B
April			[a]2,920	.485	.54	B
May	1,640	1,200	1,370	.228	.26	A
June	4,420	1,170	2,200	.365	.41	A
July	1,370	691	1,010	.168	.19	A
August	691	425	568	.094	.11	B
September	515	360	428	.071	.08	B
October	515	403	456	.076	.09	B
November	469	220	[a]400	.066	.07	B
December	403		315	.052	.06	C

[a] Estimated.

Monthly discharge of Red River at Fargo, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
January			[a]290	0.048	0.06	C
February			[a]250	.042	.05	C
March			[a]500	.083	.10	C
April		563	1,100	.183	.20	B
May	1,010	563	691	.115	.13	A
June	2,600	885	1,720	.286	.32	A
July	1,850	945	1,230	.204	.24	A
August	945	515	696	.116	.13	A
September	539	403	462	.077	.09	B
October	492	381	414	.069	.08	B
November	450		[a]360	.060	.07	B
December			[a]300	.050	.06	C
The year			668	.111	1.55	
1909.						
March (14-31)	1,250	232	523	.087	.06	D
April	1,120	770	947	.157	.18	D
May	1,780	797	937	.156	.18	B
June	1,610	743	1,110	.184	.21	A
July	743	450	609	.101	.12	A
August	853	565	685	.114	.13	A
September	970	690	791	.131	.15	A
October	825	664	762	.127	.15	A
November	664	428	574	.095	.11	C
1910.						
March			[a]2,130	.354	.41	C
April	1,960	1,120	1,430	.238	.27	A
May	1,280	662	967	.161	.19	A
June	635	380	491	.081	.09	B
July	356	131	220	.037	.04	B
August	131	43	85.3	.014	.02	B
September	60	43	47.9	.0080	.009	B
October	102	30	58.3	.0097	.01	B
November			[a]45.0	.0075	.008	C
1911.						
March	556	60	246	.041	.05	C
April	608	286	370	.062	.07	B
May	309	242	283	.047	.05	B
June	428	116	240	.040	.04	B
July	131	79	102	.017	.02	B
August	221	116	166	.028	.03	B
September	221	116	160	.027	.03	B
October	356	147	245	.041	.05	C
1912.						
April	1,070	378	560	.093	.10	C
May	1,130	405	740	.123	.14	B
June	640	461	523	.087	.10	B
July	670	328	471	.078	.09	B
August	580	194	314	.052	.06	C
September	328	178	237	.039	.04	C
October	352	246	273	.045	.05	C
November	306	118	213	.035	.04	C

[a] Estimated.

RED RIVER AT GRAND FORKS, N. DAK.

Location.—At the Northern Pacific Railway bridge between Grand Forks, N. Dak., and East Grand Forks, Minn., about one-half mile below the mouth of Red Lake River.

Records available.—May 26, 1901, to December 31, 1912. Gage height records have, however, been kept by the United States Engineer Corps since 1882.

Drainage area.—25,000 square miles.

Gage.—Staff and chain, attached to Northern Pacific Railway bridge; datum same for both and unchanged since establishment. As a rule, the chain gage is read only during periods of extremely low water. The United States Engineer Corps gage is located on the breakwater to which the United States Geological Survey staff gage is attached, but at a datum 5.00 feet higher.

Channel.—Clay and silt, shifts slightly.

Discharge measurements.—Made from the Great Northern Railway bridge about one-fifth mile above the gage.

Regulation.—There are no dams or other obstructions below, nor rapids, the channel being fairly uniform for miles. Above there are no power plants, dams, or reservoirs affecting the flow nearer than Crookston, on the Red Lake River, 25 miles above Grand Forks along the general course of the valley; about half the water comes from the Red Lake River, but the storage at the Crookston plant is so small that no fluctuations caused by it have been discovered at Grand Forks. On the other branch, the Red River proper, and its tributaries above Grand Forks, there are no reservoirs or power plants for a hundred miles above.

Winter flow.—The river flows under smooth ice from about the middle of November to the middle of April; the flow during the winter fluctuates little, and since 1906 enough discharge measurements have been made each winter to give fairly satisfactory summaries for the winter.

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

Accuracy.—Results at this station are considered excellent.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1									1,995	1,420	2,745	
2									1,802	1,520	2,865	
3									1,967	1,620	2,775	
4									1,995	1,620	2,715	
5									1,802	1,620	2,627	
6									1,912	1,570	2,545	
7									1,857	1,495	2,435	
8									1,967	1,570	2,490	
9									1,885	1,595	2,490	
10									1,857	1,495	2,160	
11									1,875	1,595	1,857	
12									1,802	1,495	1,495	
13									1,695	1,420	1,670	
14									1,645	1,395	2,215	
15									1,720	1,370	2,545	
16									1,570	1,620	2,380	
17									1,545	1,570	2,805	
18									1,570	1,520	2,955	
19									1,470	1,470	3,015	
20									1,495	1,495	3,075	
21									1,570	1,420	3,075	
22									1,470	1,320	2,865	
23									1,595	1,395	2,835	
24									1,470	1,470	2,655	
25									1,470	1,570	2,627	
26									1,570	1,670	2,490	
27									1,620	1,670	2,655	
28									1,620	2,132	2,490	
29									1,620	2,325	2,380	
30									1,670	2,655	2,380	
31										2,655		
1903.												
1				4,455	5,695	5,870	1,830	1,090	1,295	1,670	2,655	
2				6,010	5,625	5,520	2,105	1,045	1,320	1,570	2,775	
3				8,200	5,555	5,240	1,830	1,045	1,180	1,395	2,655	
4				10,395	5,520	4,780	1,670	1,045	1,320	1,470	2,655	
5				12,215	5,415	4,585	1,670	1,180	1,295	1,445	2,545	
6				13,565	5,240	4,520	1,620	1,180	1,370	1,620	2,545	
7				14,610	5,105	4,357	1,720	1,202	1,320	2,022	2,517	
8				15,710	4,975	4,227	1,720	1,090	1,420	2,600	2,435	
9				17,160	5,040	4,000	1,670	1,090	1,570	3,015	2,462	
10				18,452	4,910	3,772	1,775	1,090	1,620	3,315	2,490	
11				18,767	4,942	3,525	1,720	1,090	1,775	3,615	2,490	
12				17,010	4,910	3,555	1,620	1,000	1,940	3,870	2,545	
13				15,810	4,877	3,435	1,520	1,022	2,132	3,870	2,435	
14				14,657	4,845	3,375	1,495	1,000	2,215	3,935	2,077	
15				14,277	4,845	3,375	1,420	977	2,325	3,935	1,830	
16				13,232	4,845	3,255	1,370	955	2,490	3,870		
17				11,090	4,260	3,075	1,345	955	2,545	3,837		
18				10,225	4,520	2,775	1,320	955	2,600	3,740		
19				9,120	4,390	2,600	1,225	1,090	2,655	3,675		
20				8,280	4,585	2,435	1,320	1,045	2,325	3,555		
21				7,640	4,845	2,380	1,180	1,000	2,352	3,495	2,050	
22				7,250	5,105	2,380	1,180	955	2,545	3,435		
23				6,912	5,485	2,490	1,180	932	2,380	3,345		
24				6,725	5,555	2,270	1,180	870	2,325	3,315		
25				6,650	5,730	2,325	1,180	890	1,995	3,255		
26				6,220	6,395	2,215	1,180	1,090	1,775	3,165		
27				6,045	6,650	1,995	1,135	955	1,720	3,165		
28				6,150	7,100	1,940	1,067	977	1,620	2,895		
29				6,045	7,137	2,050	1,295	1,202	1,570	2,895		
30				5,905	6,650	1,940	1,067	1,225	1,747	2,685	2,380	
31					6,290		1,135	1,295		2,775		
1904.												
1					30,210	6,274	6,267	2,278	1,525	1,540	1,799	
2					28,750	6,155	6,190	2,228	1,600	1,590	1,772	
3					27,000	6,036	5,980	2,146	1,680	1,575	1,854	
4					24,520	5,924	5,728	2,250	1,675	1,650	1,782	
5					21,790	6,050	5,365	2,250	1,700	1,690	1,755	

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
6					19,140	6,064	5,025	2,129	1,711	1,760	1,744	
7					17,190	6,155	4,910	2,085	1,865	1,600	1,766	
8					15,760	6,316	4,637	2,002	1,876	1,744	1,744	
9					15,110	6,526	4,494	1,964	1,832	1,700	1,640	
10					14,900	6,610	4,377	1,865	1,810	1,728	1,766	
11					14,780	6,680	4,143	1,755	1,711	1,931	1,744	
12					14,690	6,750	4,010	1,755	1,650	1,766	1,711	
13					14,360	6,694	3,938	1,799	1,575	1,799	1,675	
14					13,820	6,624	3,806	1,750	1,645	1,865	1,610	
15				27,000	13,220	6,470	3,770	1,695	1,600	1,931	1,560	
16				26,330	12,610	6,155	3,602	1,716	1,525	1,948	1,625	
17				26,820	11,990	5,966	3,668	1,605	1,600	2,002	1,690	
18				26,550	11,230	5,924	3,656	1,600	1,460	2,030	1,711	
19				25,520	10,540	5,910	3,542	1,650	1,525	1,931	1,728	
20				26,150	9,916	5,966	3,488	1,560	1,460	1,948	1,675	
21				27,050	9,356	5,910	3,350	1,550	1,605	2,129	1,600	
22				27,880	8,875	5,644	3,206	1,505	1,590	1,986	1,690	
23				29,280	8,328	5,495	3,098	1,545	1,490	2,074	1,600	
24				30,750	7,915	5,313	2,978	1,595	1,490	1,964	1,690	
25				32,020	7,705	5,137	2,870	1,570	1,540	2,074	1,660	
26				32,780	7,428	5,066	2,750	1,510	1,490	1,986	1,640	
27				32,920	7,240	5,053	2,662	1,490	1,525	1,953	1,920	
28				32,650	7,086	5,462	2,558	1,495	1,550	1,838	1,700	
29				32,120	6,855	6,008	2,470	1,375	1,560	2,041	1,700	
30				31,380	6,666	6,253	2,580	1,325	1,540	1,892	1,550	
31					6,393		2,404	1,445		1,821		
1905.												
1					1,900	5,370	5,725	6,400	4,810	4,095	2,790	
2					2,100	5,230	5,875	6,025	4,680	4,030	2,570	
3					2,000	5,020	5,580	5,800	4,680	4,030	2,432	
4					2,075	4,810	5,300	5,510	4,950	3,900	2,432	
5					2,150	4,680	5,090	5,875	5,090	3,840	2,405	
6					2,432	4,745	4,880	5,950	5,090	3,660	2,790	
7				7,660	2,790	4,950	5,020	5,725	4,950	3,600	3,065	
8				6,550	3,300	5,160	5,725	5,510	4,680	3,480	3,240	
9				5,650	3,720	5,300	5,520	5,230	4,550	3,300	3,240	
10				5,160	4,030	5,230	5,370	5,160	4,290	3,300	3,010	
11				4,745	4,420	5,370	5,370	5,160	4,095	3,240	2,900	
12				4,290	5,875	5,230	5,230	5,090	3,965	3,120	2,735	
13				3,900	9,510	5,090	5,020	4,880	3,780	3,065	2,625	
14				3,540	13,380	4,950	4,810	4,745	3,720	2,955	2,515	
15				3,240	15,820	4,810	4,810	4,950	3,780	3,010	2,625	
16				3,065	16,700	4,615	4,810	5,725	3,840	3,010	2,680	
17				2,900	16,590	4,485	5,370	6,475	4,160	3,010	2,680	
18				2,625	16,260	4,420	6,100	7,500	4,420	3,010	2,735	
19				2,405	15,820	4,290	6,250	9,150	4,485	3,065	2,680	
20				2,325	15,100	4,225	6,325	10,860	4,680	3,065	2,735	
21				2,200	14,100	4,225	6,475	10,860	4,810	3,180	2,680	
22				2,200	12,930	4,225	6,475	10,050	4,950	3,300	2,680	1,840
23				2,150	11,670	4,355	6,400	9,150	5,090	3,360	2,625	
24				2,075	10,050	4,550	6,100	8,060	4,950	3,420	2,735	
25				2,050	8,540	4,680	5,800	7,340	4,810	3,420	2,735	
26				2,150	7,820	4,745	5,650	7,020	4,615	3,420	2,845	
27				2,000	7,020	4,950	5,725	6,700	4,485	3,480	2,625	
28				1,950	6,475	4,950	5,800	6,250	4,420	3,360	2,600	
29				2,025	6,100	5,020	5,950	5,800	4,225	3,360	2,500	
30				2,050	5,950	5,090	6,780	5,440	4,160	3,065	2,500	
31					5,650		6,700	5,090		2,900		
1906.												
1				7,000	9,620	7,880	5,410	3,150	2,640	2,480	2,230	
2				10,700	9,020	7,800	5,480	3,330	2,860	2,540	2,460	
3				14,000	8,680	7,640	5,420	3,450	2,890	2,480	2,460	
4				17,000	8,560	7,400	5,900	3,630	2,920	2,400	2,430	
5			1,550	20,000	8,560	7,090	6,340	3,750	2,840	2,430	2,400	
6				22,400	8,560	6,980	6,530	3,880	2,760	2,480	2,480	
7				23,900	8,520	6,860	6,340	3,910	2,560	2,510	2,300	
8				24,100	8,440	6,600	6,150	3,880	2,480	2,430	2,330	
9				23,300	8,280	6,420	5,940	3,750	2,430	2,330	2,380	
10				21,900	8,120	6,300	5,690	3,690	2,430	2,210	2,540	

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906.												
11				20,900	7,840	6,190	5,340	3,540	2,430	2,280	2,400	
12				20,000	7,560	6,190	5,160	3,450	2,380	2,210	2,400	
13				19,600	7,280	6,040	4,890	3,300	2,400	2,180	2,330	
14				20,300	6,980	5,940	4,630	3,180	2,330	2,130	2,330	
15				22,000	7,161	5,800	4,430	3,120	2,230	2,180	2,330	
16				25,200	7,680	5,550	4,200	3,030	2,180	2,130	2,080	
17				27,000	8,160	5,340	4,080	2,980	2,180	2,080	1,890	
18				27,600	8,160	5,240	3,910	2,920	2,230	2,130	1,870	
19				27,400	8,280	5,200	3,820	2,840	2,200	2,080	1,990	
20				26,600	8,520	5,410	3,690	2,810	2,280	2,060	1,990	
21				25,500	8,440	5,580	3,660	2,810	2,260	2,060	1,990	1,700
22				24,000	8,400	5,555	3,690	2,810	2,280	2,010	1,990	
23			1,880	22,100	8,240	5,410	3,540	2,780	2,330	1,990	1,990	
24				20,100	8,120	5,340	3,480	2,810	2,330	1,960	1,990	
25				18,000	7,920	5,270	3,510	2,890	2,380	1,940	1,940	
26				16,100	7,800	5,200	3,510	2,860	2,590	1,920	1,890	
27				14,200	8,120	5,240	3,510	2,760	2,620	1,940	1,840	
28				12,800	8,560	5,440	3,390	2,780	2,560	1,990	1,810	
29	1,770			11,400	8,640	5,480	3,270	2,920	2,480	2,130	1,780	
30				10,400	8,400	5,480	3,270	2,890	2,540	2,480	1,740	
31							3,210	2,700		2,080		
1907.												
1				19,300	6,300	3,690	4,630	2,280	1,500	2,680	1,610	
2				21,300	6,020	3,660	4,350	2,240	1,480	2,630	1,610	
3				22,100	5,700	3,500	4,140	2,170	1,430	2,530	1,660	
4			1,220	25,100	5,600	3,440	4,110	2,200	1,410	2,400	1,700	
5				27,000	5,460	3,470	3,930	2,240	1,370	2,430	1,660	
6				29,100	5,460	3,300	3,870	2,240	1,430	2,330	1,610	
7				30,300	5,390	3,300	3,720	2,240	1,480	2,240	1,660	
8				29,500	5,280	3,250	3,750	2,260	1,430	2,200	1,610	
9				29,400	5,220	3,170	3,660	2,280	1,410	2,150	1,610	
10				27,600	5,020	3,080	3,580	2,240	1,430	2,100	1,660	
11				25,800	4,920	3,360	3,550	2,200	1,450	2,060	1,610	
12				23,500	4,720	3,750	3,440	2,150	1,480	1,970	1,540	
13				20,800	4,630	5,420	3,420	2,100	1,560	1,920	1,480	
14				18,600	4,530	6,960	3,360	2,150	1,610	1,920	1,310	
15				15,700	4,470	8,890	3,390	2,060	1,660	1,810	1,310	
16				13,400	4,350	9,690	3,360	2,060	1,590	1,790	1,430	
17				11,600	4,260	10,100	3,250	2,020	1,520	1,790	1,300	
18				10,400	4,290	10,600	3,250	1,970	1,480	1,790	1,300	
19				9,700	4,170	10,600	3,140	1,970	1,480	1,790	1,300	
20				8,830	4,080	10,100	3,080	1,920	1,590	1,790	1,300	
21				8,730	3,990	9,350	3,030	1,880	2,310	1,790	1,200	
22				8,740	3,870	8,680	3,030	1,880	3,000	1,770	1,300	
23				8,860	3,840	7,920	2,900	1,840	2,170	1,790	1,300	
24				8,880	3,720	7,300	2,780	1,790	3,140	1,770	1,300	
25				9,060	3,870	6,840	2,730	1,740	2,980	1,770	1,300	
26				8,400	3,810	6,090	2,630	1,700	2,930	1,740	1,300	
27				7,920	3,720	5,530	2,500	1,680	2,830	1,660	1,300	
28	1,180			7,580	3,610	5,280	2,400	1,660	2,800	1,560	1,300	
29				7,070	3,550	4,890	2,430	1,590	2,800	1,590	1,300	
30				6,310	3,640	4,760	2,360	1,560	2,780	1,560	1,300	
31					3,660		2,310	1,540		1,610		
1908.												
1				4,400	5,020	8,680	5,150	2,380	2,130	1,560	1,390	
2				4,500	4,950	8,520	4,950	2,430	3,550	1,590	1,390	
3				4,500	4,860	8,040	4,820	2,480	3,550	1,560	1,390	
4				4,900	4,720	7,640	4,660	2,530	2,830	1,610	1,390	
5				6,300	4,470	7,260	4,530	2,500	2,280	1,590	1,390	
6				8,000	4,320	6,590	4,350	2,430	2,310	1,590	1,390	
7				12,100	4,170	5,950	4,140	2,280	2,100	1,560	1,350	
8				15,300	3,990	6,160	3,960	2,130	1,950	1,560	1,310	
9			924	17,900	3,780	6,990	3,840	2,100	1,790	1,560	1,370	
10				19,200	3,580	7,800	3,660	2,020	1,660	1,520	1,200	
11				20,500	3,470	8,200	3,580	2,020	1,660	1,450	1,200	
12				20,200	3,470	8,440	3,440	2,020	1,560	1,430	1,200	
13				19,000	3,390	8,480	3,300	2,020	1.520	1,450	1,200	
14				17,500	3,580	8,400	3,170	1,950	1,520	1,390	1,200	
15				15,500	3,470	8,160	3,060	1,880	1,480	1,350	1,200	

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
16				13,700	3,640	8,040	2,930	1,880	1,480	1,430	1,200	
17				12,000	4,290	7,760	2,860	1,860	1,370	1,410	1,200	
18				10,400	4,560	7,530	2,780	1,920	1,350	1,430	1,200	
19				9,060	4,790	7,260	2,730	1,860	1,350	1,350	1,200	
20	912			7,930	5,320	6,990	2,660	1,790	1,350	1,310	1,200	
21				6,580	5,980	6,810	2,580	1,790	1,330	1,270	1,200	
22				5,880	6,880	6,700	2,630	1,770	1,330	1,310	1,200	
23				5,320	8,280	6,550	2,660	1,720	1,350	1,390	1,200	
24				4,980	9,430	6,410	2,560	1,700	1,350	1,390	1,200	
25				4,720	9,520	6,230	2,480	1,660	1,350	1,430	1,200	
26				4,660	9,180	5,980	2,480	1,660	1,390	1,310	1,200	
27				4,760	9,140	5,880	2,530	1,660	1,410	1,310	1,200	
28			3,680	5,120	9,350	5,740	2,480	1,680	1,430	1,370	1,200	
29				5,360	9,430	5,500	2,460	1,700	1,480	1,430	1,200	
30				5,280	9,350	5,360	2,380	1,660	1,540	1,430	1,200	
31					9,050		2,330	1,660		1,390		
1909.												
1				2,480	3,200	4,820	2,460	7,260	4,920	2,480	2,430	
2				2,900	3,140	4,980	2,430	5,600	4,920	2,480	2,390	
3				3,290	2,980	5,050	2,400	5,320	4,800	2,470	2,390	
4				3,810	2,880	4,920	2,380	4,530	4,790	2,430	2,430	
5				4,290	2,780	4,600	2,380	4,530	4,530	2,390	2,430	
6				4,600	2,800	4,110	2,360	4,420	4,290	2,380	2,430	
7				5,120	2,880	3,750	2,330	4,380	4,080	2,370	2,310	
8				4,980	2,930	3,580	2,330	4,520	4,780	2,330	2,280	
9				4,950	2,930	3,360	2,330	4,440	3,420	2,330	2,250	
10				5,050	2,900	3,300	2,330	4,410	2,930	2,330	2,210	
11				5,050	2,980	3,200	2,330	4,410	2,860	2,330	2,210	
12				5,120	2,980	3,140	2,330	4,350	2,830	2,290	2,210	
13				5,180	2,930	2,980	2,240	4,320	2,760	2,280	2,160	
14				5,180	2,930	2,930	2,240	5,120	2,700	2,280	1,740	
15		592		5,150	2,900	2,800	2,240	6,700	2,630	2,280	1,560	
16				5,120	3,170	2,760	2,230	7,490	2,630	2,280	1,430	
17				5,050	3,300	2,730	2,200	8,040	2,630	2,260	1,310	
18				4,980	3,360	2,720	2,200	7,640	2,580	2,240	1,190	
19				4,890	3,250	2,680	2,200	7,490	2,560	2,150	1,120	
20				4,410	3,200	2,630	2,150	7,300	2,680	2,150	1,040	
21				4,530	3,250	2,630	2,150	7,110	2,660	2,110	1,120	
22				4,320	3,220	2,630	2,900	6,410	2,630	2,100	1,230	
23				4,170	3,220	2,580	5,920	5,810	2,630	2,100	1,350	
24				3,960	3,200	2,500	6,200	5,600	2,630	2,060	1,480	
25	677			3,870	3,140	2,480	6,300	5,420	2,630	2,060	1,660	
26				3,810	2,980	2,430	6,660	5,250	2,580	2,050	1,840	
27				3,750	2,980	2,430	7,330	5,250	2,580	2,020	2,020	
28				3,610	3,030	2,460	8,040	5,180	2,580	2,020	2,080	
29				3,360	3,030	2,430	8,040	5,060	2,540	1,970	2,150	
30				3,220	3,660	2,380	9,260	5,050	2,530	1,970	2,210	
31					3,690		8,280	4,950		2,200		
1910.												
1				8,760	8,440	2,560	1,140	682	429	410	387	410
2				8,990	7,760	2,420	1,100	691	382	400	445	410
3				8,850	7,180	2,430	1,010	635	364	410	414	410
4				8,800	6,610	2,470	1,000	613	391	400	429	
5				8,560	6,160	2,480	1,010	618	429	429	325	
6				8,290	5,920	2,530	995	587	510	410	353	
7				8,080	5,530	2,540	960	567	562	382	280	
8				7,760	5,250	2,470	925	587	460	364	359	
9				7,450	4,870	2,460	932	552	449	343	373	
10				7,170	4,620	2,380	932	460	449	433	391	
11				6,810	4,290	2,300	925	608	439	433	414	
12				6,530	4,230	2,180	918	508	441	439	340	
13				6,090	4,080	2,200	856	497	420	410	395	312
14	1,530			5,590	3,920	2,170	806	515	433	382	391	
15				5,420	3,640	2,080	790	492	439	382	356	
16			6,500	5,360	3,640	2,070	813	474	439	400	387	
17			9,000	5,250	3,660	1,920	758	474	449	373	387	
18			12,500	5,060	3,610	1,840	752	474	504	439	373	
19			16,100	5,020	3,580	1,760	764	433	400	364	387	
20			17,200	5,420	3,510	1,690	733	382	382	391	400	

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
21			18,200	6,480	3,420	1,630	727	410	364	364	400	
22			18,500	7,840	3,360	1,560	721	410	382	425	395	
23			18,400	9,690	3,410	1,440	703	410	364	453	387	
24			18,100	10,500	3,370	1,360	806	410	497	400	391	
25			18,400	10,700	3,180	1,340	840	400	354	439	400	
26			16,000	10,800	3,100	1,310	843	400	400	470	470	
27			14,500	10,800	2,980	1,230	817	391	406	492	449	
28		983	12,600	10,400	2,880	1,230	784	373	382	445	445	
29			10,500	9,730	2,820	1,190	777	373	406	439	429	
30			9,260	9,140	2,750	1,170	752	373	391	420	425	
31			8,730		2,770		727	400		410		
1911.												
1					1,570	1,210	1,010	331	397	380		
2					1,440	1,220	914	334	415	372		
3					1,440	1,370	897	347	424	331		
4					1,390	1,400	865	363	388	331		
5					1,360	1,580	850	415	380	315		
6					1,290	1,460	803	415	366	308		
7					1,220	1,390	744	419	388	271		
8					1,190	1,460	779	434	406	363		
9					1,190	1,570	750	454	380	380		
10				2,020	1,240	2,080	738	434	372	388		
11				2,110	1,260	3,200	750	424	372	397		
12				2,230	1,300	3,500	715	411	397	388		
13				2,330	1,550	3,440	634	415	380	315		
14				2,580	1,680	3,070	585	434	380	434		
15				2,720	1,570	2,600	562	458	388	434		
16				2,640	1,470	2,290	518	454	380	415		
17				2,560	1,550	2,100	507	464	424	464		
18				2,460	2,210	1,870	486	430	454	522		
19				2,360	2,380	1,820	458	380	450	585		
20				2,180	2,010	1,700	450	363	388	562		
21				1,900	1,970	1,700	419	350	380	562		
22				1,710	1,980	1,550	383	347	366	585		
23				1,660	1,820	1,310	366	350	406	597		
24				1,640	1,660	1,280	347	350	380	629		
25				1,610	1,550	1,260	344	344	383	639		
26				1,600	1,440	1,150	347	366	401	622		
27				1,600	1,310	1,070	347	363	411	609		
28				1,530	1,150	1,050	331	350	347	585		
29				1,670	1,120	1,070	333	372	363	550		
30				1,650	1,150	1,050	318	397	372	525		
31					1,190		318	394		500		
1912.												
1				550	1,100	1,600	742	600	515	2,590	1,030	
2				613	1,060	1,690	733	635	613	2,530	995	
3				960	1,020	1,540	673	823	504	2,390	863	
4				1,230	1,040	1,540	662	668	439	2,230	856	
5				1,350	1,060	1,520	640	538	449	1,980	856	
6				1,830	1,060	1,480	640	567	449	1,780	823	
7				2,110	1,140	1,460	640	572	460	1,560	800	
8				2,360	1,280	1,400	654	587	492	1,500	813	
9				2,430	1,500	1,290	733	580	504	1,450	856	
10				2,320	1,880	1,200	712	562	510	1,380	856	
11				2,460	2,060	1,150	646	550	460	1,310	840	
12				2,750	2,230	784	646	613	460	1,260	797	
13				2,900	2,230	721	668	562	568	1,170	768	
14				3,200	2,230	674	774	515	515	1,100	749	
15				2,980	2,290	960	774	532	556	1,060	689	
16			185	2,630	2,370	960	806	640	550	1,010	582	
17			185	2,260	2,330	960	840	890	515	960	646	
18			175	2,070	2,300	1,060	850	758	544	978	492	
19			185	1,930	2,170	995	790	661	600	953	575	
20			206	1,660	2,090	1,110	817	647	580	960	626	
21			212	1,600	2,000	1,060	856	587	654	932	600	
22			218	1,600	1,960	1,090	883	640	661	883	790	
23			218	1,500	1,890	1,230	890	697	735	942	668	
24			230	1,420	1,750	1,270	840	600	823	1,010	727	
25			236	1,300	1,760	1,360	774	550	995	1,030	587	

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
26	......	......	252	1,280	1,680	1,250	733	538	1,030	1,030	587	......
27	......	......	275	1,130	1,630	960	721	538	1,730	1,030	697	......
28	......	......	289	1,080	1,630	856	727	626	2,080	1,030	613	......
29	......	......	310	1,030	1,630	806	721	526	2,360	1,030	640	......
30	......	......	322	995	1,600	721	727	470	2,670	1,030	515	......
31	......	......	398	......	1,550	......	742	470	......	1,030	......	......

Daily discharges computed from a number of well-defined rating curves.

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

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1882.						
April	40,800	....	26,380	....	....	C
May	26,060	10,030	13,870	....	....	C
June	9,770	5,950	7,080	....	....	C
July	6,090	4,530	5,660	....	....	C
August	4,530	2,540	3,300	....	....	C
Sept	2,490	1,880	2,160	....	....	C
October	2,430	1,830	2,180	....	....	C
November (1-15)	....	....	2,250	....	....	C
1883.						
January	....	....	1,500	....	....	D
April	33,400	....	16,820	....	....	C
May	28,300	6,440	14,420	....	....	C
June	6,370	3,360	5,020	....	....	C
July	3,300	2,030	2,660	....	....	C
August	2,030	1,450	1,730	....	....	C
September	1,450	1,190	1,310	....	....	C
October	1,360	1,190	1,260	....	....	C
November (1-15)	....	....	1,330	....	....	D
1884.						
April	20,600	....	10,980	....	....	C
May	6,370	3,530	4,760	....	....	C
June	5,120	2,430	3,570	....	....	C
July	2,480	1,780	2,270	....	....	C
August	2,540	1,190	1,520	....	....	C
September	2,590	2,080	2,330	....	....	C
October	4,790	1,980	2,990	....	....	C
November (1-20)	2,860	....	2,440	....	....	C
1885.						
April	13,040	....	6,730	....	....	C
May	6,160	4,110	4,320	....	....	C
June	5,120	3,250	4,790	....	....	C
July	9,430	3,810	5,670	....	....	C
August	5,880	2,700	4,950	....	....	C
September	3,030	1,980	2,560	....	....	C
October	2,180	1,630	1,850	....	....	C
November	1,780	1,630	1,690	....	....	C
1886.						
March	....	....	1,560	....	....	D
April	10,300	4,660	6,340	....	....	C
May	9,600	3,000	6,060	....	....	B
June	3,120	2,000	2,610	....	....	B
July	2,180	900	1,550	....	....	B
August	890	670	740	....	....	C
September	560	520	540	....	....	C
October	730	520	610	....	....	C
November	....	....	600	....	....	D

Monthly discharge of Red River at Grand Forks, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1887.						
April	7,100		3,010			C
May	2,430	1,190	1,770			B
June	1,400	900	1,240			B
July			1,200			D
August			1,240			D
September	1,000	730	880			C
October	730	610	660			C
November	610	560	590			C
1888.						
April	19,000		9,330			C
May	6,580	2,700	4,340			B
June	15,100	3,030	8,530			B
July	6,580	2,700	4,650			B
August	2,540	1,320	1,990			B
September	1,110	890	980			C
October	1,000	790	900			C
November	1,110	730	960			C
1889.						
April		1,450	2,020			C
May	1,540	960	1,180			B
June	890	590	710			C
July	700	540	600			C
August	610	410	490			C
September	640	390	490			C
October	590	430	510			C
1890.						
April	3,470		1,830			C
May	1,110	860	990			C
June	1,500	1,030	1,300			B
July	1,230	760	1,040			B
August	730	540	610			C
September	640	490	560			C
October	920	590	700			C
November	960	700	800			C
1891.						
April	8,360		3,410			C
May	1,980	890	1,440			B
June	1,630	920	1,280			B
July	1,450	1,070	1,330			B
August	1,270	790	1,160			B
September	860	760	800			C
October	2,430	820	1,470			B
November (1-20)			1,250			C
1892.						
April	23,000	8,200	17,400			C
May	15,200	4,790	8,760			B
June	13,300	4,530	7,280			B
July	6,730	1,880	3,410			B
August	1,830	1,190	1,380			B
September	1,270	1,070	1,180			B
October	1,190	960	1,020			B
November (1-15)			880			C
1893.						
April	37,500		16,000			C
May	32,000	4,850	15,240			B
June	4,660	2,330	3,250			B
July	2,330	1,630	2,110			B
August	1,630	960	1,120			B
September	1,030	760	820			C
October	960	760	840			C
November (1-15)			830			C
1894.						
April	16,450		10,000			C
May	9,350	4,600	5,900			B
June	4,530	2,280	2,980			B
July	2,330	930	1,520			C
August	930	610	760			D
September	610	430	530			D
October	790	520	730			D

Monthly discharge of Red River at Grand Forks, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1895.						
April		890	1,110			D
May	1,110	790	920			D
June	2,230	760	1,460			C
July	1,880	1,110	1,440			C
August	1,110	610	760			D
September	610	470	550			D
October	640	470	550			D
November (1-20)			670			D
1896.						
April	11,400		6,740			C
May	21,600	5,390	12,400			B
June	20,500	5,050	12,000			B
July	4,860	1,630	2,650			B
August	1,730	1,070	1,410			C
September	1,190	990	1,110			C
October	1,110	990	1,060			C
November (1-15)			1,340			C
1897.						
April	42,400	2,030	30,500			C
May	21,900	3,870	8,640			B
June	3,810	2,920	3,220			B
July	21,600	4,170	9,080			B
August	16,800	3,250	6,640			B
September	3,200	1,930	2,500			B
October	2,030	1,680	1,820			C
November			1,580			D
December			1,150			D
1898.						
January			910			D
February			990			D
March			1,330			D
April	6,300		2,570			C
May	2,330	1,540	1,920			C
June	4,920	2,030	2,840			B
July	5,880	1,830	3,440			B
August	1,780	1,320	1,510			C
September	1,360	1,110	1,200			C
October	1,630	1,070	1,330			C
November	1,360	920	1,120			D
December			800			D
1899.						
January			590			D
February			550			D
March			650			D
April	11,100		4,270			C
May	4,290	2,760	3,540			B
June	5,530	3,690	4,910			B
July	5,180	2,230	3,850			B
August	2,230	1,780	2,010			B
September	1,830	1,320	1,500			C
October	1,540	1,230	1,370			C
November	1,500	1,000	1,260			C
December			1,040			D
1900.						
January			740			D
February			560			D
March			800			D
April	4,290	1,150	2,020			C
May	1,580	730	1,060			C
June	920	430	630			D
July	860	410	670			D
August	1,270	560	890			D
September	3,990	760	2,470			B
October	7,400	3,810	5,690			B
November	6,500		4,590			C
December			2,740			D

Monthly discharge of Red River at Grand Forks, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1901.						
January			1,830			D
February			1,500			D
March			1,620			D
April	15,000	7,030	10,700			C
May	8,280	2,810	4,590			B
June	6,730	2,590	3,470			B
July	11,600	3,690	6,810			B
August	3,580	1,980	2,510			B
September	1,880	1,230	1,520			B
October	2,540	1,540	2,020			B
November			1,640			C
December			1,200			D
1902.						
September	2,000	1,470	1,700	0.068	0.08	B
October	2,660	1,320	1,640	.066	.08	B
November	3,080	1,500	2,540	.102	.11	B
1903.						
January			[a]1,600	.064	.07	D
February			[a]1,420	.057	.06	D
March			[a]2,100	.084	.10	D
April	18,800	4,460	10,600	.424	.47	B
May	7,140	4,260	5,390	.216	.25	A
June	5,870	1,940	3,340	.134	.15	A
July	2,100	1,070	1,440	.058	.07	A
August	1,300	870	1,050	.042	.05	A
September	2,660	1,180	1,890	.076	.08	A
October	3,940	1,400	2,980	.119	.14	A
November			2,200	.088	.10	B
December			[a]1,960	.078	.09	C
The year			3,000	.120	1.63	
1904.						
April (15-30)	32,900	25,500	29,200	1.17	.69	B
May	30,200	6,390	13,700	.548	.63	A
June	6,750	5,050	6,020	.241	.27	A
July	6,270	2,400	3,910	.156	.18	A
August	2,280	1,320	1,760	.070	.08	A
September	1,880	1,460	1,610	.064	.07	A
October	2,080	1,540	1,850	.074	.09	A
November	1,920	1,550	1,700	.068	.08	B
1905.						
April (7-30)	7,660	1,950	3,290	.132	.12	B
May	16,700	1,900	8,140	.326	.38	A
June	5,370	4,220	4,830	.193	.22	A
July	6,780	4,810	5,850	.234	.27	A
August	10,900	4,740	6,560	.262	.30	A
September	5,090	3,720	4,510	.180	.20	A
October	4,100	2,900	3,340	.134	.15	A
November	3,240	2,400	2,710	.108	.12	B
1906.						
January			[a]1,750	.070	.08	C
February			[a]1,590	.064	.07	C
March			[a]1,890	.076	.09	C
April	27,600	7,000	19,800	.792	.88	B
May	9,620	6,980	8,220	.329	.38	A
June	7,880	5,200	6,060	.242	.27	A
July	6,530	3,210	4,560	.182	.21	A
August	3,910	2,700	3,180	.127	.15	A
September	2,920	2,180	2,470	.099	.11	A
October	2,540	1,920	2,200	.088	.10	A
November	2,540	1,740	2,150	.086	.10	B
December			[a]1,630	.065	.07	C
The year			4,620	.185	2.51	

[a] Estimated from a few discharge measurements.

Monthly discharge of Red River at Grand Forks, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off. (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1907.						
January			[a]1,400	0.056	0.06	C
February			[a]1,090	.044	.05	C
March			[a]3,070	.123	.14	D
April	30,300	6,310	16,700	.668	.75	B
May	6,300	3,550	4,550	.182	.21	A
June	10,600	3,080	6,000	.240	.27	A
July	4,630	2,310	3,290	.132	.15	A
August	2,280	1,540	2,000	.080	.09	A
September	3,170	1,370	1,950	.078	.09	A
October	2,680	1,560	1,970	.079	.09	A
November	1,700		1,440	.058	.06	B
December			[a]1,200	.048	.06	C
The year	30,300		3,560	.149	2.02	
1908.						
January			[a] 890	.036	.04	C
February			[a] 800	.032	.03	C
March			[a] 960	.078	.09	C
April	20,500	4,400	9,850	.394	.44	B
May	9,520	3,390	5,790	.232	.27	A
June	8,680	5,360	7,140	.286	.32	A
July	5,150	2,330	3,290	.132	.15	A
August	2,530	1,660	1,970	.079	.09	A
September	3,550	1,330	1,760	.070	.08	A
October	1,610	1,270	1,440	.058	.07	A
November	1,390	1,200	1,250	.050	.06	C
December			[a] 830	.033	.04	C
The year	20,500		3,080	.123	1.68	
1909.						
January			[a] 703	.028	.03	D
February			[a] 564	.023	.02	D
March			[a] 925	.037	.04	D
April	5,180	2,480	4,340	.174	.19	D
May	3,690	2,780	3,090	.124	.14	A
June	5,050	2,380	3,110	.124	.14	A
July	9,260	2,150	3,780	.151	.17	A
August	8,040	4,320	5,590	.224	.26	A
September	4,920	2,530	3,210	.128	.14	A
October	2,480	1,970	2,230	.089	.10	A
November	2,430	1,040	1,900	.076	.08	C
December			[a]2,430	.097	.11	D
The year	9,260		2,660	.106	1.42	
1910.						
January			[a]1,520	.061	.07	C
February			[a]1,300	.052	.05	C
March	18,500		8,420	.336	.39	C
April	10,800	5,020	7,840	.314	.35	A
May	8,440	2,750	4,340	.174	.20	A
June	2,560	1,170	1,950	.078	.09	A
July	1,140	703	860	.034	.04	A
August	691	373	490	.020	.02	A
September	562	354	426	.017	.02	A
October	492	343	413	.017	.02	A
November	470	280	395	.016	.02	B
December			[a] 310	.012	.01	B
The year	18,500		2,360	.094	1.28	

[a] Estimated from a few discharge measurements.

Monthly discharge of Red River at Grand Forks, N. Dak.—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
January			[a] 210	0.0084	0.01	C
February			[a] 185	.0074	.008	B
March			[a] 760	.030	.03	C
April	2,720		1,880	.075	.08	B
May	2,380	1,120	1,500	.060	.07	A
June	3,500	1,050	1,760	.070	.08	A
July	1,060	318	578	.023	.03	A
August	464	331	392	.016	.02	B
September	454	347	391	.016	.02	B
October	639	271	463	.018	.02	B
November			[a] 370	.015	.02	C
December			[a] 340	.014	.02	D
The year	3,500		736	.029	.41	
1912.						
January			[a] 139	.0056	.006	C
February			[a] 111	.0044	.005	C
March			[a] 189	.0076	.009	D
April	3,200	550	1,780	.071	.08	C
May	2,370	1,020	1,730	.069	.08	B
June	1,600	674	1,150	.046	.05	B
July	890	640	744	.030	.03	B
August	823	470	605	.024	.03	B
September	2,670	439	801	.032	.04	B
October	2,590	883	1,330	.053	.06	B
November	1,030	492	731	.029	.03	B

[a] Estimated from a few discharge measurements.

NOTE.—The monthly discharge from 1882 to 1901 was estimated from daily gage heights of the United States Engineer Corps, reduced to the United States Geological Survey gage, three low water discharge measurements made in 1886, 1888 and 1890, and the discharge measurements made since 1902 by the United States Geological Survey. Corrections for ice effect were made during the latter part of November, March, and the first half of April, and were based on the necessary corrections made for those periods since 1905.

PELICAN RIVER NEAR FERGUS FALLS.

Location.—At the private highway bridge 6 miles northwest of Fergus Falls in Sec. 18 of that township, about 5 miles above junction with Red River.

Records available.—June 19, 1909, to December 31, 1912.

Drainage area.—433 square miles.

Gage.—Vertical staff; datum unchanged since established. Gage is read twice a day and the mean of the readings is recorded as the mean for the day.

Channel.—Permanent except after periods of high water.

Discharge measurements.—From the bridge except at low stages, when measurements are made at a wading section.

Winter flow.—Ice is present from the middle of November to the first of April and during that time discharge measurements are made to determine the winter flow.

Regulation.—The nearest dam is at Elizabeth, 6 miles above; the intermittent operation of the mill at Elizabeth causes a slight daily fluctuation in gage heights.

Accuracy. —Conditions of flow are excellent, except for fluctuations caused by operation of mill at Elizabeth. Backwater from Red River does not extend to the station, as the range in stage of that stream is small.

The records should probably be considered good.

Daily discharge, in second-feet, of Pelican River near Fergus Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							111	89	170	190	144	
2							107	103	178	195	154	
3							107	84	190	185	154	
4							93	73	180	180	151	
5							93	75	182	185	151	
6							56	84	190	180	144	
7							77	138	190	185	151	
8							82	147	180	182	151	
9							66	144	182	200	151	
10							75	135	180	226	156	
11							93	154	190	168	151	
12							111	182	182	180	147	128
13							120	218	180	168	151	
14							91	218	170	170	150	
15							80	185	185	168	150	
16							75	166	200	166	150	
17							82	154	205	185	150	
18							77	151	180	158	140	
19						170	77	144	192	142	140	
20						170	36	144	185	156	140	
21						144	175	135	200	168	140	
22						147	154	138	200	158	130	
23						142	144	168	190	168	130	
24						129	133	190	195	180	130	
25						208	113	182	192	168	130	
26						138	101	195	200	168	130	
27						71	91	182	200	166	120	
28						73	93	180	205	147	120	
29						109	91	180	200	142	120	
30						113	84	178	192	158	120	
31							89	170		168		
1910.												
1				161	182	93	45	11	3.4	4.6	13	
2				170	178	93	43	16	8.0	5	28	
3				178	180	99	30	11	4.6	18	30	
4				182	178	93	9.8	12	3.4	16	40	
5				202	170	99	8.6	10	3.4	21	45	
6				180	168	109	42	8.6	3.0	20	16	
7				178	158	99	11	7.4	3.0	19	8	
8				166	166	99	8.6	6.2	3.4	12	7.4	
9				178	158	107	15	5.6	3.0	8.6	8	
10				182	161	93	13	6.2	3.4	15	8.6	
11				154	158	89	42	5.6	2.6	21	8	
12				178	154	84	15	6.2	3.0	20	8.6	
13				170	156	80	20	8.0	5.6	15	9.8	
14				180	142	73	9.8	7.4	16	8	11	
15				170	168	80	18	8.6	5.6	5.6	8	
16				205	161	36	9.8	9.8	15	1.4	12	
17				215	151	73	5.6	8.0	13	1.8	11	
18				208	161	66	53	9.8	8.6	4.2	10	
19				208	156	40	8.0	8.6	5	4.6	15	
20		73	190	208	142	37	8.6	8.0	2.6	1.8	10	

Daily discharge, in second-feet, of Pelican River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
21	......	......	180	231	135	56	10	7.4	3.4	.9	10	......
22	......	......	182	228	138	59	12	5.6	7.4	1.4	8	1
23	......	......	190	231	129	50	13	30	5	3	8	......
24	......	......	182	215	138	53	8.0	8.0	7.4	2.6	8	......
25	......	......	178	182	135	56	10	5.0	5.6	3	8	......
26	......	......	178	178	135	55	12	28	5	3	7	......
27	......	......	170	175	120	45	13	5.0	5	3.4	7	......
28	......	......	168	192	113	43	13	5.0	5	2.6	6	......
29	......	......	170	166	111	35	42	4.6	3.4	2.6	6	......
30	......	......	175	178	103	31	16	5.6	4.6	3.4	5	......
31	......	......	178	......	99	......	10	5.6	......	5.6	......	......
1911.												
1	......	......	......	64	28	21	36	6	10	14	64	......
2	......	......	......	58	31	35	15	10	4	49	45	......
3	......	......	......	64	49	40	32	6	4	56	42	......
4	......	......	......	42	64	58	9	30	10	28	21	......
5	......	......	......	64	56	42	19	30	4	10	10	......
6	......	......	......	53	50	42	7	8	19	30	49	......
7	......	......	......	42	24	48	14	45	9	31	56	......
8	......	......	......	56	50	36	5	42	9	10	42	......
9	......	......	......	19	21	84	6	17	9	30	49	......
10	......	......	......	30	45	30	3	6	4	30	53	......
11	......	......	......	53	45	17	2	9	31	42	......	......
12	......	......	......	36	59	70	5	24	49	42	......	......
13	......	......	......	28	42	12	1	10	40	42	......	......
14	......	......	......	10	9	58	6	5	42	42	......	......
15	......	......	......	10	56	43	1	14	28	10	......	......
16	......	......	......	19	43	21	4	4	49	30	......	......
17	......	......	......	42	59	50	19	31	5	30	......	......
18	......	......	......	56	36	45	26	14	24	56	......	......
19	......	......	......	49	20	19	12	6	21	10	......	......
20	......	......	......	40	36	36	4	9	28	10	......	......
21	......	......	......	45	10	10	3	4	30	49	......	......
22	......	......	......	56	19	35	8	30	24	26	......	......
23	......	......	......	10	20	11	4	40	12	70	......	......
24	......	......	......	19	12	36	10	24	17	73	......	......
25	......	......	......	14	24	19	4	14	15	53	......	......
26	......	......	......	28	12	10	10	4	18	49	......	......
27	......	......	......	42	19	32	28	5	9	49	......	......
28	......	......	......	30	28	49	21	10	10	40	......	......
29	......	......	......	42	14	10	28	4	19	10	......	......
30	......	......	......	29	21	17	5	10	10	45	......	......
31	......	......	......	......	32	......	7	4	......	42	......	......
1912.												
1	......	......	......	......	126	200	42	49	22	75	49	......
2	......	......	......	......	139	170	42	40	22	116	50	......
3	......	......	......	......	170	153	42	16	38	26	13	......
4	......	......	......	......	167	126	38	14	22	14	36	......
5	......	......	......	......	167	116	42	42	48	42	42	......
6	......	......	......	73	170	111	42	42	42	14	50	......
7	......	......	......	98	170	98	42	56	36	64	50	......
8	......	......	......	93	170	93	42	119	14	73	49	......
9	......	......	......	64	170	93	38	142	14	55	45	......
10	......	......	......	56	170	93	42	104	31	55	14	......
11	......	......	......	64	167	93	42	75	31	53	42	......
12	......	......	......	73	170	93	36	59	31	43	45	......
13	......	......	......	73	167	104	42	43	31	13	49	......
14	......	......	......	53	170	137	42	40	31	40	49	......
15	......	......	......	64	170	164	64	31	14	43	55	......
16	......	......	......	75	170	148	41	29	49	42	49	......
17	......	......	......	56	170	142	14	27	49	45	53	......
18	......	......	......	66	170	116	14	22	49	48	42	......
19	......	......	......	64	170	116	56	22	53	45	48	......
20	......	......	......	66	185	107	21	31	56	14	42	......
21	......	......	......	56	200	85	14	27	59	42	45	......
22	......	......	......	83	200	70	14	31	15	48	......	......
23	......	......	......	93	200	56	26	24	14	48	......	......
24	......	......	......	98	200	42	16	22	21	56	......	......
25	......	......	......	89	200	42	24	22	73	55	......	......

Daily discharge, in second-feet, of Pelican River near Fergus Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
26	......	......	......	81	200	43	20	22	64	50	......	......
27	......	......	......	93	215	42	16	22	64	18	......	......
28	......	......	......	75	230	42	14	24	31	59	......	......
29	......	......	......	81	230	42	14	26	31	49	......	......
30	......	......	......	102	215	31	40	56	31	49	......	......
31	......	......	......	......	215	......	45	22	......	49	......	......

Daily discharges computed from a well-defined rating curve, except Nov. 20 to 30, 1910, for which period is estimated because of ice. Operations of flour mill at Elizabeth, a few miles above, have a decided influence on the flow, especially in winter and during periods of low water. The 1912 rating curve was not well defined.

Monthly discharge of Pelican River near Fergus Falls.

[Drainage area, 433 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (19-30)	208	71	134	0.309	0.14	A
July	175	36	96	.222	.26	A
August	218	73	151	.349	.40	A
September	205	170	189	.436	.49	A
October	226	142	173	.400	.46	A
November	156	120	142	.328	.37	B
December	....	....	[a]125	.289	.33	C
1910.						
January	....	....	[a]125	.289	.33	C
February	....	....	[a] 80	.185	.19	C
March	....	....	[a]180	.416	.48	C
April	231	154	188	.434	.48	A
May	182	99	149	.344	.40	A
June	109	31	70.8	.164	.18	A
July	53	5.6	18.5	.043	.05	A
August	30	4.6	9.15	.021	.02	B
September	16	2.6	5.58	.013	.01	B
October	21	.8	8.06	.016	.02	B
November	45	....	12.7	.029	.03	D
December	....	....	[a]3.00	.0069	.01	D
The year	231	....	70.6	.163	2.20	
1911.						
January	....	....	[a] 2.0	.0046	.005	D
February	....	....	[a] 2.0	.0046	.005	D
March	....	....	[a] 10.0	.023	.03	D
April	64	10	38.3	.088	.09	C
May	64	9	33.4	.077	.09	B
June	84	10	34.5	.080	.09	B
July	36	1	11.4	.026	.03	C
August	45	4	15.3	.035	.04	C
September	49	4	18.8	.043	.05	C
October	73	10	35.7	.082	.09	B
November	64	....	22.4	.052	.06	D
December	....	....	[b] 10.0	.023	.03	D
The year	84	....	19.3	.045	.61	

[a] Estimated from one discharge measurement, semi-weekly gage heights and climatological records.
[b] Estimated from discharge of Ottertail River near Fergus Falls.

Monthly discharge of Pelican River near Fergus Falls—Continued.

Month.	Discharge in second-feet.				Run-off. (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1912.						
January			c2.0	0.0046	0.005	
February			c2.0	.0046	.005	
March			c8.0	.018	.02	
April			71.3	.165	.18	C
May	230	126	182	.420	.48	B
June	200	31	98.9	.228	.25	B
July	64	14	33.1	.076	.09	C
August	142	14	42.0	.097	.11	B
September	73	14	36.2	.084	.09	C
October	116	13	46.5	.107	.12	C
November		13	42.6	.098	.11	C

[c] Estimated from discharge measurements, climatological records, gage heights and discharge of adjacent drainage areas.

SOUTH BRANCH OF TWO RIVERS AT HALLOCK.

Location.—At private wagon bridge on farm of John Ross in Sec. 12, T. 161 N., R. 49 W., one-half mile north of Hallock, a mile below the nearest tributary,—a small creek entering from the east.

Records available.—April 29, 1911, to November 15, 1912.

Drainage area.—776 square miles.

Channel.—Probably permanent, as the control point is an abandoned loose rock dam 4 feet high, located a mile or more below the station. The dam was formerly used to raise the water level for a railroad water tank.

Discharge measurements.—Made from the bridge.

Winter flow.—From November to April the river is frozen over and gage readings are discontinued.

Accuracy.—The records are good.

Daily discharge, in second-feet, of South Branch of Two Rivers at Hallock.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1					24	39	76	8	13	20	20	
2					20	45	76	8	13	20	20	
3					16	51	69	8	13	20	20	
4					16	161	63	8	13	51	20	
5					16	206	51	8	13	51	16	
6					16	197	51	13	10	76	16	
7					16	197	39	13	10	76	16	
8					16	295	39	13	8	76	16	
9					13	491	39	8	8	69	16	
10					16	601	39	8	8	69	16	
11					45	634	39	8	8	51		
12					54	634	29	8	8	51		
13					66	634	29	8	8	69		
14					83	579	29	8	8	76		
15					97	535	24	8	8	76		
16					103	458	24	8	8	69		
17					97	502	24	8	8	69		
18					100	502	20	8	16	51		
19					90	458	20	8	20	51		
20					104	414	20	8	20	34		

Daily discharge, in second-feet, of South Branch of Two Rivers at Hallock—Cont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
21	......	......	......	......	112	381	20	8	16	20	......	......
22	......	......	......	......	69	348	16	13	16	20	......	......
23	......	......	......	......	51	305	13	13	10	20	......	......
24	......	......	......	......	57	245	13	16	10	20	......	......
25	......	......	......	......	51	215	13	20	10	20	......	......
26	......	......	......	......	45	197	8	20	10	20	......	......
27	......	......	......	......	34	152	8	13	10	20	......	......
28	......	......	......	......	29	112	8	13	20	20	......	......
29	......	......	......	29	29	90	8	13	20	20	......	......
30	......	......	......	26	34	76	8	13	20	20	......	......
31	......	......	......	......	34	......	8	13	......	20	......	......
1912.												
1	......	......	......	39	20	63	1	20	13	179	69	......
2	......	......	......	60	34	63	1.5	20	10	179	69	......
3	......	......	......	76	20	57	1.5	16	8	197	69	......
4	......	......	......	69	20	45	2	13	8	206	76	......
5	......	......	......	60	16	39	2	13	13	206	76	......
6	......	......	......	76	13	34	2	45	16	206	69	......
7	......	......	......	97	16	34	3	63	10	215	69	......
8	......	......	......	120	13	29	2	45	10	188	76	......
9	......	......	......	83	16	24	2	34	8	170	76	......
10	......	......	......	57	20	20	3	29	6	152	76	......
11	......	......	......	57	16	13	4.5	29	6	144	76	......
12	......	......	......	39	20	10	4.5	20	4.5	136	69	......
13	......	......	......	34	16	8	6	20	4.5	120	63	......
14	......	......	......	57	34	6	6	10	6	104	63	......
15	......	......	......	29	34	6	4.5	10	6	104	63	......
16	......	......	......	16	20	6	4.5	10	7	83	......	......
17	......	......	......	20	13	6	3	10	7	76	......	......
18	......	......	......	20	13	6	3	8	6	69	......	......
19	......	......	......	20	13	6	2	8	6	63	......	......
20	......	......	......	20	13	4.5	1.5	6	16	63	......	......
21	......	......	......	6	13	3	1.5	6	29	63	......	......
22	......	......	......	13	13	3	1.5	6	39	54	......	......
23	......	......	......	20	16	3	1.5	6	45	51	......	......
24	......	......	......	51	16	3	1.5	6	51	51	......	......
25	......	......	......	83	20	3	1.5	6	57	39	......	......
26	......	......	......	63	24	3	10	6	83	39	......	......
27	......	......	......	34	29	2	20	8	100	39	......	......
28	......	......	......	20	24	2	34	8	112	39	......	......
29	......	......	......	13	34	1.5	57	10	120	51	......	......
30	......	......	......	13	45	1.5	34	10	128	51	......	......
31	......	......	......	......	57	......	20	13	......	63	......	......

NOTE.—Daily discharge computed from a fairly well-defined rating curve.

Monthly discharge of South Branch of Two Rivers at Hallock.

[Drainage area, 776 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
May	112	13	50.1	0.065	0.07	B
June	634	39	325	.419	.47	B
July	76	8	29.8	.038	.04	D
August	20	8	10.6	.014	.02	D
September	20	8	12.1	.016	.02	D
October	76	20	43.4	.056	.06	D
November	20		[a]12.5	.016	.02	D
December			[a] 8.0	.010	.01	
1912.						
April	120	6	45.5	.059	.07	C
May	57	13	21.6	.028	.03	D
June	63	1.5	16.8	.022	.02	D
July	57	1	7.81	.010	.01	D
August	63	6	16.6	.021	.02	D
September	128	4.5	31.2	.040	.04	C
October	215	39	110	.142	.16	B
November	76		50.3	.065	.07	C

[a] Estimated.

WEST BRANCH OF ROSEAU RIVER NEAR MALUNG.

Location.—At the highway bridge near the center of Sec. 7, T. 161 N., R 39 W., 6¼ miles south of Roseau, 1 mile west of Malung Post-office, and ½ mile above the mouth of the East Branch.

Records available.—May 6, 1911, to November 15, 1912.

Drainage area.—265 square miles.

Gage.—Vertical staff.

Channel.—Probably fairly permanent, although there is a possibility of temporary backwater effect from the East Branch.

Discharge measurements.—Made at the bridge except during low stages when they are made at a wading section. Discharge measurements are also made on the East Branch at the bridge at Malung 1 mile above the junction, and on Roseau River at Roseau for the purpose of determining the portion of the flow at Roseau that comes from the East Branch, and to determine the entire flow below that point, as conditions of flow below the junction of the two branches are very unfavorable for the establishment of a regular station.

Winter flow.—From November to April the river is frozen over and observations are discontinued.

Regulation.—Much of the area drained by Roseau River is so swampy that it can not be cultivated without drainage. In connection with this work the river channel has been straightened and widened to 80 feet for a distance of 40 miles,—a drainage system benefiting 90,000 acres of land south of the river discharges into the Roseau by 10 ditches 1 mile apart in T. 163 N., Rs. 43 and 44. Another ditch system, draining about 20,000 acres enters Roseau River in Sec. 6, T. 162 N., R. 39 W.

Accuracy.—The records are good.

Daily discharge, in second-feet, of West Branch of Roseau River near Malung.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1						7.6	7.6	3.0	2.2	2.2	2.2	
2						6.6	7.6	3.0	2.2	2.2	2.2	
3						11	7.6	3.0	1.5	3.8	2.2	
4						15	6.6	3.0	1.5	3.8	2.2	
5						29	5.6	3.8	.8	3.8	2.2	
6					3.8	25	5.6	4.7	.8	3.8	2.2	
7					3.8	18	5.6	4.7	.8	3.8	2.2	
8					3.0	20	8.7	3.8	.8	3.8	1.5	
9					3.0	43	7.6	3.0	.8	3.8	1.5	
10					3.8	122	7.6	3.0	.8	3.0	1.5	
11					3.8	342	6.6	2.2	.8	3.0	1.5	
12					5.6	507	6.6	1.5	.8	2.2	3.8	
13					5.6	473	5.6	1.5	.8	3.0		
14					6.6	314	5.6	8.7	.8	3.8		
15					8.7	182	4.7	6.6	.8	3.8		
16					8.7	126	3.8	4.7	.8	3.0		
17					7.6	115	3.8	3.8	.8	2.2		
18					6.6	87	3.8	3.0	.8	2.2		
19					5.6	58	3.8	2.2	.8	2.2		
20					5.6	46	3.8	2.2	1.5	2.2		
21					5.6	31	3.8	3.8	1.5	2.2		
22					4.7	23	3.0	3.8	2.2	3.0		
23					4.7	15	3.0	3.0	2.2	3.0		
24					3.8	14	3.0	2.2	2.2	3.0		
25					3.8	9.8	3.0	2.2	2.2	3.0		
26					5.6	9.8	3.0	1.5	2.2	2.2		
27					5.6	8.7	2.2	2.2	2.2	2.2		
28					6.6	8.7	2.2	3.0	2.2	2.2		
29					5.6	8.7	2.2	2.2	2.2	2.2		
30					7.6	7.6	2.2	2.2	2.2	2.2		
31					7.6		2.2	2.2		2.2		
1912.												
1					8.7	9.8	1.5	3.8	3.8	1,040	115	
2					18	12	1.5	3.8	3.8	1,030	108	
3					15	12	1.5	3.8	3.0	926	101	
4					15	12	.8	2.2	3.0	807	80	
5					18	11	.8	2.2	3.0	660	80	
6					18	9.8	.8	2.2	2.2	514	73	
7				52	18	8.7	.8	2.2	2.2	421	73	
8				43	33	8.7	3.8	3.8	2.2	396	73	
9				33	31	7.6	3.0	5.6	2.2	384	80	
10				14	31	7.6	3.0	6.6	2.2	360	94	
11				15	29	6.6	2.2	5.6	2.2	325	94	
12				18	25	5.6	2.2	4.7	2.2	314	87	
13				18	27	5.6	2.2	4.7	2.2	303	80	
14				15	21	4.7	2.2	3.8	2.2	292	73	
15				12	21	3.8	2.2	3.8	2.2	260	67	
16				12	18	3.8	2.2	3.0	3.8	230	55	
17				12	18	3.8	2.2	2.2	7.6	200	55	
18				9.8	18	3.8	2.2	2.2	9.8	173		
19				9.8	16	3.8	2.2	2.2	9.8	155		
20				9.8	15	3.8	2.2	2.2	12	138		
21				8.7	12	3.0	1.5	2.2	12	122		
22				8.7	12	3.0	1.5	2.2	15	108		
23				8.7	12	2.2	.8	2.2	49	94		
24				7.6	12	2.2	.8	2.2	84	80		
25				7.6	12	2.2	.8	2.2	164	73		
26				9.8	11	2.2	.8	2.2	314	67		
27				9.8	11	2.2	3.8	2.2	556	61		
28				8.7	11	2.2	3.8	2.2	652	55		
29				9.8	9.8	2.2	3.8	3.8	773	61		
30				9.8	9.8	2.2	3.8	3.8	900	80		
31					9.8		3.8	3.8		115		

NOTE.—Daily discharge computed from a rating curve fairly well-defined below 486 second-feet, but may be 10 per cent in error at a discharge of 960 second-feet.

Monthly discharge of West Branch of Roseau River near Malung.

[Drainage area, 265 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
May (6-31)	8.7	3.0	5.50	0.021	0.02	C
June	507	6.6	89.8	.339	.38	B
July	8.7	2.2	4.77	.018	.02	C
August	8.7	1.5	3.22	.012	.01	C
September	2.2	.8	1.41	.0053	.006	D
October	3.8	2.2	2.87	.011	.01	D
November	3.8	....	2.04	.0077	.009	....
December	....	....	1.5	.0057	.007	....
1912.						
January	....	....	0.4	.0015	.002	....
February	....	....	0.2	.00075	.0008	....
March	....	....	0.5	.0019	.002	....
April	....	....	20.5	.077	.09	C
May	33	8.7	17.3	.065	.07	B
June	12	2.2	5.60	.021	.02	C
July	3.8	.8	2.09	.0079	.009	D
August	6.6	2.2	3.21	.012	.01	D
September	900	2.2	120	.453	.51	C
October	1,040	55	318	1.20	1.38	C
November	115	....	58.0	.219	.24	C

NOTE.—Discharge from November 13, 1911, to April 6, 1912, estimated from climatological records, and discharge of adjacent drainage areas.

DEVELOPED WATER POWER.

The uniformity of flow of Ottertail River below Ottertail Lake, together with the heavy fall of the river, makes the Ottertail an important power stream. There are six developed sites on the Ottertail and four on the Pelican, a tributary. These developments are as follows:

OTTERTAIL RIVER.

Maine Mills, on Line Between Secs. 26 and 35, T. 134 N., Range 41 W.—At this point, which is just below the outlet of Lake Leon, is located the Maine Roller mill. By means of an 8-foot masonry dam about 160 feet long a head of 8 feet is created. A flume conducts the water to a 60-inch Flenniken wheel, having a capacity of 56 horsepower, and a 40-inch Victor wheel, having a capacity of 75 horsepower. The turbines are set on vertical shafts connected by bevel-gearing to a horizontal shaft which operates the machinery in the mill. Each turbine is controlled by a hand gate. The plant is operated a quarter of the time.

Fergus Falls City Power Plant, in Sec. 31, T. 133 N., R. 42 W.—This plant which contained a turbine generating about 500 horsepower was destroyed by high water in the fall of 1909 and has not yet been rebuilt. When the dam went out an older dam 8 feet high, located a short distance above, was uncovered. This dam was submerged by the building of the first one.

City Water Co. Plant, in Sec. 36, T. 133 N., R. 43 W.—By means of a dam 12 feet high and 200 feet long a head of 12 feet is created which is utilized in furnishing power to the city to operate the water works system. A flume conducts the water to two old turbines whose capacity is probably in excess of 100 horsepower, but as the lease calls for not more than that amount, that is the limit of development. The plant operates continuously and has an emergency steam plant of 100 horsepower capacity.

Upper Dam at Fergus Falls.—At Fergus Falls is the plant of the Ottertail Power Co. A timber crib dam 14 feet high and about 100 feet long creates a head of 14 feet which is utilized by 4 wheels. The Ottertail Power Co. has two 23-inch Leffel wheels of 56 horsepower capacity each, operated by a Lombard governor. The wheels are direct connected to a General Electric 50 KW direct current generator of 220 voltage at 245 revolutions per minute. This plant furnishes power to Fergus Falls and operates continuously. In addition to operating these wheels, water is sold to the Fergus Flour mill for use in running a 54-inch Eclipse wheel of 100 horsepower capacity which is owned by the milling company. The average power developed at this dam is about 135 horsepower. There is no auxiliary steam plant.

Lower Dam at Fergus Falls.—At this point is the dam of the Red River Milling Co. which is 9 feet high and creates a head of 11 feet. At the north end of the dam a flume carries the water to a 56-inch Samson wheel of 230 horsepower capacity which is belt connected to the machinery of the mill. At the south side of the dam The Fergus Falls Manufacturing Co. has a 60-inch American wheel of 80 horsepower capacity belt connected to the machinery of the sash and blind factory. The milling company uses an average of 100 horsepower for 10 hours per day, and the Fergus Mfg. Co. about 25 horsepower for the same period. Each wheel is entitled to one-half the flow, and although the latter company has sufficient water at all times the former company does not. There is practically no pondage as this dam is only a short distance below the upper dam. Flashboards are used continuously to give additional head. Neither plant has auxiliary steam power.

Dayton Hollow, in Sec. 20, T. 132 N., R. 43 W.—The Ottertail Power Co. has recently built a 40-foot reinforced concrete dam 400 feet long which gives an available head of 36 feet. The power house is located at the south end of the dam. This is designed for three units, each unit consisting of a pair of 30-inch S. Morgan Smith wheels and a 12-inch S. Morgan Smith exciter, having an effective capacity of 700 horsepower and controlled by a Lombard governor.

(At the present time two units have been installed.) Each unit is directly connected to a 450-KW General Electric, alternating current, 3-phase, 60-cycle generator of 2,300 voltage. The exciter wheel has a 30-KW generator of 125 voltage. The voltage of the transmission line, by which the power is transmitted to Fergus Falls, Wahpeton and Breckenridge is 22,000. The available pondage is 300 acres with an allowable draft of 1 foot. Flashboards are used during the period of low water. The plant operates continuously. There is no auxiliary steam plant.

PELICAN RIVER.

Lake View.—A flour mill is operated by water power at this point, but no details of the plant are available. It is probable that the power developed does not exceed 50 horsepower.

Kingsbury Lock, near Bucks Mills Postoffice.—A lock between Melissa and Big Pelican lakes affords a head of 11 feet which is utilized by a 65 horsepower American wheel in running a saw mill. About 30 horsepower is the average development. The dam at the lock holds the water on Lake Melissa, affording considerable storage.

Pelican Rapids.—At this point a head of 12 feet is utilized in running a flour mill and an electric lighting plant. Two wheels are installed, one developing 45 horsepower and the other 60. The average development is 100 horsepower.

Elizabeth.—The Pelican River Mill Co. utilizes a head of 13 feet to run its flour mill at Elizabeth. There is an old wheel whose make and capacity are unknown—it develops an average of 100 horsepower. It has a vertical shaft that is bevel geared to a horizontal shaft by which the mill machinery is operated. There is a small generator only used to light the mill. There is an auxiliary steam plant of 85 horsepower capacity.

BUFFALO RIVER.

Richwood.—At this point a head of 11 feet is utilized by a wheel developing an average of 40 horsepower which is used in operating a flour mill and saw mill.

SAND HILL RIVER.

Fertile.—Two wheels develop an average of 50 horsepower under a head of 15 feet. No further details of this plant are available.

AVAILABLE HORSEPOWER.

From the records of flow of Ottertail and Pelican rivers the following table has been compiled, showing the available continuous horsepower at the developed sites:

Available horsepower at developed power sites.

Developed Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low,year	Lowest month	Lowest month average low year	6 Highest months average low year
Ottertail River.							
Main Mills	8	32	145	236	23	105	172
Fergus Falls:							
City Power Plant [a]	.....	33	145	238	.....	.....	.....
City Water Co.	12	33	145	238	36	158	260
Upper Dam	14	34	145	240	43	185	305
Lower Dam	11	34	145	240	34	145	240
Dayton Hollow	36	41	214	330	134	700	1080
Pelican River.							
Lake View	.....	0	.....	.....	.....	.....	.....
Kingsbury Lock	11	0	21	31	0	21	31
Pelican Rapids	12	1	46	76	1	50	83
Elizabeth	13	2	48	79	2	57	93

[a] Dam destroyed.

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

Owing to the natural regulation of the lower Ottertail River by Ottertail Lake this stream is one of the best suited for power development. To determine the possible power developments a survey of the river from Maine Mills near Phelps Postoffice to sec 34, T. 132 N., R. 44 W., was made during 1910. The results of this survey are given on plates 40 to 46, inclusive of the atlas, and from these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Ottertail River from Phelps Dam to Sec. 34, T. 132 N., R. 44 W.

Stations	Distance in miles		Elevation in feet above sea level	Descent in feet between points	
	From Phelps, dam	Point to Point		Total	Per Mile
Phelps dam, crest	0.0	.....	1,317.5	.....	.....
foot	0.0	0.0	1,310	7.5	.....
.....	2.0	2.0	1,305.5	4.5	2.2
Entrance to West Lost Lake	3.7	1.7	1,303	2.5	1.5
Outlet of West Lost Lake	6.6	2.9	1,303	0.0	0.0
Oliver dam, crest	8.7	2.1	1,301.5	1.5	0.7
foot	8.7	2.0	1,298	3.5	.....
.....	10.0	1.3	1,290	8.0	6.1
Section line 29-30	12.8	2.8	1,287	3.0	1.1
.....	14.0	1.2	1,272.5	14.5	12.1
Highway bridge township line 133-134	16.2	2.2	1,265	7.5	3.4
Section line 6-7	17.8	1.6	1,260.5	4.5	2.8
Section line 7-18	19.2	1.4	1,253	7.5	5.4
Highway bridge	21.2	2.0	1,250.5	2.5	1.2
Highway bridge section line 21-28	25.4	4.2	1,238	12.5	3.0
N. P. Ry. bridge	27.6	2.2	1,232.5	5.5	2.5
.....	29.0	1.4	1,230	2.5	1.8
Upper end pond old dam at City power plant	31.7	2.7	1,215	15.0	5.6
Old dam at City power plant, crest	31.9	0.2	1,215	0.0	0.0
foot	31.9	0.0	1,206	9.0	.....

Elevations and distances along Ottertail River from Phelps Dam to Sec. 34, T. 132 N., R. 44 W.—Continued.

Stations	Distance in miles		Elevation in feet above sea level	Descent in feet between points	
	From Phelps dam	Point to Point		Total	Per Mile
Upper end pond City Water Co. dam	32.9	1.0	1,197	9.0	9.0
City Water Co. dam, crest	33.6	0.7	1,197	0.0	0.0
foot	33.6	0.0	1,185.5	11.5	....
Upper end pond Fergus Falls mill dam	34.1	0.5	1,182	3.5	7.0
Fergus Falls mill dam, crest	35.2	1.1	1,182	0.0	0.0
foot	35.2	0.0	1,168.5	13.5	....
Red River Milling Co. dam, crest	35.4	0.2	1,166.5	2.0	10.0
foot	35.4	0.0	1,158	8.5	....
Section line 4-5	36.9	1.5	1,131	27.0	18.0
Pelican River	39.4	2.5	1,118.5	12.5	5.0
Upper end pond Ottertail Power Co. dam	41.0	1.6	1,108	10.5	6.6
Ottertail Power Co. dam, crest	44.6	3.6	1,108	0.0	0.0
foot	44.6	0.0	1,073.5	34.5	....
Range line 43-44	47.7	3.1	1,050	23.5	7.6
Highway bridge	50.8	3.1	1,035.5	14.5	4.7

The upper part of Ottertail River as far down as a point several miles below Height of Land Lake has considerable fall which is utilized somewhat by logging dams, but the flow is too small to make possible important power developments. From Frazee to the dam at Phelps there is little fall and the topography is unfavorable for power development.

Below the lower limits of the survey the Ottertail (or Red River) has considerable fall as far as the mouth of the Bois des Sioux River, but the banks are too low to permit of extensive development. From the Bois des Sioux River to the International Boundary the slope is very flat as shown by the following table compiled from a survey made by the United States Engineer Corps:

Elevations and distances along Red River from International Boundary to Breckenridge.

Point	Distance in Miles		Elevation in feet above sea level	Ascent in feet between points	
	From International Boundary	Point to Point		Total	Per Mile
International Boundary	0	....	748	....	....
Lower end Pelican Bars	48.0	48.0	757	9	0.19
Turtle River	118.5	70.5	778	20	0.28
Grand Forks	143.5	25.0	784	6	0.24
Frog Point	178.5	35.0	797	13	0.37
Goose Rapids	200.5	22.0	818	21	0.95
Moorhead	298.5	98.0	869	51	0.52
Fort Abercrombie	369.5	71.0	907	38	0.54
Breckenridge	395.5	26.0	943	36	1.38

The survey of Ottertail River shows the following feasible power sites:

In sec. 31, T. 134 N., R. 42 W.—At mile 13.7 a 34-foot dam would back the water 13.7 miles upstream to the foot of Phelps dam which is the controlling feature. This would store water 7 feet deep on Lost Lake and West Lost Lake, and would overflow 750 acres of land the greater portion of which is marsh and water surface with very little cultivated area. A 500-foot pipe line would add three feet to the available head, making a total development of 37 feet.

On sec. Line 28-21, T. 133 N., R. 42 W.—At mile 25.5 a 32-foot dam would back the water 11 miles upstream nearly to the dam site in sec. 31. It would overflow 1,350 acres, consisting chiefly of meadow and marsh, with very little cultivated land.

In sec. 31, T. 133 N., R. 42 W.—A quarter of a mile above the ruins of the Fergus Falls power plant, at mile 31.8, the banks are steep and close together, affording a dam site. A 27-foot dam would back the water 5.3 miles upstream or nearly to the dam site on section line 28-21. The overflowed area would be 100 acres, consisting of marsh and meadow land.

In sec. 4, T. 132 N., R. 43 W.—In the northeast corner of sec. 4, at mile 36.9, a 24-foot dam would back the water 1½ miles upstream, nearly to the foot of the lower dam in Fergus Falls, which is the controlling feature. Owing to the high banks there would be practically no land overflowed.

In sec. 6, T. 132 N., R. 43 W.—A 20-foot dam at mile 40.5, 1 mile below the mouth of Pelican River would back the water 3½ miles upstream to the dam site in section 4, which is the controlling feature. This dam would overflow 220 acres mostly meadow and timber land.

In sec. 26, T. 132 N., R. 44 W.—If a 34-foot dam were erected at mile 50.9, 5½ miles below the Dayton Hollow Dam it would back the water upstream nearly to that dam which limits the head at the present site. The area overflowed would be 580 acres.

AVAILABLE HORSEPOWER.

From the records of flow of Ottertail River the following estimates of horsepower have been made:

Undeveloped horsepower on Ottertail River.

Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Sec. 31, T. 134 N., R. 42 W.	37	32.6	145	236	110	488	794
Sec. line 28-21, T. 133 N., R. 42 W.	32	32.6	145	236	95	422	687
Sec. 31, T. 133 N., R. 42 W.	27	32.6	145	236	80	356	579
Sec. 4, T. 132 N., R. 43 W.	24	34.0	147	245	74	321	535
Sec. 6, T. 132 N., R. 43 W.	20	41.0	210	324	75	382	589
Sec. 26, T. 132 N., R. 44 W.	34	42.0	216	333	130	667	1029

PELICAN RIVER.

The following table of elevations and distances along Pelican River, a tributary of the Ottertail, has been compiled from various sources and can only be considered approximate:

Elevations and distances along Pelican River from mouth to Lake Elsa.

Point.	Distance in Miles.		Elevation in feet above sea level.	Ascent in feet between points	
	Above Mouth.	Point to Point.		Total.	Per Mile.
Ottertail River	0		1,118		
Sec. 13, T. 133 N., R. 44 W.	4	4	1,149	31	7.8
Elizabeth dam, tailwater	41	7	1,215	66	9.4
headwater	11	0	1,228	13	
Erhard	18	7	1,268	40	5.7
Pelican Rapids, (G. N. Ry.)	23	5	1,280	12	2.4
Pelican Rapids dam, tailwater	25	2	1,289	9	4.5
headwater	25	0	1,301	12	
Lake Lizzie, outlet	30	5	1,315	14	2.8
inlet	35	5	1,315	0	0.0
Pelican Lake, outlet	37	2	1,320	5	2.5
inlet	41	4	1,320	0	0.0
Lake Melissa, outlet	45	4	1,330	10	2.5
inlet	47	2	1,330	0	0.0
Detroit Lake, outlet	50	3	1,335	5	1.7
inlet	52	2	1,335	0	0.0
Lake Elsa, outlet	55	3	1,345	10	3.3

As no topographic survey has been made of Pelican River, there is no information regarding dam sites. From the preceding table, the following sections have been selected as offering the best opportunity for power development. The estimates of horsepower are based on the records of flow of Pelican River.

Undeveloped horsepower on Pelican River.

Section of river.	Total fall in feet.	Minimum Run-off.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Between Ottertail River and Sec. 13, T. 133 N., R. 44 W.	31	2	48	79	6	135	223
Between Sec. 13, T. 133 N., R. 44 W., and Elizabeth dam. .	66	2	48	76	12	288	456
Between Elizabeth dam and Erhard.	40	2	46	76	7	167	276

STORAGE STUDY OF OTTERTAIL LAKE.

There are a number of lakes in the channel of Ottertail River which are available as reservoir sites. Although some of the upper lakes, notably Height of Land Lake, are used as storage reservoirs for log driving, their tributary runoff is too small to have much effect on the flow of the lower river. Pine, Rush and Ottertail lakes all have sufficient tributary runoff, but as there is very little fall between Pine and Ottertail lakes there are no power possibilities, and therefore the regulation of flow is not needed above Ottertail Lake. For that reason the storage investigations were confined to Ottertail Lake which is by far the largest lake and most feasible reservoir. Below Ottertail Lake there are no important reservoir sites.

A survey of Ottertail Lake was made in 1911 by the Topographic Branch of the United States Geological Survey. This survey (see plate 39 of the atlas) shows not only the outline of the lake itself but also the line of five-foot depth, and the five-foot contour above the water surface. In many places the ten-foot contour is also shown.

From this survey it is seen that the elevation of Ottertail Lake is only about 2 feet higher than the crest of the power dam near Phelps. Therefore, it is not feasible to secure storage capacity by drawing down the water surface below its present level. This necessitates raising the water level to secure storage.

The following table shows the available storage at different elevations of the water surface:

Capacity of Ottertail Lake reservoir.

Contour.	Area.		Capacity of Section Acre-feet.	Total Capacity.	
	Square miles.	Acres.		Acre-feet.	Cubic-feet.
1,320	22.69	14,521	. . . .	. . . .	. . . .
1,323	23.23	14,867	44,082	44,082	. . . .
1,323	33.20	21,248	0	44,082	. . . .
1,324	33.74	21,594	21,421	65,503	. . . .
1,325	34.27	21,933	21,764	87,267	3,801,350,520

The elevation of Ottertail Lake is 1,320. The elevation of Rush Lake is 1,323. Between 1,320 and 1,323 the storage area will not include Rush Lake area, but *above* 1,323 the area of the 1,323 contour will include Rush Lake.

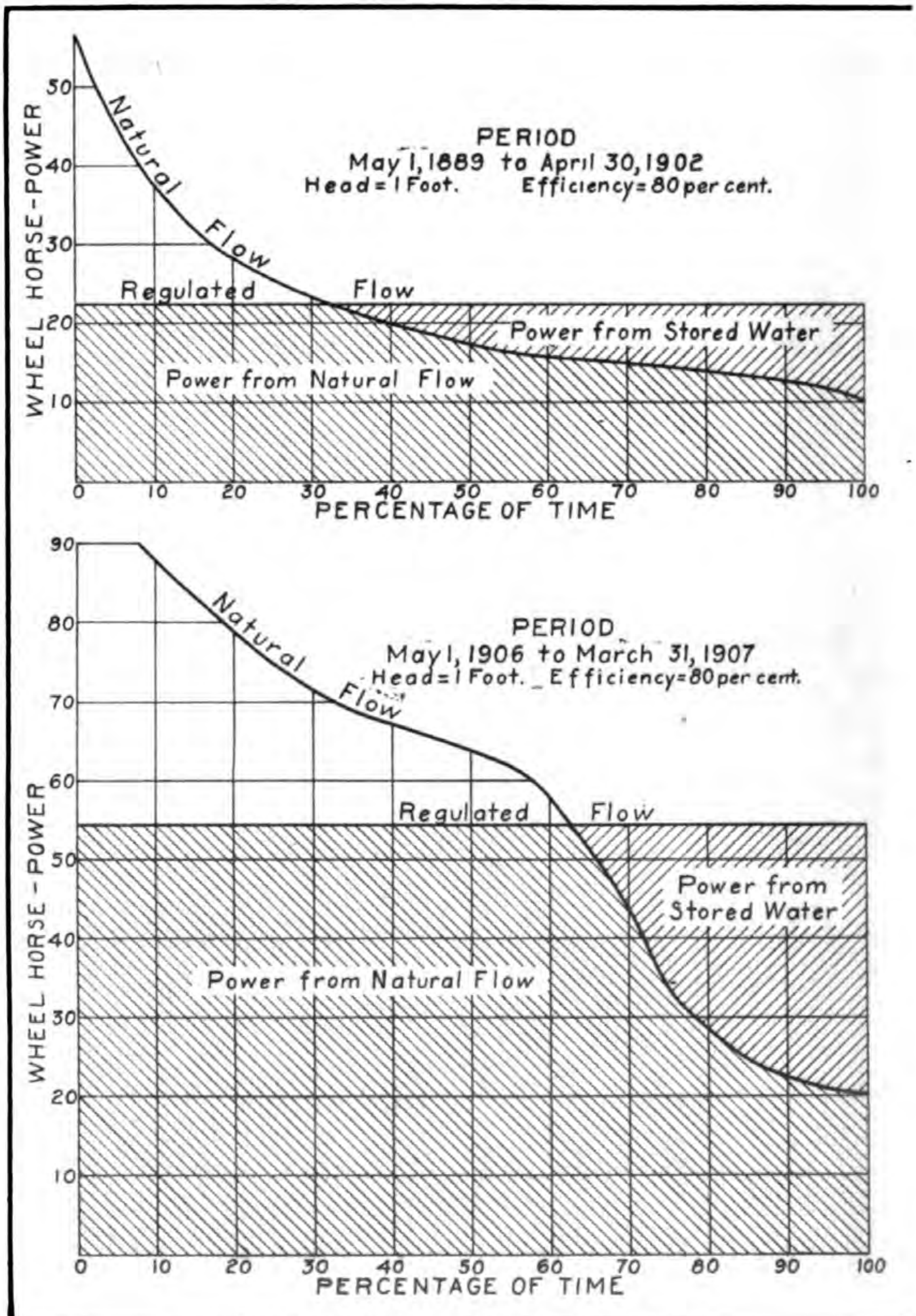
The area at the 1,320 contour, which is the present elevation of the lake, includes Walker Lake, and Ottertail River for a distance of a mile or more above the inlet. As the elevation of Rush Lake is 1,323 feet, 3 feet of storage on Ottertail Lake will raise the water even with the level of the former, and any further rise will increase the storage capacity by the area of that lake. As the elevation of Dead Lake is 1,327 feet any rise less than 7 feet will not affect it. Although Long Lake has an elevation of 1,323 it has no surface outlet, and, therefore, will not be affected by any rise of 5 feet or less as the land between the two lakes is at least 5 feet high. A rise of 5 feet on the lake surface would overflow very little land, as in the main the banks are higher than that. Above that point, however, the land becomes flat as shown by the many breaks in the ten-foot (1330) contour. For this reason it has been decided that the feasible limit of storage is about 5 feet or approximately 4,000,000,000 cubic feet.

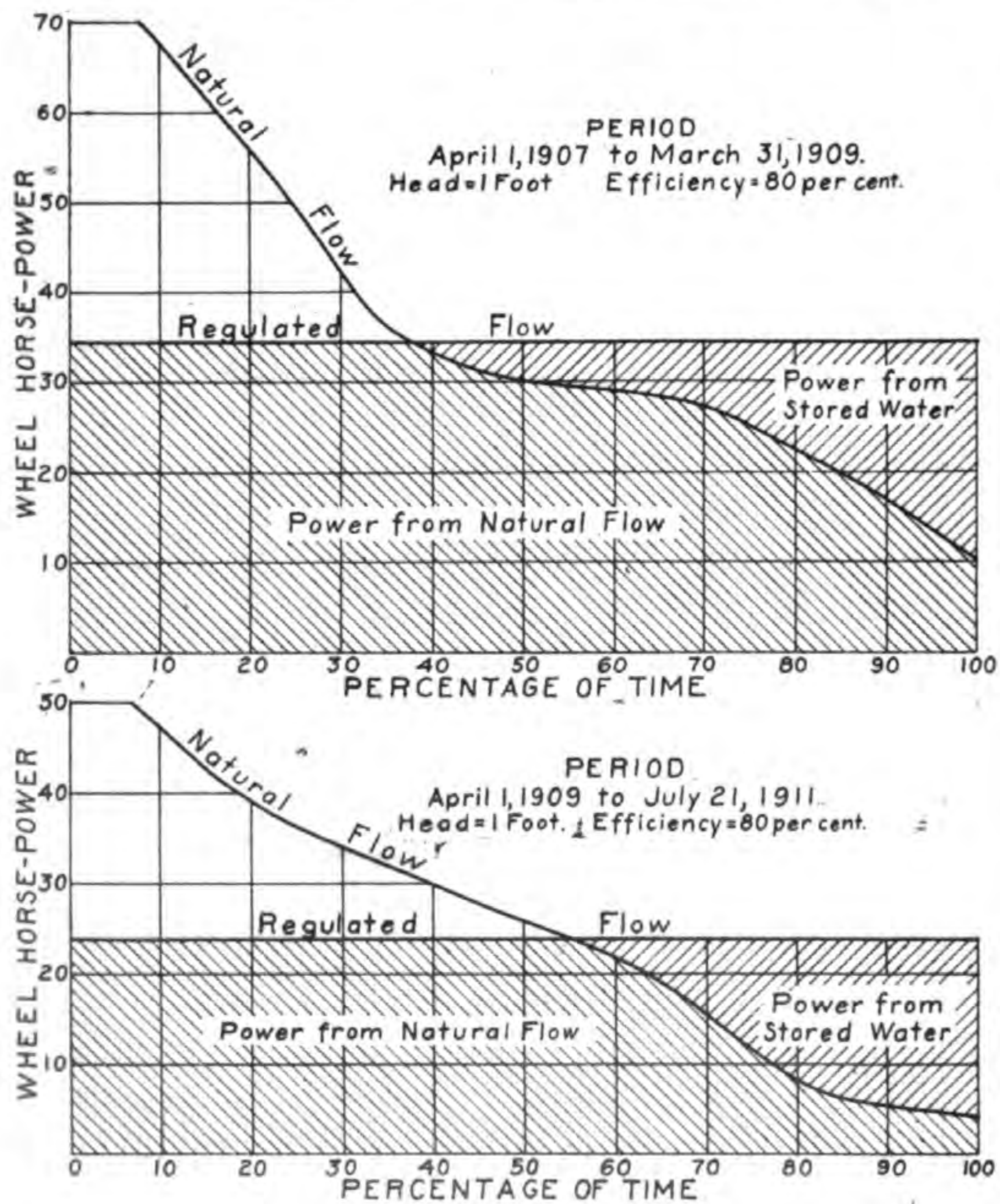
The possible regulation of the flow with a storage capacity of 4,000,000,000 cubic feet can best be shown by means of the mass-curve presented herewith. (Plate XI.)

In preparing this curve, records of flow are available from May 1, 1899, to May 14, 1904, by the U. S. Engineer Corps records at the outlet of Ottertail Lake, and by the records of the U. S. Geological Survey from May 9, 1904, to date, about 20 miles below Ottertail Lake.

The difference in drainage areas at the two points is not more than 12 per cent, and as no tributaries enter, the flow at the two points has been considered the same as representing the water available for storage. As the records show the discharge below the lake, this represents the runoff *in excess of evaporation* which is a constant factor in lowering the lake surface. As the area of the water surface when raised to the proposed high level will be but little greater than at the present level, there will be little or no increase in the amount of water lost by evaporation. Therefore, this factor will not enter further in the computations.

An inspection of the mass-curve shows that with the reservoir a quarter full on May 1, 1899, it would have been theoretically possible to regulate the flow of Ottertail River at the outlet of the lake as follows:


PERIOD
May 1, 1889 to April 30, 1902
Head = 1 Foot. Efficiency = 80 per cent.
WHEEL HORSE-POWER
50
40
30
20
10
Natural Flow
Regulated Flow
Power from Stored Water
Power from Natural Flow
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF TIME
PERIOD
May 1, 1906 to March 31, 1907
Head = 1 Foot. Efficiency = 80 per cent.
WHEEL HORSE-POWER
90
80
70
60
50
40
30
20
10
Natural Flow
Regulated Flow
Power from Stored Water
Power from Natural Flow
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF TIME



DIAGRAMS SHOWING INCREASED POWER, PER FOOT FALL; ON OTTERTAIL RIVER FROM STORED WATER AT OTTERTAIL LAKE.

Regulation of flow of Ottertail River.

Period.	Regulated flow in second-ft.
May 1, 1899, to April 30, 1902	250
May 1, 1902, to August 31, 1904	255
September 1, 1904, to May 31, 1905	470
June 1, 1905, to April 30, 1906	520
May 1, 1906, to March 31, 1907	600
April 1, 1907, to March 31, 1909	380
April 1, 1909, to July 31, 1910	280
August 1, 1910, to May 31, 1912	180

The effect of this regulated flow upon water power development on Ottertail River below the reservoir is shown by the power-percentage of time curves (plate XII.) These curves show the increased horsepower per foot fall due to the additional flow from storage, and the percentage of time of such increase.

In actual practice it is probable that the flow would not be regulated as uniformly as shown here, but it is evident from the mass-curve that with a storage capacity of 4,000,000,000 cubic feet, that a minimum flow of 250 second-feet can be secured except during a period of extremely low water as occurred from 1910 to 1912, when the flow might be reduced to 150 second-feet.

The foregoing discussion of the effect of the reservoir on the flow has dealt entirely with the question of power development below Ottertail Lake. The only other purposes to be served by the operation of the reservoir are flood prevention and aid to navigation.

The portion of the valley subject to severe floods is chiefly below Fargo. Runoff tributary to this portion of the valley is from a drainage area increasing from 6,020 square miles at Fargo to 34,300 square miles at the International Boundary. The drainage area at the outlet of Ottertail Lake is 1,160 square miles, and as the variation in flow is very small as compared with that of the lower valley, any withholding of the spring highwater in the reservoir would have but a slight effect on the flood flow in the lower valley. The operation of the reservoir for this purpose would seriously reduce its efficiency for power purposes as it would be necessary to have available storage capacity at the beginning of the spring period to take care of possible highwater. As the high water stage is a variable quantity there would be years when the reservoir would not be filled in this manner, and there would not be stored sufficient water to increase the low water flow of summer and fall for power purposes.

There is not the conflict of interest between power development and navigation needs that exists between the former and flood prevention. For navigation the need is to increase the low water flow which usually occurs during the late summer and fall. The same need exists for power development. The only conflict is during the winter period when power development usually requires its strongest draft on the reservoir while navigation is suspended during that period, and would be better served if the entire winter flow were stored for use during the following navigation season.

From the foregoing it is seen that the operation of the reservoir on Ottertail would be of the most value, if operated in the interest of power development, as that would be benefited to a much greater extent than either flood prevention or navigation and at the same time the two latter would be benefited to a certain extent. If operated primarily for either flood prevention or navigation the direct benefits would be small, and these benefits would only be secured at the cost of a very much smaller power development.

SANITARY STATISTICS.

To show the sanitary quality of the water in Red River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply, and disposal or sewage have been compiled for all towns of 500 inhabitants or more located on the river. These data are given in the following table, in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on Red (including Ottertail) River.

Town.	Distance above Inter. Bdry.	Population 1910.	Water Works System.			Sewerage System.		Rural population per square mile.
			Source of Supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
		Red R iver (includ ng Otter tail.)						
Frazee	536	1,645	no system	....	....	....	....	....
Fergus Falls	451	6,887	river	no	1,250,000	river	no	19.2
Mouth Pelican River	447	....	....	....	....	....	....	....
Breckenridge	395	1,840	river	yes	350,000	river	no	....
Wahpeton, N. Dak.	395	2,425	wells	no	200,000	river	no	....
Moorhead	298	4,840	river	no	440,000	river	no	....
Fargo, N. Dak	298	14,331	river	yes	2,000,000	river	no	....
Mouth Buffalo River	250	....	....	....	....	....	....	....
Mouth Wild Rice River	205	....	....	....	....	....	....	....
Grand Forks, N. Dak.	143	12,478	Red Lake River	yes	750,000	RedRiver	no	....
Mouth Red Lake River	143	....	....	....	....	....	....	....
Mouth Snake River	70	....	....	....	....	....	....	....
Mouth Two Rivers	25	....	....	....	....	....	....	....
			Pelica n River.					
Detroit	46	2,807	Detroit Lake	no	350,000	Lake St. Clair	Septic tank	....
Pelican Rapids	25	1,019	no system	....	....	none	....	....

From the preceding table it is seen that no urban sewage enters the river above Fergus Falls. The rural population of the basin above this point is 19.2 per square mile but as there are so many lakes above Fergus Falls it is probable that sedimentation removes the greater part of any rural pollution before the water reaches Fergus Falls. At this point the raw river water is used for municipal purposes, and the city sewage enters the river without treatment.

Between Fergus Falls and Breckenridge, a distance of 56 miles, the river has an average fall of 3.8 feet per mile, which insures pollution of the river at the latter point.

From Breckenridge to the International boundary, a distance of 395 miles, the river receives untreated sewage from Breckenridge, Wahpeton, Moorhead, Fargo, and Grand Forks, representing a population of 23,436. Only one of these cities, Moorhead, uses the raw river water for municipal purposes. As the average slope of the river from Breckenridge to the boundary is only 0.5 foot per mile, sedimentation plays a more important part in purifying the water than in the section of river above Breckenridge.

None of the tributaries of Red River from the Minnesota side carry urban sewage except Red Lake River which receives the sewage from a population of 10,733.

WILD RICE RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Wild Rice River next to Red Lake River, the most important tributary of Red River, rises in Upper Rice Lake (at an elevation of 1500 feet above sea level) in T. 145 N., R. 37 W., in the southern part of Clearwater County. It flows southwestward into Lower Rice Lake which has an area of about 4 square miles, and thence in a general westerly course to its junction with Red River (at an elevation of about 870 feet) near Hendrum postoffice in Norman County. Its chief tributaries are Simon Lake outlet, Twin Lake outlet, White Earth and Marsh rivers and the South Branch. During periods of highwater Wild Rice River overflows to Marsh River which is a slough near Ada and has no connection with the Wild Rice at any other time.

For the first 2 miles below Lower Rice Lake the river is an arm of the lake controlled by a logging dam which stores water on the lake to a depth of 8 feet or more. Below the dam the slope becomes steeper, and between the mouth of White Earth River and a point 10 miles below Heiberg the average is 4.8 feet per mile. From this point the slope gradually decreases until it nearly disappears below range line 46-47. Notwithstanding this comparatively steep slope the river is in places extremely tortuous. Between Mahnomen and Faith for example, it travels 20 miles in a distance of 7 miles.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

Above Beaulieu the area is rolling and there is no well-defined bluff line, but below that point the ground becomes more level and well defined bluffs appear. From White Earth River to Heiberg the Wild Rice flows through a valley having an average width of ¼ mile and lying 20 to 30 feet below the general surface level. Below Heiberg the valley is much narrower. In the upper portion of the basin the surface is somewhat undulating, but along the lower course it is in general flat. Elevations in the basin range from 870 to 1550 feet above sea level.

With scarcely an exception the valley lands, although not subject to overflow except during unusual floods, are not under cultivation but are heavily timbered. In the prairie section west of Beaulieu, much of the land is under cultivation. East of Beaulieu the area is largely covered with brush interspersed with tracts of prairie which constitute possibly a third of this part of the basin, and this condition prevails to a point within a few miles of Lower Rice Lake, where the rest of the basin is heavily covered with pine.

The geology of the basin is very similar to that of the Red Lake basin, the surface formation consisting chiefly of blue till overlain in its lower portion by lacustrine clays and underlain by cretaceous rocks. The area contains about 50 lakes, all located in its upper third, the lake surface comprising 5 to 10 per cent of that part of the basin. Many of these lakes are small and have no visible outlet.

RAINFALL.

The mean annual rainfall ranges from 25 inches in the upper portion of the area to 21 inches at the mouth of the river. The highest recorded rainfall occurred in 1882 and amounted to 34 inches at Moorhead. The lowest occurred in 1910 and was about 10.5 inches. Of the average amount, about 2 inches fall as snow which remains during the winter.

FLOODS.

There is little swamp land in the basin and few lakes except in the upper portion and as Wild Rice River has a comparatively heavy fall except in its lower portion, the rainfall tends to reach the river quickly, causing sharp rises. The severest flood for many years, occurred during the latter part of July 1909. At Twin Valley the river rose more than 12 feet in 24 hours with a further rise of 2 feet in the next 48 hours. It fell much more slowly, requiring nearly a month to reach a normal stage again. This flood was caused by an extremely heavy rainfall which was local in character. On July 20, the first day of the flood, the rainfall at Beaulieu was 10.75 inches, and that at Bagley 10.00 inches.

On the preceding day, the rainfall at Fosston was 8.97 inches, with no rainfall on the 20th. On the 21st, the rainfall at Beaulieu was 0.28 and at Bagley 0.08 showing that the storm was of short duration but extremely violent. In the lower portion of the basin, the rainfall was very much less, being 1.29 inches at Halstad and practically nothing at Crookston, although the rainfall at the latter place was 1.07 inches on the 19th. That the heaviest portion of the storm was confined to the upper portion of the drainage basin, is shown by the fact that the rainfall on the 20th was only 1.15 inches at Cass Lake with 1.10 inches on the 19th and 0.12 inch at Red Lake with 2.70 inches on the 19th. It is also shown by the additional fact that the river rose 2 feet higher on the 21st and 22d, although the rainfall on those days was very small.

The result of this flood was to inundate the lower valley, and to destroy the earth dam at Faith, by cutting around one end.

REGULATION OF FLOW.

The lakes in the upper portion of the basin tend to equalize the flow in that portion but this is more than offset, by the logging dam at the lower end of Lower Rice Lake. This dam can store water to a depth of about 8 feet on the lake, and as the lake area is 4 square miles this represents a storage capacity of 895,000,000 cubic feet.

In addition to the Lower Rice Lake dam, there is one at the outlet of Twin Lakes. These dams are closed during the winter time, to fill the lake reservoirs. In the spring and early summer the stored water is released to aid the natural highwater flow drive logs to the mills at Ada. The Minnesota Forest Service has estimated the amount of log driving on Wild Rice River as 11,500,000 feet in 1909; 7,600,000 feet in 1910, and 7,700,000 feet in 1911. During the winter period which is naturally the low water season, as there are no thaws, and the only sources of supply are the lakes and ground water, the flow is still further decreased by the storage of the runoff from 150 square miles or more of drainage area. The period of highwater flow in the spring is prolonged by the release of the stored water.

DRAINAGE WORK.

It has been estimated by the State Drainage Commission that the area of original swamp area in the Wild Rice basin was about 100,000 acres. In the lower portion of the basin ditching has been carried on actively which has resulted in the benefiting of about

185,000 acres, the greater part of which were not classed as original swamp land. Two drainage projects were concerned with the improvement of Wild Rice River, one was a 5 mile cutoff in T. 144 N., Rs. 46 and 47 W., and the other a 4 mile improvement of the channel of the river between Upper and Lower Rice lakes.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Wild Rice River basin.

River.	Drainage area above.	Square miles.
Wild Rice	Lower Rice Lake outlet	128
Do	Mouth White Earth River	405
Do	Faith	567
Do	Sec. 20, T. 144 N., R. 43 W	752
Do	Gaging station at Twin Valley	805
Do	Sec. 18, T. 144 N., R. 44 W	908
Do	Mouth	1,440
Twin Lake outlet	Mouth	56
White Earth	Mouth	140
South Fork Wild Rice	Mouth	287

GAGING STATION RECORDS.

WILD RICE RIVER AT TWIN VALLEY.

Location.—At the highway bridge at Twin Valley, 2 miles above the nearest tributary, which enters at Heiberg.

Records available.—June 30, 1909, to December 31, 1912.

Drainage area.—805 square miles.

Gage.—Vertical staff; datum unchanged since establishment.

Channel.—Permanent. The river overflows at a stage of 12 feet on the gage and covers a width of several hundred feet.

Discharge measurements.—From the bridge except during extreme low water, when measurements are made at a wading section.

Winter flow.—The river is frozen over from the latter part of November to the first of April, and measurements are made through the ice to determine the winter flow discharge.

Floods.—An exceptionally severe flood occurred in July, 1909, which overflowed the lower part of the valley and wrecked the power dam at Faith by cutting around the end and greatly increasing the width of the channel. The maximum stage of the flood at Twin Valley was 20.0 feet and the discharge 9,200 second feet.

Regulation.—There is a dam across the river at Heiberg but the highest backwater effect is at a point more than a mile below Twin Valley.

Accuracy.—The estimate for the flood discharge above 14 feet is based on Kutter's formula in connection with the known area of the cross section and may be somewhat in error, but it is believed this error will not exceed 10 per cent. The remaining estimates are based on a well defined discharge rating curve and should be reliable.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							295	1,750	343	138	129	
2							272	1,480	355	92	168	
3							307	1,300	319	52	168	
4							272	1,300	295	67	168	
5							272	1,520	295	75	148	
6							208	1,300	295	52	152	
7							250	1,180	272	32	148	
8							228	1,300	307	75	129	
9							228	1,210	295	67	129	
10							319	1,140	331	75	133	
11							343	1,300	295	75	129	
12							367	1,560	380	92	135	
13							319	1,430	319	92	158	
14							343	1,290	295	129	129	
15							250	1,120	307	92	129	
16							261	979	272	129	129	
17							228	1,040	295	92	133	
18							170	895	307	101	129	
19							170	816	250	120	129	
20							7,230	740	295	129	129	
21							7,500	705	331	92	129	
22							9,120	606	295	92	129	
23							6,780	487	295	130	129	
24							4,820	459	272	168	129	
25							4,020	516	272	168	129	
26							3,250	487	250	148	129	
27							2,920	445	179	148	129	
28							2,700	406	188	129	129	
29							2,620	380	179	129	129	
30						362	1,950	343	208	148	129	
31							1,790	319		138		
1910.												
1				228	1,110	272	92	32	17	32	28	
2				208	1,180	272	92	32	17	23	28	
3				188	1,070	261	75	32	20	23	28	
4				188	875	272	59	32	20	23	28	
5				178	722	272	59	28	20	23	28	
6				198	695	250	59	28	20	23	28	
7				178	722	295	59	28	20	23		
8				168	688	473	59	28	20	23		
9				148	705	530	59	28	20	23		
10				129	638	419	59	23	20	23		
11				110	575	406	59	23	23	20		
12				92	545	487	59	20	23	20		
13				75	501	432	59	17	23	20		
14				75	467	459	59	17	23	20		
15				84	445	406	59	17	23	20		
16				133	545	432	59	17	20	20		
17				445	622	295	44	17	20	20		
18				501	437	188	44	14	20	23		21
19				622	445	188	38	14	20	23		
20				777	432	208	32	17	20	28		
21				827	432	178	32	17	20	28		
22				843	419	168	32	17	20	28		
23				855	406	168	52	17	20	28		
24				1,250	419	148	59	17	20	28		
25				1,430	380	148	67	17	20	28		
26			208	1,560	367	129	59	17	20	28		
27			188	1,380	367	129	44	17	28	28		
28			188	1,300	343	129	44	17	28	28		
29			198	1,210	331	101	32	17	32	28		
30			208	1,180	319	92	32	17	32	28		
31			239		250		32	17		28		
1911.												
1				148	343	110	228	32	23	32	75	
2				75	343	110	295	32	23	32	59	
3				110	295	110	295	32	20	32	59	
4				110	295	110	331	32	20	32	44	
5				188	272	110	367	32	20	32	32	

Daily discharge, in second-feet, of Wild Rice River at Twin Valley—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6				188	250	92	331	32	20	32	32	
7				23	250	84	284	28	23	32	32	
8				120	228	59	250	23	32	38	44	
9				120	158	59	218	23	32	38	44	
10				120	148	75	188	23	32	38	44	
11				148	129	75	250	23	32	120	32	
12				250	129	75	208	23	28	172		
13				272	158	75	158	23	28	192		
14				246	129	59	120	23	23	188		
15				198	148	59	75	23	23	198		
16				250	168	59	44	28	23	188		
17				228	367	59	32	28	23	208		
18				198	380	52	32	92	23	228		
19				168	307	52	32	67	23	246		38
20				239	250	44	32	67	28	228		
21				406	228	44	32	44	28	218		
22				445	188	110	32	44	28	208		
23				459	158	144	38	44	23	198		
24				424	138	184	32	44	23	198		
25				440	129	208	32	32	23	188		
26				343	110	188	38	23	23	188		
27				295	110	75	38	23	23	158		
28				295	110	208	23	23	32	148		
29				307	101	228	23	23	32	129		
30				343	92	188	28	23	32	110		
31					92		28	23		92		
1912.												
1				501	110	295	32	52	32	168	148	
2				419	92	284	32	52	32	148	138	
3				393	96	254	32	32	32	138	138	
4				367	96	239	32	32	32	120	129	
5		10		343	144	218	38	28	28	110	129	
6				343	272	178	38	28	23	110	129	
7				295	343	152	32	32	23	110	129	
8				228	380	144	32	32	23	92	129	
9				228	445	144	32	32	23	75	129	
10				198	501	125	32	32	23	75	92	
11				172	688	129	32	32	75	75	75	
12				168	654	125	32	32	78	75	67	
13				168	560	110	32	28	148	75	59	
14				158	473	110	32	23	148	75	44	
15				164	501	114	32	23	148	59	44	
16			17	129	501	110	32	23	138	59	44	
17			20	75	473	92	32	44	138	92		
18				92	501	75	32	44	129	307		
19				92	501	75	44	59	110	268		
20				84	622	75	59	44	110	272		
21				78	560	67	92	44	129	272		
22				84	530	59	110	32	148	272		
23				67	530	52	110	32	148	272		
24				62	473	52	92	32	168	272		
25				59	530	52	75	28	188	250		
26				72	530	44	75	23	188	228		
27				75	445	44	67	17	188	208		
28				78	367	44	59	23	188	208		
29				92	367	38	44	23	168	198		
30				92	319	32	59	32	168	188		
31					307		59	32		168		

NOTE.—Discharge computed from a fairly well-defined rating curve.

Monthly discharge of Wild Rice River at Twin Valley.

[Drainage area, 805 square miles.]

Month.	Discharge in second-feet. Maximum.	Minimum.	Mean.	Per square mile.	Run-off (depth in inches on drainage area).	Accuracy.
1909.						
July	9,120	170	1,930	2.40	2.77	C
August	1,750	319	961	1.19	1.37	A
September	355	179	286	.355	.40	B
October	168	32	105	.130	.15	B
November	168	....	136	.169	.19	B
1910.						
April	1,560	75	552	.686	.77	A
May	1,180	250	563	.699	.81	A
June	530	92	274	.340	.38	A
July	92	32	53.8	.067	.08	A
August	32	14	21.0	.026	.03	B
September	32	17	21.6	.027	.03	C
October	32	20	24.5	.030	.03	C
November	....	....	[a]25	.031	.03	D
December	....	....	[a]20	.025	.03	D
1911.						
January	....	....	[a]22	.027	.03	[a]
February	....	....	[a]18	.022	.02	[a]
March	....	....	[a]70	.087	.10	[a]
April	459	23	239	.297	.33	B
May	380	92	200	.248	.29	B
June	228	44	104	.129	.14	B
July	367	23	133	.165	.19	B
August	92	23	33.3	.041	.05	C
September	32	20	25.5	.032	.04	C
October	246	32	134	.166	.19	B
November	75	....	[a]32.4	.040	.04	C
December	....	....	[a]35	.044	.05	D
The year	459	....	87.5	.109	1.47	
1912.						
January	....	....	[b]31	.039	.04	D
February	....	....	[b]13	.016	.02	D
March	....	....	[b]25	.031	.04	D
April	501	59	179	.222	.25	C
May	688	92	416	.517	.60	B
June	295	32	118	.147	.16	B
July	110	32	49.5	.061	.07	C
August	59	17	33.0	.041	.05	C
September	188	23	106	.132	.15	B
October	307	59	163	.202	.23	B
November	148	....	68.1	.085	.09	C

[a] Estimates of discharge for November and December, 1910, and January, February and March, 1911, are very rough and are based on one discharge measurement made in December, 1910, fortnightly gage heights and gage observer's notes.

[b] Discharge January 1 to March 31 and November 17 to 30, 1912, estimated from four discharge measurements, climatological records, weekly gage heights and discharge of adjacent areas.

DEVELOPED WATER POWER.

There are two developed water powers on Wild Rice River, described as follows:

At Heiberg in sec. 16, T. 144 N., R. 44 W.—The Heiberg mill has a dam 5 feet high. This dam with the aid of a tail race which empties into Wild Rice River more than a mile below, creates a head of about 15 feet. A canal 30 feet long conveys water to the mill located near the north end of the dam, where power is generated for use in running the mill and in furnishing lighting to Twin Valley. There are 1 26-inch and 1 40-inch Leffel turbines giving a combined capacity of 125 horsepower. These are connected to a 75 KW Allis-Chalmers 3-phase alternating current generator of 2300 volts. There is a pondage area of 10 acres with a draft of 3 feet secured by the use of flashboards. Electric lighting is furnished 12 hours per day and power for mill use 24 hours. There is no auxiliary steam plant.

In sec. 13, T. 144 N., R. 48 W.—At this point is located a 6-foot dam owned by J. G. Johnson, which is utilized in developing about 50 horsepower used in running a flour and feed mill.

The following table has been compiled to show the available continuous horsepower at the developed sites, based on the records of flow of Wild Rice River.

Available horsepower at developed power sites.

Developed Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Heiberg	15	13	48	165	18	65	225
Sec. 13, T. 144 N., R. 48 W.	6	23	86	288	13	47	157

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

For the purpose of determining the power and storage feasible of development on Wild Rice River a survey was made in 1911 from a point a short distance above White Earth River to sec. 15, T. 114 N., R. 45 W., where it was joined to a previous survey made by the State Drainage Commission which extended to the township line between townships 144 and 143 N. The results of these two surveys are given on plates 87 to 94, inclusive of the atlas. From these sheets, the following table of elevations and distances has been compiled:

Elevations and distances of Wild Rice River from White Earth River to township line between Townships 143 and 144.

Stations	Distance		Elevation above sea level	Descent between points	
	From White Earth River	Point to Point		Total	Per mile
White Earth River	0.0	....	1,187	....	....
Upper end pond, logging dam	0.9	0.9	1,184	3	3.3
Logging dam near Mahnomen, crest	2.0	1.1	1,184	0	0.0
foot	2.0	0.0	1,180	4	....
Section line 10-11	3.8	1.8	1,173	7	3.9
Highway bridge section line 9-10	6.1	2.3	1,164	9	3.9
....	10.0	3.9	1,152	12	3.1
....	13.0	3.0	1,141	11	3.7
Range line 42-43	16.7	3.7	1,127	14	3.8
Section line 13-14	19.9	3.2	1,110	17	5.3
Section line 22-23	22.2	2.3	1,093	17	7.4
....	26.0	3.8	1,068	25	6.6
Range line 43-44	32.4	6.4	1,033	35	5.5
Creek	34.4	2.0	1,025	8	4.0
....	35.9	1.5	1,014	11	7.3
Bridge near Twin Valley	38.1	2.2	1,005	9	4.1
Heiberg dam, crest	41.4	3.3	992	13	3.9
foot	41.4	0.0	987	5	....
Tailrace Heiberg power plant	42.9	1.5	978	9	6.0
....	44.0	1.1	973	5	4.6
....	46.0	2.0	960	13	6.5
Section line 23-24	49.5	3.5	945	15	4.3
Highway bridge	53.2	3.7	933	12	3.2
....	56.0	2.8	923	10	3.6
....	57.7	1.7	915	8	4.7
Section line 14-23	62.9	5.2	899	16	3.1
Highway bridge section line 27-28	66.1	3.2	891	8	2.5
Highway bridge	71.0	4.9	878	13	2.7
Creek	76.0	5.0	870	8	1.6
South Branch Wild Rice River	82.7	6.7	861	9	1.3
Upper end pond Johnson dam	87.0	4.3	857	4	0.9
Johnson dam, crest	92.1	5.1	857	0	0.0
foot	92.1	0.0	851	6	....
....	93.0	0.9	850	1	1.1
Highway bridge section line 14-15	96.7	3.7	845	5	1.4
Highway bridge section line 8-9	101.2	4.5	841	4	0.9
Township line 143-144	104.7	3.5	838	3	0.9

Above White Earth River, the Wild Rice has considerable fall but the topography is unsuited to power development of any considerable magnitude, while below the lower limit of the surveys the slope of the river is too slight to afford power development. Within the limits given herewith, the surveys show the following power sites:

In sec. 18, T. 144 N., R. 42 W.—If a 40-foot dam were built at mile 14, 5 miles southwest of Mahnomen, it would back the water 12 miles upstream to the log sluicing dam under the railroad bridge near Mahnomen. This dam would have a crest length of 900 feet and would overflow 550 acres of brush land.

Just above Faith.—At mile 20.2 a short distance above Faith, a 30-foot dam would back the water 7 miles upstream to the dam site in section 18. The crest length of the dam would be 700 feet and the area overflowed 240 acres of land covered with brush.

In sec. 20, T. 144 N., R. 43 W.—A 36-foot dam at mile 28.2 would back the water 5.8 miles upstream, overflowing 350 acres of brush land. The crest length of the dam would be 500 feet.

In sec. 22, T. 144 N., R. 44 W.—Just above the highway bridge near Twin Valley (at mile 38.1), the bluff lines approach each other so that a 45 foot dam having a crest length of 1,200 feet could be built. This dam would back the water 9.2 miles upstream to a point within a mile of the dam site in section 20, and would overflow 680 acres.

Between this dam site and the crest of the Heiberg Dam there is a fall of not more than 13 feet.

In sec. 18, T. 144 N., R. 42 W.—Below the Heiberg dam (the tailwater from which empties into the river at mile 42.9), the topography becomes less suited for developments of comparatively high head, and the slope of the river becomes very much less.

If a 15-foot dam were built at mile 46, 2.5 miles west of Heiberg, the water would be backed upstream nearly to the tailwater from the Heiberg Dam, which is the controlling feature.

AVAILABLE HORSEPOWER.

Records of flow of Wild Rice River have only been maintained since 1909 and as that period includes the very low years of 1910 and 1911, it is impossible to make a close estimate of the flow to be expected during an ordinary low year. As an aid in determining the flow under those conditions, the long time records of the Red Lake River at Crookston have been utilized. But with these data, the estimates for an ordinary low year can only be considered approximate.

Based on data as just described, the following table shows the available power at each dam site:

Undeveloped horsepower on Wild Rice River.

Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Sec. 18, T. 144 N., R. 42 W...	40	9	33	121	33	120	440
Just above Faith............	30	9	34	125	25	93	341
Sec. 20, T. 144 N., R. 43 W...	36	12	45	160	39	147	524
Sec. 22, T. 144 N., R. 44 W...	45	13	48	165	53	196	675
Sec. 18, T. 144 N., R. 44 W..	15	15	55	182	20	75	248

STORAGE.

The few lakes within the drainage basin of Wild Rice River are so near the upper end of the basin that their tributary runoff is too small to make them of much value in regulating the flow for any considerable period. Therefore, the only opportunity for storage is in the main valley below White Earth River as above that point the bluff lines give way to rolling topography.

If dams were built at each of the sites described under undeveloped water power they would create reservoirs having the following capacities:

Capacities of possible reservoirs on Wild Rice River.

Mahnomen Reservoir.

[Formed by dam in section 18, T. 144 N., R. 42 W.]

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity	
			Acre-feet	Cubic feet
1,140	10	....	....	....
1,150	63	365	365	....
1,160	212	1,375	1,740	....
1,170	471	3,415	5,155	....
1,180	770	6,205	11,360	495,000,000

Faith Reservoir.

[Formed by dam just above Faith.]

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity	
			Acre-feet	Cubic feet
1,110	1	....	....	....
1,120	68	345	345	....
1,130	151	1,095	1,440	....
1,140	314	2,325	3,765	 164,000,000

Marsh River Reservoir.

[Formed by dam in Sec. 20, T. 144 N., R. 43 W.]

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity	
			Acre-feet	Cubic feet
1,055	1	....	....	....
1,060	9	25	25	....
1,070	115	620	645	....
1,080	229	1,720	2,365	....
1,090	406	3,180	5,545	242,000,000

Twin Valley Reservoir.

[Formed by dam in Sec. 22, T. 144 N, R. 44 W.]

Contour	Area Acres	Capacity of Section Acre-feet	Total Capacity	
			Acre-feet	Cubic feet
1,010	14	....	....	....
1,020	153	840	840	....
1,030	321	2,370	3,210	....
1,040	611	4,660	7,870	....
1,050	777	6,940	14,810	645,000,000

The combined capacity of the above reservoirs would be 1.5 billion cubic feet, and in order to utilize this storage it would be necessary to draw the water nearly to the bottom of the reservoirs, destroying the power value of the dam sites. Without the utilization for power development it is possible that the value of the reservoirs to navigation and flood control would not be sufficient to warrant their construction.

SANITARY STATISTICS.

To show the sanitary quality of the water in Wild Rice River and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants or more located on the river. These data are given in the following table:

Municipal water supply and sewage disposal of towns on Wild Rice River.

Town	Distance above mouth	Population 1910	Water Works Systems			Sewerage Systems		Rural population per square mile
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
Mahnomen	118	796	[a]	no	....	none	....	7.4
Twin Valley	82	543	deep well	no	5,000	none	....	....

[a] Used for fire protection only.

From the preceding table it is seen that no urban sewage enters Wild Rice River nor is the water used for municipal purposes.

RED LAKE RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Red Lake River, the principal tributary of Red River, drains a large area in Beltrami and Polk counties. It is the outlet of Red Lake, which is the largest lake wholly in Minnesota, its area being 441 square miles. From Red Lake the river flows in a general westerly though very tortuous course until it reaches Red Lake Falls, where it receives the water from Thief River, and turning sharply to the south pursues a southerly and then a westerly course to Red River, joining that stream at Grand Forks. Above the junction it carries a larger volume than Red River.

From the outlet of Red Lake to Thief River Falls the river has very little fall and is bordered by low banks. For a distance of 30 miles below Red Lake the river is bordered by swampy banks, whose elevation is nearly the same as the river. Below Thief River Falls the stream flows through a narrow valley that increases in depth from 20 feet at the upper end to 60 feet at Red Lake Falls. In this portion there are stretches of river that have a heavy fall. From Red Lake Falls to Crookston the valley becomes deeper and has an average width of three-quarters of a mile, except for the first few miles below Red Lake Falls, where the width is one-quarter mile. The fall below Red Lake Falls, becomes less. No tributaries enter the river between Red Lake and Thief River, a distance of 71 miles; below Thief River the only important tributaries are Clearwater and Black rivers.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The entire basin is very flat and is covered with a sheet of blue till of glacial origin. Overlying the till and separated from it is a layer of clay loam. In the lower part of the basin in the valley of the Red River are lacustrine deposits of clay. The drift is underlain by cretaceous rocks which form the source of supply of the water in the artesian basin in North and South Dakota.

The lakes in the area are chiefly in the section above Red Lake and in the upper part of the region drained by Clearwater River. In the former section the lake surface comprises about 500 square miles, or 25 per cent of the area of 1,950 square miles. Of the 1,310 square miles drained by the Clearwater, not more than 1 per cent is lake surface.

The basin is forested except in the part chiefly below Crookston, which lies in the Red River Valley. North of Red Lake there are extensive areas of muskeag containing chiefly a dense growth of short and stubby spruce. Beside the muskeag there are considerable areas of virgin pine north of the lake. West and south of the lake the basin is within the heavy timber belt where white and Norway pine, spruce, cedar, balsam, and tamarack are found. Although this region has been logged over the growth is dense.

In the middle third of the basin, in Marshall, Pennington, and Red Lake counties, the dense forest is interspersed with open prairie which comprises one-third of this part of the area. Above Red Lake Falls very little of the land is under cultivation, but below that point the cultivated area is larger.

RAINFALL AND RUNOFF.

The mean annual rainfall ranges from 25 inches on Red Lake to 21 inches at the mouth. Of this amount $3\frac{1}{2}$ inches are precipitated as snow which remains usually from November to April. The longest rainfall record in the basin is at Crookston and extends to 1890. Since that time the year of heaviest rainfall was 1896 when 30.3 inches fell. The longest rainfall record in the Red River Valley is at Pembina, N. Dak., which extends to 1872. That record indicates that 1878 was the wettest year when 33.8 inches fell at that point. The driest year was 1910 when 11.2 inches fell at Crookston. Complete runoff records of Red Lake River have been maintained by the U. S. Geological Survey since 1906. During this period the runoff has varied from 0.71 to 5.43 inches or from 3.5 to 23.8 per cent of the rainfall.

The following table shows the annual variation between rainfall and runoff:

Relation between rainfall and runoff.

Station	Year	Rainfall in inches	Runoff in inches	Percentage of Runoff
Red Lake at Crookston	1906	24.62	5.43	22.1
	1907	18.80	3.50	18.6
	1908	20.68	4.01	19.4
	1909	27.76	3.23	11.6
	1910	12.73	3.03	23.8
	1911	20.32	.71	3.5

FLOODS.

Another effect of the natural regulation of Red Lake and the swamp areas upon the runoff, is seen in the absence of severe floods throughout the upper river. In the lower river, as the percentage of water and swamp area to the entire area becomes less the flood storage of the river increases. The longest record is at Crookston which extends back to 1901. Even here the rise is not excessive, in no case exceeding 15 or 16 feet above the usual summer stage.

The following table shows the maximum stage for each year:

Maximum stage of Red Lake River at Crookston.

Year.	Date.	Gage height.
1901		No highwater record
1902	May 21	10.0
1903		No highwater record
1904	April 24	20.3
1905	May 13	14.1
1906	April 15	21.0
1907	April 4	12.0
1908	April 7	16.6
1909	April 5	8.3
1910	March 20	13.8
1911	March 18	5.4
1912	April 8	7.1

Below Crookston (except near the mouth) the rise is not more than 15 or 16 feet in the extreme, and this means that little land is overflowed as the banks are usually high enough to be above this rise. Coming so early in the spring, little or no damage is done to agricultural interests in case some low lands are inundated to a limited extent.

Just above the gaging station at Crookston is the dam and although this may be drowned out during the extreme floods, the banks are high enough to prevent any extended overflow.

REGULATION OF FLOW.

Of the 2420 square miles above the mouth of Thief River at least three-quarter comprise swamp and lake area, and of the 1030 square miles, drained by Thief River fully half are swampy, (although recently drained). The effect of the natural reservoir afforded by the lake and swamp area is seen not only in the comparatively small flood heights but also in the relatively uniform flow, as far down the river as Crookston (143 miles below Red Lake). Prior to the extreme low flow of 1910 and 1911 the average ratio of the minimum monthly discharge to the maximum monthly discharge for each year was 1 to 7. The range was from 1 to 3.7 to 1 to 11.0.

The discharge of Red Lake River is not controlled artificially although logs are driven from Red Lake to saw mills at Thief River Falls and Crookston.

NAVIGATION.

Prior to 1910, Red Lake River was navigable from Red Lake to Thief River Falls and small steamers furnished the best method of transportation to the settlers of that section. The low water of 1910 and 1911 together with the many logs stranded in the channel, made navigation impossible. During highwater in the spring of the year, the lower portion of the river is navigable for a few miles above Grand Forks.

DRAINAGE WORK.

The upper part of the basin contains large areas of swamp land. In the part drained by Thief River, drainage work is being actively carried on. Three systems, draining 470,000 acres lying west of Thief River, have their outlets in that stream in townships 155 and 156. One of the outlets passes through Mud Lake, which has been drained. The channel of Thief River has been enlarged and straightened for a distance of 21 miles, beginning a few miles above the gaging station and extending upstream. The average width is 50 feet and the depth 12 feet.

This drainage work has been carried on partly by the organization of drainage districts, and partly by the State Drainage Commission, the latter draining chiefly state lands.

DRAINAGE AREAS.

The following drainage areas have been measured in the drainage basin:

Drainage areas in Red Lake River basin.

River.	Drainage area above.	Square Miles.
Red Lake River	Red Lake Outlet	1,950
Do	Mouth Thief River	2,420
Do	Gaging Station at Thief River Falls	3,430
Do	Crookston	5,320
Do	Mouth	5,760
Tamarack	Sec. 19, T. 159 N., R. 49 W	354
Do	Mouth	578
Battle	Mouth	156
Black Duck	Mouth	258
Cormorant	Mouth	110
Mud Creek	Mouth	56
Sandy	Mouth	74
Thief	Gaging Station in sec. 3, T. 154 N., R. 43 W	1,010
Do	Mouth	1,030
Moose	Mouth	151
Clearwater	Mouth Lost River	521
Do	Mouth	1,310
Lost	Mouth Hill River	311
Do	Mouth	610
Hill	Mouth	162
Poplar	Mouth	133
Badger	Mouth	147
Black	Mouth	145

GAGING STATION RECORDS.

RED LAKE RIVER ABOVE THIEF RIVER.

Location.—Five miles above the mouth of Thief River. There is no tributary of importance between this point and Red Lake. This station was maintained by the United States Engineer Corps.

Records available.—May 1, 1899, to August 31, 1901. These records have been compiled from unpublished data in the United States Engineer Office at St. Paul.

Drainage area.—2,400 square miles.

Gage.—No data. This was of relatively little importance as discharge measurements were made almost daily, and the estimates based directly on these.

Winter flow.—The river is frozen over during the winter months, but measurements were made to determine the discharge.

Regulation.—Of the 2,400 square mile drainage area above this station, the runoff from 1950 square miles is regulated naturally by Red Lake which has an area of 441 square miles. The effect of this regulation is seen in the comparatively uniform flow.

Daily discharge, in second-feet, of Red Lake River above Thief River.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1	......	......	......	......	950	1,180	1,070	788	800	730	480	580
2	......	......	......	......	930	1,110	1,070	788	790	735	480	575
3	......	......	......	......	1,050	1,090	1,080	800	790	730	490	570
4	......	......	......	......	1,080	1,200	1,080	788	760	728	490	540
5	......	......	......	......	1,000	1,280	1,090	800	755	725	500	500
6	......	......	......	......	980	1,280	1,100	789	755	722	500	470
7	......	......	......	......	990	1,270	1,290	788	750	724	500	440
8	......	......	......	......	970	1,190	1,290	795	745	720	500	435
9	......	......	......	......	975	1,110	1,260	805	740	725	500	430
10	......	......	......	......	980	1,100	1,240	800	750	725	500	425
11	......	......	......	......	970	1,090	1,300	795	760	730	500	420
12	......	......	......	......	962	1,090	1,760	800	750	725	490	430
13	......	......	......	......	950	1,140	1,600	740	750	720	490	440
14	......	......	......	......	960	1,160	1,400	730	750	725	480	440
15	......	......	......	......	930	1,250	1,300	725	740	723	480	440
16	......	......	......	......	991	1,090	1,250	725	740	720	480	440
17	......	......	......	......	1,090	1,100	1,220	715	735	745	490	460
18	......	......	......	......	1,020	1,120	1,180	705	745	735	510	475
19	......	......	......	......	962	1,150	1,150	705	750	730	530	480
20	......	......	......	......	940	1,140	1,130	720	745	733	620	490
21	......	......	......	......	940	1,100	1,120	740	750	733	610	500
22	......	......	......	......	935	1,110	1,110	740	740	732	610	505
23	......	......	......	......	930	1,130	1,100	740	730	730	600	495
24	......	......	......	......	861	1,160	1,090	730	730	735	590	485
25	......	......	......	......	870	1,100	1,080	720	729	790	570	490
26	......	......	......	......	900	1,090	1,090	750	728	805	575	490
27	......	......	......	......	820	1,090	1,060	760	735	815	580	475
28	......	......	......	......	880	1,080	1,030	775	750	700	610	460
29	......	......	......	......	865	1,100	1,000	790	740	600	610	460
30	......	......	......	......	900	1,100	980	785	750	540	590	460
31	......	......	......	......	1,200	......	950	780	......	515	......	460
1900.												
1	455	450	440	510	500	460	450	290	1,580	1,860	1,780	1,140
2	445	460	440	560	490	280	460	300	1,580	1,850	1,760	1,140
3	440	470	430	575	490	280	500	305	1,600	1,930	1,730	1,130
4	430	480	420	590	500	410	490	390	1,600	1,910	1,710	1,130
5	430	490	410	590	510	430	485	470	1,630	1,890	1,780	1,150
6	425	490	410	595	510	450	460	508	1,650	1,940	1,660	1,080
7	425	490	420	700	520	460	440	580	1,660	1,990	1,630	1,060
8	425	480	420	900	520	480	430	682	1,660	2,020	1,600	1,130
9	420	470	410	1,400	485	560	420	785	1,660	2,040	1,680	1,090
10	425	470	410	1,300	465	550	430	835	1,660	2,070	1,650	1,060
11	425	460	415	700	260	540	440	900	1,660	2,090	1,520	1,050
12	425	460	415	750	280	530	440	900	1,650	2,100	1,500	974
13	430	460	420	600	300	520	450	970	1,630	2,160	1,470	960
14	435	460	430	550	375	510	455	980	1,610	2,100	1,460	964
15	435	460	430	530	440	495	500	1,040	1,640	2,060	1,420	935
16	440	450	430	525	430	490	620	1,080	1,640	2,000	1,410	933
17	450	450	430	490	440	480	500	1,160	1,630	2,070	1,400	931
18	470	440	435	490	470	460	495	1,160	1,680	2,080	1,380	958
19	490	430	435	480	485	460	490	1,150	1,720	2,090	1,370	956
20	480	420	435	470	470	470	490	1,330	1,750	2,060	1,360	940
21	480	420	440	470	405	475	460	1,380	1,840	2,030	1,340	947
22	470	420	440	460	285	450	430	1,410	1,870	2,020	1,330	970
23	450	420	450	460	265	430	430	1,400	1,900	1,990	1,310	967
24	440	410	455	460	245	430	420	1,400	1,920	1,960	1,300	965
25	430	410	460	460	250	335	410	1,390	1,910	1,950	1,270	966
26	420	415	470	440	270	415	300	1,420	1,910	1,920	1,250	965
27	430	415	470	450	330	415	275	1,450	1,900	1,890	1,220	904
28	430	415	475	490	330	450	250	1,460	1,960	1,870	1,190	895
29	440	......	475	520	375	440	240	1,470	2,020	1,850	1,170	918
30	440	......	480	520	420	460	230	1,550	2,000	1,830	1,140	922
31	440	......	490	......	470	......	210	1,570	......	1,800	......	926
1901.												
1	877	822	767	980	1,970	1,270	1,560	1,230	......	......	......	......
2	829	789	769	1,120	1,940	1,200	1,610	1,350	......	......	......	......
3	835	781	778	1,180	1,810	1,220	1,660	1,280	......	......	......	......
4	816	773	788	1,250	1,840	1,200	1,560	1,250	......	......	......	......
5	808	757	747	1,360	1,790	1,200	1,470	1,230	......	......	......	......

Daily discharge, in second-feet, of Red Lake River above Thief River—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
6	812	733	739	1,600	1,730	1,200	1,470	1,210	......	......	......	......
7	815	766	731	1,760	1,680	1,200	1,450	1,120	......	......	......	......
8	817	783	725	1,900	1,620	1,200	1,460	1,170	......	......	......	......
9	808	769	740	2,050	1,630	1,300	1,470	1,220	......	......	......	......
10	794	777	753	2,210	1,550	1,170	1,450	1,200	......	......	......	......
11	766	785	765	2,370	1,540	1,150	1,510	1,190	......	......	......	......
12	812	742	769	2,530	1,480	1,220	1,510	1,160	......	......	......	......
13	814	759	800	2,700	1,430	1,240	1,500	1,160	......	......	......	......
14	816	777	807	2,900	1,440	1,290	1,540	1,160	......	......	......	......
15	798	789	801	3,120	1,420	1,140	1,570	1,130	......	......	......	......
16	818	783	808	2,920	1,500	1,300	1,420	1,090	......	......	......	......
17	793	793	817	2,910	1,460	1,300	1,380	1,100	......	......	......	......
18	689	804	825	2,810	1,440	1,340	1,400	1,080	......	......	......	......
19	583	787	843	2,610	1,430	1,330	1,430	1,060	......	......	......	......
20	635	793	831	2,420	1,250	1,280	1,370	1,030	......	......	......	......
21	687	785	820	2,260	1,320	1,240	1,330	1,100	......	......	......	......
22	700	769	828	2,100	1,830	1,280	1,290	1,160	......	......	......	......
23	743	759	833	2,020	1,140	1,200	1,310	1,140	......	......	......	......
24	747	754	831	1,910	1,060	1,290	1,230	1,120	......	......	......	......
25	751	749	828	1,830	1,440	1,340	1,190	1,130	......	......	......	......
26	739	750	831	1,730	1,420	1,390	1,190	1,140	......	......	......	......
27	781	760	826	2,400	1,390	1,430	1,270	1,080	......	......	......	......
28	823	768	819	2,200	1,370	1,500	1,280	1,100	......	......	......	......
29	810	......	813	2,000	1,320	1,520	1,290	1,000	......	......	......	......
30	800	......	844	2,000	1,330	1,500	1,280	1,100	......	......	......	......
31	799	......	912	......	1,300	......	1,150	1,100	......	......	......	......

Monthly discharge of Red Lake River above Thief River.
[Drainage area, 2,400 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1899.					
May	1,200	820	961	.400	.46
June	1,280	1,080	1,140	.475	.53
July	1,760	950	1,180	.492	.57
August	805	705	762	.318	.37
September	800	728	749	.312	.35
October	815	515	718	.299	.34
November	620	480	532	.222	.25
December	580	420	476	.198	.23
1900.					
January	490	420	441	.184	.21
February	490	410	449	.187	.19
March	490	410	438	.182	.21
April	1,400	440	601	.250	.28
May	520	245	406	.169	.19
June	560	280	454	.189	.21
July	620	210	423	.176	.20
August	1,570	290	1,020	.425	.49
September	2,020	1,580	1,730	.721	.80
October	2,160	1,800	1,980	.825	.95
November	1,780	1,140	1,460	.608	.68
December	1,140	895	1,000	.417	.48
The year	2,160	210	867	.361	4.89
1901.					
January	877	583	778	.324	.37
February	822	733	773	.322	.34
March	912	725	800	.333	.38
April	3,120	980	2,100	.875	.98
May	1,970	1,060	1,510	.629	.73
June	1,520	1,140	1,280	.533	.59
July	1,660	1,150	1,410	.588	.68
August	1,350	1,030	1,150	.479	.55

RED LAKE RIVER AT THIEF RIVER FALLS.

Location.—One-third mile below the dam at Thief River Falls, and a mile or more below the mouth of Thief River.

Records available.—July 2, 1909, to December 31, 1912.

Drainage area.—3,430 square miles.

Gage.—Vertical and inclined staff; datum unchanged since establishment. The gage is read morning and evening and the mean of the two readings is recorded as the mean for the day.

Channel.—Permanent. The control is changed temporarily by log jams forming below.

Discharge measurements.—From a car and cable located at the gage.

Winter flow.—The river is frozen over from the latter part of November to the first of April, and measurements are made through the ice to determine the winter flow discharge.

Regulation.—A short distance above is the dam used by the Hansen & Barzen Milling Company and the city lighting plant. The fluctuating loads on the turbines cause fluctuations in the river stage below the dam. This fluctuation is produced by the operation of the lighting plant at night, and by the mill chiefly during the day time.

Accuracy.—Logs floated down the river may jam below the station and cause backwater. Conditions at this station are not satisfactory and similar conditions exist at all points on the upper river. Therefore, the records can not be considered better than fair.

Daily discharge, in second-feet, of Red Lake River at Thief River Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							850	735	972	740	1,050	
2							872	757	960	725	1,040	
3							710	779	960	695	1,030	
4							685	779	930	762	1,050	
5							834	801	872	779	1,090	
6							1,090	762	845	746	1,130	
7							1,000	779	817	762	1,110	
8							1,090	900	735	735	1,180	
9							1,160	936	665	735	1,130	
10							1,080	948	710	640	1,080	
11							1,070	1,110	675	834	1,160	
12							1,700	1,120	710	1,020	1,130	
13							1,800	1,110	817	984	1,020	
14							1,900	1,050	845	924	245	
15							1,940	936	845	900	100	
16							1,980	990	872	889	90	
17							1,820	906	872	930	635	
18							1,660	872	930	936	790	
19							2,970	801	900	966	735	
20							3,500	746	912	954	762	
21							2,920	735	1,050	1,080	750	
22							1,780	762	1,140	1,140	750	
23							1,210	735	1,210	1,170	750	
24							1,090	1,020	1,320	1,110	725	
25							1,010	1,280	1,320	1,170	725	
26							990	1,350	1,280	1,180	725	
27							1,070	1,240	1,280	1,070	725	
28							900	1,140	1,280	1,020	725	
29							845	1,070	1,270	1,030	700	
30							695	1,140	1,010	1,040	700	
31							710	1,090		1,050		

Daily discharge, in second-feet, of Red Lake River at Thief River Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1				2,720	1,920	1,080	486					
2				2,670	1,720	1,060	495					
3				2,610	1,800	1,040	430					
4				2,670	1,700	1,010	430					
5		690		2,660	1,620	984	472					
6				2,620	1,620	972	504					
7				2,510	1,500	1,050	472					
8				2,420	1,310	990	430					
9				2,340	1,410	930	370					
10				2,290	1,360	878	378					
11				2,120	1,350	834	362					
12				1,860	1,320	834	362					
13				1,590	1,280	872	386					
14				1,700	1,390	762	386					
15				1,590	1,580	790	370					
16				1,820	1,470	779	309					
17				1,970	1,360	762	350					
18				2,120	1,240	685	350					
19				2,490	1,200	685	350					
20				2,870	1,220	615	418					
21				2,270	1,200	585	430					
22				2,570	1,080	585	370					
23				2,290	1,140	610	350					
24				2,210	1,060	735	374					
25				2,320	1,070	615	378					
26				2,090	1,040	610	370					
27				2,000	1,060	625	472					
28				1,990	1,180	562	418					
29				2,030	1,020	472	418					
30				2,030	1,030	562	418					
31					1,110		472					
1911.												
1						350	254	30	20	3.5	4	
2						320	20	3	16	4	42	
3						450	192	13	16	79	3	
4						325	179	8	43	5.5	25	
5						340	226	25	13	114	3	
6						400	184	129	36	59	16	
7						500	206	10	16	6.8	4.8	
8						2,070	234	77	51	5.5	102	
9						3,820	36	10	30	3	13	
10						2,480	153	59	2.5	127	102	
11						1,070	25	36	4	3.5		
12						770	20	43	5.5	4.8		
13						644	1.8	1	20	127		
14						565	1.8	43	141	3.5		
15						456	1.8	30	8	3		
16						474	1	30	43	5.5		
17						456	0	77	1.5	114		
18						389	10	43	4	3		
19						389	2	16	51	127		
20						324	16	2	10	6.8		
21						278	43	51	13	51		
22						234	4	59	5.5	3.5		
23						234	2.5	51	6.8	4.8		
24						206	43	1.2	2.5	4.8		
25						8	36	13	68	4		
26						263	5.5	1.2	6.8	10		
27						220	4.8	0	4	6.8		
28						166	5.5	25	4	114		
29						234	5.5	36	51	4		
30						278	59	20	87	5.5		
31							25	13		3		
1912.												
1					32	132	212	90	38	310	372	
2					50	43	212	110	165	325	248	
3					28	132	132	121	176	340	166	
4					8	57	43	117	176	356	389	
5					72	57	57	200	154	340	406	

Daily discharge, in second-feet, of Red Lake River at Thief River Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6					325	54	28	165	188	278	340	
7					132	50	43	200	147	372	293	
8				165	110	30	32	110	81	356	340	
9				188	121	12	64	121	200	356	356	
10				132	110	50	225	212	188	340	220	
11				212	110	64	110	50	154	340	389	
12				165	50	50	72	212	121	324	372	
13				72	38	57	64	188	176	234	372	
14				14	81	72	165	200	200	340	372	
15				100	69	121	358	212	125	308	356	
16				110	72	64	212	200	212	278	293	
17				54	81	154	200	200	200	293	102	
18				90	72	188	252	38	225	293	324	
19				43	43	165	90	165	238	278	356	
20				23	136	154	280	200	252	179	324	
21				6	100	158	154	165	238	324		
22				23	165	158	325	176	81	324		
23				121	154	100	200	188	238	293		
24				7	121	176	188	188	718	293		
25				7	154	110	325	43	540	293		
26				32	64	132	176	212	325	356		
27				121	106	121	143	238	540	234		
28				5.8	110	128	132	212	582	324		
29				7	86	132	188	154	540	324		
30				7	28	28	165	121	540	372		
31					57		176	165		356		

Daily discharges for 1909 and 1910 computed from a rating curve that is not well defined. Owing to backwater from log jams no daily discharges have been computed for 1911 prior to June 1. Subsequent to June 7 the daily discharges are computed from a fairly well defined rating curve. Water held back by logs November 14, 15 and 16, 1909. Daily discharge for 1912 computed from three fairly well defined rating curves. From July 10 to 31 the indirect method was used.

Monthly discharge of Red Lake River at Thief River Falls.
[Drainage area, 3,430 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July	3,500	685	1,380	0.402	0.46	C
August	1,350	735	948	.276	.32	C
September	1,320	665	967	.282	.31	C
October	1,180	640	926	.270	.31	C
November	1,180		828	.241	.27	C
December			[a]700	.204	.24	C
1910.						
January			[a]530	.155	.18	C
February			[a]530	.155	.16	C
March			[a]2,200	.641	.74	D
April	2,870	1,590	2,260	.659	.74	C
May	1,920	1,020	1,330	.388	.45	C
June	1,080	472	786	.229	.26	C
July	504	309	406	.118	.14	C
1911.						
January			[b]125	.036	.04	D
February			[b] 95	.028	.03	D
March			[b]150	.044	.05	D
April			[b]375	.109	.12	C
May			[b]290	.085	.10	C
June	3,820	8	624	.182	.20	C
July	254	0	64.4	.019	.02	B
August	129	0	30.8	.0090	.01	B
September	141	1.5	26.0	.0076	.008	B
October	127	3	32.8	.0096	.011	C
November	102		13.8	.0040	.005	C
December			9.0	.0026	.003	D
The year	3,820	0	152	.044	.596	

[a] Estimated from a few ice measurements.
[b] Monthly mean discharge January, February, March, April and May estimated by comparison with records at Red Lake River at Crookston, and Clearwater River at Red Lake Falls.

Monthly discharge of Red Lake River at Thief River Falls—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1912.						
January			c 4	.0012	.001	
February			c 4	.0012	.001	
March			c 7	.0020	.002	
April	212	5.8	b85.5	.025	.03	C
May	325	8	93.1	.027	.03	B
June	188	12	98.3	.029	.03	B
July	358	28	162	.047	.05	C
August	238	38	160	.047	.05	B
September	718	38	259	.076	.08	C
October	372	179	314	.092	.11	B
November	406		280	.082	.09	C

[b] Partly estimated.
[c] Discharge Jan. 1 to April 7 and Nov. 21 to 30 estimated from discharge measurements, gage heights, climatological records and runoff from adjacent areas.

RED LAKE RIVER AT CROOKSTON.

Location.—At new Sampson's Addition highway bridge in Crookston, less than ¼ mile below the dam and power house of the Crookston Water Works Power & Light Co.—no tributaries within several miles.

Records available.—May 19, 1901, to December 31, 1912.

Drainage area.—5,320 square miles.

Gage.—Until July 1, 1909, the gage was located at the old "Sampson's Addition" bridge, but on that date a chain gage was installed on the new bridge 20 rods below, and set to read the same as the original gage, the datum of which has remained constant since the establishment of the station. In September, 1911, an automatic gage was substituted for the chain gage. A vertical staff nearby reads to the same datum.

Channel.—Slightly changing from year to year.

Discharge measurements.—Made from new bridge.

Winter flow.—At the original section the channel was wholly or partly open at the station throughout the winter, owing to the presence of the dam; at the present section the river freezes entirely across from December to March, and discharge measurements are made through the ice to determine the approximate winter flow.

Accuracy.—The operation of the power plant causes fluctuations in the water surface at the station, but the use of the automatic gage should give excellent results, as the section is well rated.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1						2,020	3,510	2,300	1,080	1,380	1,700	
2						1,960	3,660	2,300	1,080	1,380	1,670	
3						2,020	3,710	1,920	1,050	1,290	1,800	
4						2,500	3,740	2,020	1,080	1,410	1,760	
5						2,400	4,470	2,120	1,120	1,380	1,740	
6						2,580	5,360	2,060	1,100	1,400	1,460	
7						2,560	5,970	2,060	1,080	1,410	1,360	
8						2,420	5,970	1,500	1,080	1,380	1,290	
9						2,330	5,720	1,840	1,140	1,380	1,200	
10						2,340	5,440	1,810	1,200	1,350	1,200	
11						2,460	5,320	1,780	1,140	1,260	1,180	
12						2,400	4,870	2,090	1,260	1,200	1,160	
13						2,120	4,370	1,410	1,290	1,110	1,110	
14						2,780	4,000	1,410	1,410	1,100	1,080	
15						2,460	3,870	1,440	1,380	1,110	1,100	
16						2,460	3,820	1,640	1,350	1,750	1,090	
17						2,820	3,670	1,740	1,340	1,780	1,080	
18					3,660	3,200	3,740	1,350	1,380	1,780	1,050	
19					3,400	3,100	3,460	1,440	1,410	1,810	1,070	
20					3,510	3,060	3,240	2,020	1,420	1,820	1,050	
21					3,150	3,130	3,330	1,670	1,400	1,840	1,040	
22					3,240	3,180	3,150	1,600	1,410	1,880	1,020	
23					3,060	3,150	3,100	1,810	1,350	1,870	1,020	
24					2,660	2,900	2,980	1,780	1,440	1,820	1,050	
25						2,850	2,780	1,780	2,300	1,810	1,050	
26						5,270	2,420	2,060	2,340	1,780	1,020	
27						4,470	2,346	1,700	1,500	1,750	1,040	
28						4,570	2,380	1,700	1,490	1,740	1,050	
29						4,000	2,380	1,670	1,440	1,700	1,060	
30					2,290	3,820	2,360	1,600	1,410	1,670	1,090	
31					2,200		2,340	1,500		1,740		
1902.												
1				3,330	3,420	3,380	2,160	960	1,170	1,170	1,230	
2				3,060	3,960	3,200	2,230	1,290	1,140	1,260	1,200	
3				2,580	5,120	3,560	2,260	1,290	1,080	1,230	1,230	
4				2,500	4,820	4,280	2,340	1,350	1,080	1,350	1,230	
5				2,740	4,720	4,320	2,420	1,380	1,110	1,170	1,230	
6				2,660	4,230	4,280	2,400	1,530	1,110	1,110	1,350	
7				2,260	4,100	4,370	2,420	1,470	1,110	1,050	1,380	
8				2,660	3,820	4,770	2,420	1,110	1,050	1,080	1,290	
9				2,230	3,640	4,970	2,260	735	1,020	1,110	1,320	
10				2,120	3,740	4,870	2,260	1,290	1,080	1,140	1,350	
11				1,780	3,820	4,770	2,260	1,050	1,060	1,110	1,380	
12				1,840	3,920	4,770	2,160	1,110	1,080	1,110	1,410	
13			2,780	1,640	3,920	4,670	2,090	935	1,080	1,110	1,440	
14			2,780	1,600	4,000	4,870	2,160	835	1,020	1,080	1,410	
15			2,780	2,120	3,820	4,470	2,120	990	1,020	1,080	1,380	
16			2,880	1,920	3,740	4,280	2,020	1,290	935	1,110	1,410	
17			2,980	1,780	3,820	4,180	1,980	835	935	1,110	1,410	
18			3,020	1,920	4,000	4,180	1,950	1,110	910	1,140	1,470	
19			3,020	1,470	4,280	4,180	1,950	1,470	910	1,140	1,470	
20			3,150	1,840	4,770	4,180	1,950	1,350	910	1,140	1,470	
21			2,980	1,200	5,170	3,820	1,920	1,230	935	1,140	1,440	
22			2,940	1,640	4,970	3,740	1,920	1,170	960	1,110	1,440	
23			3,240	1,640	4,920	3,740	1,880	1,050	960	1,140	1,410	
24			3,380	1,640	4,180	3,560	1,700	1,080	990	1,170	1,110	
25			3,780	1,200	4,180	3,280	1,640	1,110	1,020	1,230	1,080	
26			4,000	1,700	3,960	2,780	1,230	1,140	1,020	1,350	1,110	
27			4,420	3,060	3,820	2,500	1,200	1,170	1,020	1,320	1,410	
28			5,020	2,980	3,820	2,460	1,020	1,170	1,020	1,350	1,340	
29			4,770	3,240	3,740	2,380	885	1,200	1,050	1,350	1,440	
30			4,720	3,280	3,640	2,230	1,050	1,230	1,080	1,350	1,440	
31			4,180		3,640		1,050	1,170		1,290		
1903.												
1						2,940	1,050	860	1,170	735	1,810	
2						2,700	935	760	1,110	860	1,600	
3						2,620	885	785	835	990	1,600	
4						2,620	935	810	1,290	835	1,980	
5						2,580	1,050	735	1,410	1,290	1,600	

Daily discharge, in second-feet, of Red Lake River at Crookston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
6						2,500	1,350	660	1,110	1,410	1,530	
7						2,500	1,140	685	1,290	1,920	1,470	
8						2,340	1,080	710	1,110	2,270	1,840	
9						2,060	990	710	1,470	2,300	1,530	
10						2,060	835	710	1,410	2,380	1,500	
11						2,020	835	635	1,670	2,380	1,500	
12						1,950	1,170	585	1,740	2,460	1,440	
13						1,810	1,140	610	1,810	2,460	1,230	
14						1,880	1,290	585	2,380	2,460	990	
15						1,740	1,200	560	1,640	2,420	835	
16		680				1,600	710	520	1,600	2,420	635	
17						1,560	785	560	1,470	2,380	785	
18						1,530	1,170	560	1,410	2,120	610	
19						1,380	1,050	463	1,670	2,340	1,320	
20						1,440	1,020	560	1,950	1,810	1,170	
21						1,350	1,050	446	1,740	2,020	1,170	
22						1,320	1,020	560	1,570	2,300	1,050	
23						1,350	960	401	1,320	2,060	1,020	
24						1,410	785	560	1,170	1,980	760	
25					3,690	1,290	1,080	610	1,200	2,420	481	
26					3,510	1,140	935	446	990	1,810	910	
27					3,640	1,410	835	910	1,170	2,080		
28				4,060	3,510	1,170	810	910	1,170	1,670		
29					3,240	1,050	1,020	1,110	885	2,060		
30					3,100	1,140	860	735	935	1,670		
31					2,940		885	1,050		1,740		
1904.												
1					7,620	3,660	2,640	1,290	1,450	760	1,120	510
2					6,860	3,460	2,580	1,270	1,320	1,150	1,090	630
3				3,780	6,460	3,340	2,500	1,090	1,300	810	1,000	470
4				6,120	5,900	3,440	2,360	1,270	1,330	1,090	940	510
5				9,630	5,560	3,580	2,330	1,260	1,270	1,000	900	470
6				11,000	5,270	3,580	2,470	1,150	1,450	1,000	860	810
7				11,900	5,950	3,620	2,190	810	1,300	1,090	810	910
8				10,800	6,420	3,780	2,260	1,070	1,300	810	1,090	885
9				9,150	6,420	3,820	2,160	1,040	1,330	1,180	1,210	970
10				8,140	6,420	3,700	1,800	910	1,300	860	1,320	970
11				9,410	6,160	3,620	2,020	835	910	940	1,180	910
12				11,500	6,220	3,620	2,020	810	1,150	940	1,000	1,120
13				10,600	6,270	3,700	1,940	810	860	1,050	1,000	1,390
14				10,460	6,46	3,220	1,860	940	910	875	1,090	1,270
15				10,200	6,330	3,020	1,600	910	1,000	1,150	1,120	1,450
16				9,770	6,330	2,940	1,940	810	1,000	810	1,180	1,330
17				9,450	5,990	2,940	1,660	825	690	910	1,080	1,390
18				7,420	5,480	3,140	1,840	860	670	1,030	970	1,330
19				8,920	5,280	3,620	1,660	875	650	940	860	1,330
20				7,110	5,140	3,540	1,480	875	1,030	970	810	1,390
21				7,600	4,880	3,180	1,420	785	610	1,120	760	1,480
22				9,140	4,120	3,180	1,450	860	760	1,050	670	1,480
23				12,600	4,650	3,220	1,420	885	850	1,120	690	1,090
24				13,600	4,390	3,100	1,510	885	970	1,180	710	1,150
25				12,900	4,380	3,060	1,440	835	810	970	630	1,150
26				11,900	4,200	3,140	1,480	910	860	1,150	690	1,150
27				10,200	4,200	3,260	1,450	810	970	1,150	430	1,060
28				9,600	4,200	2,980	1,330	885	735	1,150	470	1,060
29				9,090	3,820	2,820	1,280	710	785	1,330	550	1,060
30				8,120	3,700	2,940	1,180	810	1,030	1,210	550	1,060
31					3,760		1,090	1,030		860		
1905.												
1				2,540	1,280	2,240	3,020	2,860	2,540	3,100	1,400	
2				2,660	1,250	2,060	2,470	2,820	2,620	3,020	1,400	
3				4,650	1,370	1,950	2,400	2,780	3,020	2,940	1,160	
4				4,060	1,430	2,100	2,210	3,420	3,260	2,820	1,110	
5				4,140	1,640	2,360	2,130	3,740	3,100	2,620	2,360	
6				3,970	1,880	2,300	2,510	3,420	2,940	2,470	2,210	
7				2,540	2,070	2,210	2,660	3,200	2,700	2,400	1,980	
8				2,240	2,280	1,980	2,470	2,940	2,660	2,320	1,950	
9				2,540	2,320	2,050	2,700	2,780	2,620	2,320	1,980	
10				2,320	2,510	2,470	2,470	2,780	2,580	2,240	1,880	

Daily discharge, in second-feet, of Red Lake River at Crookston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
11	......	......	......	2,100	2,660	2,170	2,210	2,430	2,510	2,170	2,020	......
12	......	......	......	1,810	4,740	2,100	2,210	2,320	2,360	2,100	1,810	......
13	......	......	......	1,880	8,390	2,100	2,170	2,320	2,320	2,100	1,810	......
14	......	......	......	1,780	7,620	1,920	2,130	2,320	2,210	2,100	1,740	......
15	......	......	......	1,740	6,260	2,020	2,240	2,860	2,700	2,100	2,020	......
16	......	......	......	1,600	5,420	1,670	3,740	2,620	3,340	2,100	2,060	......
17	......	......	......	1,370	4,480	1,740	3,900	3,660	3,340	2,100	2,170	......
18	......	......	......	1,340	4,560	2,130	4,220	4,900	3,420	2,020	1,840	......
19	......	......	......	1,370	3,900	1,810	3,740	4,900	3,580	1,780	1,670	......
20	......	......	......	1,080	3,660	1,530	4,220	4,400	3,820	1,640	1,740	......
21	......	......	......	1,030	3,420	1,810	3,580	3,660	3,820	1,920	1,780	......
22	......	......	......	1,110	3,260	1,780	3,420	3,420	3,580	2,360	1,670	......
23	......	......	......	1,220	3,100	1,950	3,660	3,180	3,420	2,740	1,740	......
24	......	......	......	1,340	2,780	1,950	2,860	2,860	3,260	2,280	1,880	......
25	......	......	......	1,160	2,780	2,130	2,580	2,620	3,180	2,400	2,100	......
26	......	......	......	1,340	2,700	2,060	2,540	2,540	3,180	2,400	1,740	......
27	......	......	......	1,060	2,470	2,100	2,620	2,540	3,180	2,210	980	......
28	......	......	......	1,340	2,400	2,240	3,420	2,540	3,100	1,880	680	......
29	......	......	......	1,310	2,430	2,280	4,310	2,470	3,100	1,810	582	......
30	......	......	......	1,060	1,950	3,100	3,580	2,400	3,020	1,980	810	......
31	......	......	......	......	2,210	......	3,100	2,400	......	1,810	......	......
1906.												
1	......	......	......	8,090	5,240	3,300	2,240	1,530	1,340	1,100	1,220	......
2	......	......	......	8,090	4,900	3,380	2,100	1,670	1,340	1,100	1,100	......
3	......	......	......	8,090	4,560	3,190	2,210	1,600	1,640	1,250	1,100	......
4	......	......	......	8,090	4,480	3,100	2,060	1,400	1,430	1,400	815	......
5	......	......	......	9,410	4,480	3,060	2,130	1,460	1,280	1,250	660	......
6	......	......	......	6,940	4,560	3,030	2,100	1,500	1,220	1,220	760	......
7	......	......	......	7,030	4,440	2,820	2,020	1,600	1,400	1,400	815	......
8	......	......	......	5,160	4,270	2,780	1,880	1,310	1,250	1,130	815	......
9	......	......	......	5,880	4,140	2,780	1,840	1,470	1,400	1,040	870	......
10	......	......	......	6,320	4,020	2,820	1,780	1,530	1,030	980	660	......
11	......	......	......	6,690	3,980	2,900	1,880	1,500	1,130	1,190	710	......
12	......	984	......	7,610	3,900	2,700	1,840	1,400	1,160	952	710	......
13	......	......	......	8,650	3,820	2,620	1,810	1,430	1,310	1,100	660	......
14	......	......	......	13,200	3,740	2,530	1,780	1,530	1,010	870	760	......
15	......	......	......	14,200	3,820	2,470	1,740	1,670	1,130	1,160	815	......
16	......	......	......	13,200	3,740	2,320	1,740	1,740	1,310	1,130	660	......
17	......	......	......	12,100	3,700	2,170	1,670	1,740	1,400	1,070	660	......
18	......	......	......	10,800	3,980	2,060	1,670	1,840	815	870	660	......
19	......	......	......	9,210	3,820	2,360	1,670	1,670	1,100	638	660	......
20	......	......	......	8,820	3,660	2,210	1,670	1,600	1,340	815	660	......
21	......	......	......	8,090	3,460	2,020	1,740	1,740	1,250	925	1,040	......
22	......	......	......	7,460	3,300	2,210	1,740	1,530	1,120	760	925	......
23	......	......	......	6,940	3,140	2,210	1,670	1,250	1,040	815	710	......
24	......	......	......	6,690	3,060	2,210	1,640	1,430	1,310	815	710	......
25	......	......	......	6,520	3,140	2,170	1,670	1,430	1,400	870	925	......
26	......	......	......	6,180	3,030	2,130	1,670	1,400	1,420	710	710	......
27	......	......	......	5,920	2,900	2,230	1,600	1,460	1,400	660	1,040	......
28	......	......	......	5,760	2,860	2,170	1,560	1,560	1,250	760	1,100	......
29	......	......	......	5,670	3,020	2,210	1,600	1,340	1,100	760	1,040	......
30	......	......	......	5,880	3,020	2,180	1,600	1,280	1,310	815	1,100	......
31	......	......	......	......	3,100	......	1,500	1,400	......	925	......	......
1907.												
1	......	......	......	4,000	2,680	1,580	1,610	952	705	1,120	925	......
2	......	......	......	4,160	2,720	1,550	1,610	815	655	1,260	925	......
3	......	......	......	5,340	2,570	1,640	1,580	870	705	1,320	870	......
4	......	......	......	6,260	2,570	1,460	1,790	1,060	655	1,290	898	......
5	......	......	......	6,220	2,570	1,460	1,550	980	760	1,170	952	......
6	......	......	......	6,050	2,650	1,460	1,640	1,090	898	1,090	870	......
7	......	......	......	6,010	2,460	1,430	1,610	1,090	842	1,200	870	......
8	......	......	......	5,630	2,250	1,350	1,670	1,090	925	1,150	925	......
9	......	......	......	5,380	2,390	1,430	1,520	1,090	842	1,120	898	......
10	......	......	......	4,760	2,250	1,610	1,400	1,090	788	1,090	760	......
11	......	458	......	4,720	2,110	1,980	1,150	980	732	1,090	680	......
12	......	......	......	4,360	2,050	3,410	1,260	980	760	1,090	582	......
13	......	......	......	4,120	2,150	3,760	1,090	815	760	925	538	......
14	......	......	......	3,760	2,250	3,530	925	760	788	1,150	538	......
15	......	......	......	3,960	1,950	3,290	1,060	760	680	1,010	475	......

Daily discharge, in second-feet, of Red Lake River at Crookston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
16				4,000	2,010	2,870	1,260	952	760	952		
17				3,840	2,050	3,490	1,090	815	705	1,040		
18				4,400	1,920	3,220	1,090	705	980	1,010	621	
19				3,680	1,920	2,830	815	760	605	1,040		
20				4,240	1,950	2,280	1,230	760	1,230	925		
21				4,160	1,640	2,150	1,010	760	1,290	1,040		
22				4,280	1,760	2,050	1,090	788	1,580	1,040		
23				5,030	1,610	2,180	842	870	1,520	980		
24				4,480	1,920	2,110	1,040	760	1,610	925		
25			2,500	3,640	1,850	2,110	1,040	760	1,580	815		
26			2,900	3,260	1,610	2,050	980	515	1,260	925		
27			3,000	2,910	1,790	1,920	980	788	1,550	870		
28			4,100	2,610	1,730	1,850	1,060	760	1,260	815		
29			3,800	2,680	1,700	1,760	1,090	760	1,320	952		
30			3,400	2,610	1,580	1,670	1,010	705	1,090	898		
31			3,200		1,760		870	605		925		
1908.												
1				2,000	2,800	4,640	1,820	1,320	3,490	980	760	
2				2,000	2,760	4,480	1,790	1,090	2,830	980	605	
3				2,000	2,680	4,240	1,790	1,350	2,180	966	925	
4				2,000	2,540	3,920	1,760	1,350	1,580	952	925	
5				2,000	2,540	3,060	1,610	1,320	1,610	925	760	
6				8,630	2,390	2,950	1,640	1,320	1,430	980	925	
7				10,300	2,390	3,370	1,370	1,200	1,320	952	925	
8				9,760	2,180	3,840	1,610	1,120	1,120	925	815	
9				9,580	2,050	3,760	1,550	925	1,040	842	842	
10		607		9,620	1,950	3,180	1,350	1,040	1,090	815		
11				8,480	2,050	3,370	1,550	980	952	760		
12				8,990	2,150	3,330	1,200	1,090	980	760		
13				6,050	2,650	3,180	1,320	980	788	760		
14				5,960	2,830	3,020	1,320	925	898	870		
15				5,800	2,980	2,980	1,230	1,060	870	898		
16				5,540	2,910	2,910	1,230	1,320	952	605		
17				4,930	3,060	2,910	1,290	1,040	870	870		
18				4,000	3,140	2,800	1,150	1,040	760	760		
19				3,570	4,000	2,830	1,150	1,040	788	898		
20				2,950	4,520	2,540	1,090	1,090	788	705		
21				2,570	4,800	2,760	1,170	1,010	842	760		
22				2,320	6,380	2,760	1,200	1,060	870	1,040		
23				2,250	6,470	2,680	1,200	1,060	842	815		495
24		408		2,080	6,380	2,540	1,170	1,090	870	842		
25				2,250	5,380	2,610	1,150	842	870	560		
26				2,540	5,540	2,460	980	1,200	925	1,010		
27				3,060	5,750	2,320	1,320	1,090	952	815		
28				3,180	5,590	2,110	1,060	1,170	1,040	925		
29				2,830	5,340	1,980	1,200	1,230	1,010	925		
30				2,610	5,090	1,850	1,090	1,200	980	898		
31					4,970		1,170	3,290		870		
1909.												
1				1,960	1,450	1,610	1,750	2,140	2,060	1,200	1,610	
2				2,450	1,290	1,750	1,480	2,240	1,960	1,200	1,540	
3				2,710	1,290	1,380	1,580	2,230	1,680	1,140	1,480	
4				3,150	1,200	1,420	1,080	2,310	1,680	1,230	1,420	
5				3,290	1,230	960	930	2,030	1,820	1,170	1,540	
6				3,210	1,320	930	710	1,610	1,610	1,110	1,540	
7				3,210	1,480	1,230	816	2,090	1,350	1,170	1,320	
8				2,900	1,320	1,170	1,020	2,170	1,200	1,240	1,450	
9				2,710	1,420	1,110	510	2,020	1,170	1,180	1,480	
10		323		2,600	1,490	1,260	608	2,240	1,140	1,080	1,420	
11				2,670	1,480	1,200	510	2,000	710	1,170	1,350	
12				2,390	1,450	960	930	2,030	990	1,200	1,110	
13				2,240	1,480	762	736	2,310	1,020	1,450	1,110	
14				2,200	1,580	990	872	2,740	990	1,750		
15				1,890	1,750	872	608	2,520	1,080	1,680		
16				1,820	1,540	960	658	2,310	1,110	1,640	321	
17				1,780	1,920	1,020	1,020	2,170	1,110	1,480		
18				1,780	1,890	805	789	2,000	1,110	1,580		
19				1,680	1,960	816	464	1,960	1,140	1,610		
20				1,960	1,820	558	1,750	1,890	1,140	1,640		

Daily discharge, in second-feet, of Red Lake River at Crookston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
21				2,340	1,960	805	3,630	1,890	1,170	1,610		
22				2,000	1,890	736	3,620	2,030	1,200	1,580		
23				1,860	1,820	633	3,490	2,100	1,580	1,750		
24				1,920	1,610	633	3,430	2,310	1,540	1,890		
25				1,860	1,720	534	3,130	3,000	1,750	1,920		
26				2,020	1,420	558	3,490	3,250	1,450	1,890		
27				1,760	1,140	558	2,990	3,210	1,420	1,820		
28				1,680	1,140	608	2,740	2,820	1,450	1,750		
29				1,720	1,380	762	2,450	2,480	1,350	1,640		
30				1,540	1,170	1,720	2,370	2,480	1,260	1,640		
31					1,420		1,820	2,100		1,580		
1910.												
1			646	5,380	3,280	1,230	680	898	204	416	196	325
2			650	5,300	3,080	1,230	630	433	269	224	224	310
3			650	5,130	2,970	1,240	538	382	301	325	72	319
4			650	4,970	2,720	1,250	495	379	196	340	157	
5			700	4,890	2,720	980	615	372	515	325	144	
6			700	4,640	2,680	1,260	596	372	495	310	96	
7			700	4,640	2,540	1,320	582	376	560	340	170	
8	767		700	4,240	2,220	1,460	640	280	475	340	170	
9			800	4,080	2,110	1,320	605	458	340	340	266	
10			900	3,920	1,980	1,320	458	356	310	416	238	
11			1,000	3,760	2,060	1,200	538	398	280	334	252	
12			1,500	3,450	1,850	1,670	475	366	340	289	252	
13			3,760	3,060	1,820	1,230	412	356	310	272	266	
14			4,800	2,910	1,790	1,240	495	325	325	310	224	
15			5,340	2,910	1,730	1,050	582	346	325	196	196	
16			5,540	2,910	1,770	1,090	582	346	310	196	252	
17			5,800	3,140	1,760	1,060	507	295	310	196	310	
18			6,430	3,180	1,760	980	515	170	280	196	280	
19			7,360	3,530	1,670	925	440	310	295	260	252	
20			7,830	4,600	1,670	980	440	295	310	310	196	
21			5,960	5,380	1,700	881	388	340	310	340	224	185
22			4,840	5,540	1,700	815	430	295	216	340	252	
23			5,130	5,090	1,680	716	655	313	340	340	238	
24			5,260	4,320	1,640	804	680	316	412	331	266	
25			5,340	4,160	1,680	870	605	310	356	310	224	
26			5,460	3,960	1,550	560	605	346	325	210	238	
27			5,300	3,840	1,550	898	592	280	272	331	224	
28			4,440	3,610	1,490	788	574	340	340	210	218	
29			4,240	3,530	1,520	815	560	280	340	246	196	
30			4,840	3,450	1,490	732	560	340	331	252	210	
31			5,130		1,300		458	274		244		
1911.												
1				685	561	465	304	178	72	162	44	
2				710	548	437	231	93	89	120	52	
3				570	519	685	231	140	289	80	54	
4				527	527	527	245	145	72	91	54	
5				570	477	548	128	158	72	95	152	
6				570	414	646	72	191	72	62	49	
7				570	406	615	52	93	44	68	76	
8				527	445	638	140	165	52	181	70	
9				570	283	2,320	231	170	52	29	74	
10				570	353	3,380	239	98	223	111	87	
11				815	336	3,340	191	140	49	85		
12				815	388	2,900	116	82	116	89		
13				760	445	2,350	191	72	78	76		
14				760	274	1,460	165	116	98	89		
15				815	592	1,270	116	152	56	145		
16				842	651	886	116	145	62	56		
17				815	353	1,010	72	128	44	80		
18				815	388	870	116	78	52	91		
19				788	406	925	116	76	89	111		
20				660	527	506	116	104	72	104		
21				651	485	527	116	93	72	93		
22				592	519	570	121	76	82	148		
23				760	557	320	128	62	49	72		
24			925	548	445	445	135	76	116	111		
25			980	527	377	165	171	104	44	100		

Daily discharge, in second-feet, of Red Lake River at Crookston—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
26			952	477	406	453	82	82	89	95		
27			952	527	506	260	76	76	50	95		
28			1,160	815	445	260	76	72	64	107		
29			1,100	592	406	304	82	72	62	150		
30			925	485	465	231	82	82	62	82		
31			710		445		204	72		72		
1912.												
1					217	178	288	320	332	1,720	466	
2					191	332	104	330	145	1,590	448	
3					186	165	100	173	126	1,350	395	
4					191	259	466	217	160	1,100	412	
5					259	245	259	178	194	910	395	
6					245	217	214	395	625	760	430	
7					231	209	273	363	231	965	412	
8					317	207	168	194	245	810	430	
9					317	332	140	217	152	810	430	
10					348	140	100	430	245	715	395	
11				810	363	123	170	484	502	670	430	
12				760	332	138	102	152	168	715	430	
13				715	412	201	502	181	288	502	430	
14				715	448	104	173	302	540	670	450	
15				715	466	194	87	320	540	580	484	
16				484	395	259	332	290	540	670		
17				412	395	288	259	300	540	540		
18				173	448	288	259	270	540	810		
19				273	348	259	580	190	540	540		
20				259	363	259	363	240	231	412		
21				245	302	260	412	260	450	448		
22				173	273	240	430	290	540	466		
23				217	302	160	332	288	625	395		
24				135	302	540	302	191	521	430		
25				207	217	170	288	348	670	484		
26				155	317	152	430	715	1,780	430		
27				207	448	348	379	379	1,470	395		
28				217	302	214	395	199	2,050	412		
29				116	288	121	430	212	2,120	412		
30				155	273	484	450	196	1,980	430		
31					217		810	580		466		

NOTE.—These discharges are based on well-defined rating curves.

Monthly discharge of Red Lake River at Crookston.

[Drainage area, 5,320 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1901.						
June	5,270	1,960	2,910	.547	.61	
July	5,970	2,340	3,790	.712	.82	
August	2,300	1,350	1,780	.335	.39	
September	2,340	1,080	1,350	.254	.28	
October	1,880	1,100	1,550	.291	.34	
November	1,700	1,020	1,220	.229	.26	
1902.						
March (13-31)	5,020	2,780	3,520	.662	.46	
April	3,330	1,200	2,190	.412	.46	
May	5,170	3,420	4,120	.774	.89	
June	4,970	2,230	3,900	.733	.82	
July	2,460	885	1,920	.361	.42	
August	1,530	735	1,160	.218	.25	
September	1,170	910	1,030	.194	.22	
October	1,350	1,050	1,180	.222	.26	
November	1,470	1,080	1,350	.254	.28	

Monthly discharge of Red Lake River at Crookston—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy
	Maximum.	Minimum.	Mean.	Per square mile.		
1903.						
May (25-31)	3,690	2,940	3,380	.635	.16	....
June	2,940	1,050	1,820	.342	.38	....
July	1,350	710	995	.187	.22	....
August	1,110	401	671	.126	.15	....
September	2,380	835	1,390	.261	.29	....
October	2,460	735	1,940	.365	.42	....
November	1,980	430	1,270	.239	.27	....
December	1,870	1,290	1,490	.280	.32	....
1904.						
April (3-30)	13,600	3,780	7,410	1.39	1.45	....
May	7,620	3,700	5,450	1.02	1.18	....
June	3,820	2,820	3,340	.628	.70	....
July	2,640	1,090	1,820	.342	.39	....
August	1,290	710	938	.176	.20	....
September	1,450	610	1,020	.192	.21	....
October	1,330	760	1,020	.192	.22	....
November	1,330	430	893	.168	.19	....
December	1,480	470	1,050	.199	.23	....
1905.						
April	4,650	1,030	1,990	.374	.42	B
May	8,390	1,250	3,200	.602	.69	A
June	3,100	1,530	2,080	.391	.44	A
July	4,310	2,130	2,950	.555	.64	A
August	4,900	2,320	3,040	.571	.66	A
September	3,820	2,210	3,010	.566	.63	A
October	3,100	1,640	2,260	.425	.49	A
November	2,360	582	1,680	.316	.35	A
December	....	....	[a]1,600	.301	.35	B
1906.						
January	....	....	[a]1,500	.282	.33	D
February	....	....	[a]1,020	.192	.20	C
March	....	....	[a]1,500	.282	.33	D
April	14,200	5,880	8,090	1.52	1.70	A
May	5,240	2,860	3,780	.711	.82	A
June	3,380	2,020	2,540	.477	.53	A
July	2,240	1,500	1,800	.338	.39	A
August	1,840	1,250	1,520	.286	.33	A
September	1,640	815	1,260	.237	.26	A
October	1,400	638	983	.185	.21	A
November	1,220	660	836	.157	.18	B
December	....	....	[a]700	.132	.15	C
The year	14,200	....	2,130	.400	5.43	
1907.						
January	....	....	[a]650	.122	.14	C
February	....	....	[a]460	.086	.09	C
March	....	....	[a]1,280	.241	.28	C
April	6,260	2,610	4,370	.821	.92	A
May	2,720	1,580	2,080	.391	.45	A
June	3,760	1,350	2,180	.410	.46	A
July	1,790	815	1,220	.229	.26	A
August	1,090	515	854	.161	.19	A
September	1,610	605	994	.187	.21	A
October	1,320	815	1,040	.195	.22	A
November	952	....	668	.126	.14	C
December	....	....	[a]626	.118	.14	C
The year	6,260	....	1,370	.258	3.50	

[a] Estimated.

Monthly discharge of Red Lake River at Crookston—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1908.						
January			[a] 467	.088	.10	C
February			[a] 508	.095	.10	C
March			[a] 620	.117	.13	C
April	10,300		4,660	.876	.98	B
May	6,470	1,950	3,750	.705	.81	A
June	4,640	1,850	3,050	.573	.64	A
July	1,820	980	1,340	.252	.29	A
August	3,290	842	1,190	.224	.26	A
September	3,490	760	1,180	.222	.25	A
October	1,040	605	860	.162	.19	A
November			[a] 803	.151	.17	C
December			[a] 437	.082	.09	C
The year	10,300		1,570	.295	4.01	
1909.						
January			[a] 480	.090	.10	C
February			[a] 385	.072	.07	C
March			[a] 660	.124	.14	C
April	3,290	1,540	2,240	.421	.47	A
May	1,960	1,140	1,520	.286	.33	A
June	1,750	534	977	.184	.21	B
July	3,630	464	1,680	.316	.36	A
August	3,250	1,610	2,280	.429	.49	A
September	2,050	710	1,340	.252	.28	A
October	1,920	1,080	1,480	.278	.32	A
November (1-13)	1,610	1,110	1,410	.265	.13	A
1910.						
January			[a] 754	.142	.16	C
February			[a] 700	.132	.14	C
March	7,830	646	3,630	.682	.79	B
April	5,540	2,910	4,120	.774	.86	A
May	3,280	1,300	1,980	.372	.43	A
June	1,670	560	1,060	.199	.22	A
July	680	388	546	.103	.12	A
August	898	170	352	.066	.08	A
September	560	196	333	.063	.07	A
October	416	196	293	.055	.06	A
November	310	72	217	.041	.05	A
December			[a] 219	.041	.05	D
The year	7,830		1,180	.222	3.03	
1911.						
January			150	.028	.03	D
February			120	.023	.02	D
March	1,160		434	.082	.09	C
April	842	477	658	.124	.14	B
May	651	274	450	.085	.10	B
June	3,380	165	977	.184	.21	B
July	304	52	142	.027	.03	B
August	191	62	109	.020	.02	B
September	289	44	81.4	.015	.02	B
October	162	29	98.4	.018	.02	B
November			63.7	.012	.01	C
December			80	.015	.02	D
The year	3,380		280	.053	.71	
1912.						
January			31	.0058	.007	D
February			37	.0070	.008	D
March			43	.0081	.009	D
April			391	.074	.08	C
May	466	186	313	.059	.07	B
June	510	104	236	.044	.05	B
July	810	87	310	.058	.07	C
August	715	152	297	.056	.06	C
September	2,120	126	636	.120	.13	B
October	1,720	395	697	.131	.15	B
November	484		362	.068	.08	C

[a] Estimated.

NOTE.—Discharge estimated from January 1 to March 23, 1911, and November 11, 1911, to April 11, from discharge measurements, gage heights, observer's reports, and climatological records.

THIEF RIVER NEAR THIEF RIVER FALLS.

Location.—At the Drybrooke ford, 6 miles north of Thief River Falls, in Sec. 3, T. 154 N., R. 43 W. The nearest tributary is the outlet of Mud Lake which enters Thief River in the northeastern part of R. 156 N., R. 42 W.

Records available.—July 1, 1909, to December 31, 1912.

Drainage area.—1,010 square miles.

Gage.—Inclined staff; datum unchanged since establishment. When this inclined staff gage was installed on August 19, 1909, its reading (6.36 feet) was made to agree with that of the temporary vertical staff gage which had been used from July 1 to August 18, 1909. On June 29, 1911, and September 18, 1912, it was found by wye levels that the gage was in error, the amounts being the same—probably the result of a mistake in graduating or setting the gage at the time of its installation. Assuming the 6.4 point to be correct, the results of the levels are as follows:

Inclined rod							
Gage readings..........	5.2	6.0	7.0	8.0	9.0	10.0	11.0
True elevations.........	5.28	6.03	6.96	7.90	8.85	9.80	10.75

Since the whole record at this station (except July 1 to August 18, 1909,) is referred to this inclined rod gage and is therefore consistent in itself, no correction has been made in published gage heights because of the above discrepancy.

Channel.—Permanent.

Discharge measurements.—Made by means of a boat and cable a short distance below the gage.

Winter flow.—From the middle of November to the first of April the river is entirely frozen over, and discharge measurements are made to determine the winter discharge.

Regulation.—The dam at Thief River Falls, at the mouth of Thief River, backs up the water in Thief River for several miles, but the station is protected by the rapids below from the influence of the dam. During 1910 and 1911 drainage work has been carried on extensively in Thief River basin and the effect will be to modify the regimen of the river. The extremely low flow of 1910 and 1911 was due partly to the holding back of the runoff by temporary dams for use of the floating dredges above the station.

Accuracy.—See under "Gage" above.

Daily discharge, in second-feet, of Thief River near Thief River Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							327	347	288	288	361	
2							249	334	288	288	361	
3							219	423	276	314	357	
4							187	392	294	320	354	
5							146	406	282	340	354	
6							122	361	282	354	354	
7							112	337	262	371	347	
8							103	569	259	381	337	
9							97	525	259	381	337	
10							97	514	259	381	337	
11							97	532	259	374	327	
12							221	525	259	357	320	
13							228	473	294	354	294	
14							209	459	327	354		
15							221	427	337	361		
16							191	385	320	361		
17							166	354	301	368		
18							150	327	288	361		
19							1,970	304	320	361		
20							1,700	282	320	368		
21							1,440	259	368	406		
22							1,010	307	361	395		
23							810	288	351	395		
24							736	441	327	395		
25							550	495	317	395		
26							488	466	307	388		
27							430	430	304	374		
28							388	388	304	361		
29							361	347	291	368		
30							347	288	288	368		
31							361	282		361		
1910.												
1				1,330	814	228	82	109	20	0	0	0
2				1,380	784	219	77	104	18	0	0	0
3				1,440	717	221	72	84	21	0	0	0
4				1,440	687	228	72	84	22	0	0	0
5				1,440	665	228	112	70	27	0	0	0
6				1,440	636	223	112	54	27	0	0	0
7		62		1,410	610	219	77	52	27	0	0	0
8				1,350	573	214	72	50	24	0	0	0
9				1,280	539	200	67	43	22	0	0	0
10				1,240	502	191	50	36	16	0	0	0
11				1,160	466	189	59	36	7.5	0	0	0
12				1,110	445	179	59	36	3.0	0	0	0
13				1,170	427	174	64	36	1.2	0	0	0
14				1,030	420	166	64	36	.9	0	0	0
15				1,030	409	158	63	36	.8	0	0	0
16				1,060	409	148	62	40	.5	0	0	0
17				1,030	361	146	62	40	.8	0	0	0
18				1,040	354	139	61	40	.6	0	0	0
19				1,100	374	132	56	37	.5	0	0	0
20				1,240	361	126	162	31	.4	0	0	0
21			973	1,210	327	122	196	27	.4	0	0	0
22			437	1,150	317	118	191	27	.4	0	0	0
23			569	1,000	301	135	191	25	.4	0	0	0
24			605	1,030	291	132	183	29	.3	0	0	0
25			643	1,000	288	112	176	40	.3	0	0	0
26			658	973	285	100	170	42	.3	0	0	0
27			713	935	262	104	166	36	.3	0	0	0
28			810	875	259	98	158	23	.3	0	0	0
29			1,000	848	243	77	148	22	.3	0	0	0
30			1,210	837	233	82	142	22	.3	0	0	0
31			1,270		233		137	22		0		
1911.												
1				12	82	2.1	1.8	0.2	0.0	0.9	0.9	
2				12	21	2.4	1.8	0	.0	.9	.8	
3				18	8.0	3.1	1.3	0	.0	1.0	.7	
4				19	6.5	4.8	4.0	0	.2	1.2	.6	
5				17	5.5	6.3	7.5	0	.0	1.3	.6	

Daily discharge, in second-feet, of Thief River near Thief River Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6	......	......	......	11	4.4	3.8	4.0	.0	.0	1.7	.6	......
7	......	......	......	12	4.3	2.9	3.8	.0	.0	1.7	.5	......
8	......	......	......	14	8.0	20	2.9	.0	.0	1.7	.4	......
9	......	......	......	13	4.1	12	2.4	.0	.0	1.3	.3	......
10	......	......	......	21	4.1	23	1.8	.0	.0	1.2	......	......
11	......	......	......	30	6.3	14	1.3	.0	.0	1.2	......	......
12	......	......	......	30	6.5	6.5	1.0	.0	.0	1.2	......	......
13	......	......	......	82	5.7	4.1	.9	.0	.2	1.2	......	......
14	......	......	......	33	4.5	3.4	.8	1.0	.0	1.2	......	......
15	......	......	......	57	4.0	3.1	.8	.9	.0	1.2	......	......
16	......	......	......	61	3.6	3.1	.8	.8	.0	1.2	......	......
17	......	......	......	47	3.2	12	.6	.6	.0	1.2	......	......
18	......	......	5.5	38	3.0	32	.5	.6	.0	1.2	......	......
19	......	......	4.0	32	2.9	35	.4	.5	2.0	1.0	......	......
20	......	......	5.5	28	2.6	23	.2	.4	1.8	1.0	......	......
21	......	......	14	23	2.1	18	.2	.4	1.3	1.0	......	......
22	......	......	32	35	1.9	13	.2	.0	1.2	1.0	......	......
23	......	......	32	48	1.8	12	.6	.0	1.0	1.0	......	......
24	......	......	28	77	2.4	9.8	.4	.0	1.0	1.0	......	......
25	......	......	58	105	1.7	9.8	.2	.0	1.0	.9	......	......
26	......	......	78	114	2.2	8.4	.2	.0	1.0	.9	......	......
27	......	......	28	114	1.8	5.9	.2	.6	.9	.9	......	......
28	......	......	35	97	1.8	4.1	.2	.5	.9	.9	......	......
29	......	......	17	89	1.0	2.6	.2	.4	1.0	.9	......	......
30	......	......	13	97	1.3	2.4	.2	.4	1.0	.9	......	......
31	......	......	9.3	......	2.0	......	.2	.2	......	1.0	......	......
1912.												
1	......	......	......	......	4.0	3.1	1.2	1.7	1.4	55	84	......
2	......	......	......	......	4.0	3.5	2.2	1.4	1.3	45	51	......
3	......	......	......	......	3.6	3.5	2.1	1.3	1.2	48	49	......
4	......	......	......	......	3.3	3.1	1.8	1.2	1.2	46	43	......
5	......	......	......	......	4.1	3.4	1.3	1.3	1.2	39	39	......
6	......	......	......	......	4.8	9.8	1.2	1.7	1.2	43	35	......
7	......	......	......	......	4.4	3.8	1.2	1.7	1.0	49	6.9	......
8	......	......	......	23	4.7	3.2	1.2	1.7	1.0	48	47	......
9	......	......	......	21	4.0	2.5	2.9	1.3	1.2	43	41	......
10	......	......	......	22	3.6	2.1	3.0	1.2	1.2	51	43	......
11	......	......	......	17	3.1	2.5	2.8	1.2	2.0	47	43	......
12	......	......	......	18	2.4	2.5	2.4	1.2	2.4	43	41	......
13	......	......	......	13	1.9	2.4	2.7	1.1	4.0	43	39	......
14	......	......	......	13	1.7	2.4	3.2	1.0	4.3	39	39	......
15	......	......	......	8.4	1.8	2.7	3.3	.9	4.4	37	49	......
16	......	......	......	6.3	2.0	3.1	2.9	.9	4.0	35	......	......
17	......	......	......	5.5	1.7	2.7	2.5	1.2	3.4	34	......	......
18	......	......	......	4.3	1.4	2.6	2.2	1.4	3.3	18	......	......
19	......	......	......	4.0	3.3	2.3	1.9	1.7	3.1	39	......	......
20	......	......	......	3.2	9.8	2.2	1.8	1.8	4.7	39	......	......
21	......	......	......	3.0	7.1	2.2	2.0	1.8	5.7	45	......	......
22	......	......	......	2.9	8.4	2.1	2.9	1.4	5.9	33	......	......
23	......	......	......	2.6	13	1.8	2.7	1.4	5.9	8.8	......	......
24	......	......	......	2.5	16	1.3	2.4	1.8	56	21	......	......
25	......	......	......	2.6	13	1.0	2.2	1.7	84	90	......	......
26	......	......	......	3.6	6.5	.9	1.9	1.3	84	51	......	......
27	......	......	......	4.0	3.3	.9	2.5	1.2	119	32	......	......
28	......	......	......	4.1	3.3	.9	2.8	1.3	111	42	......	......
29	......	......	......	3.4	3.4	.8	2.2	1.7	90	45	......	......
30	......	......	......	3.5	3.5	.6	1.9	1.7	119	33	......	......
31	......	......	......	......	3.3	......	1.8	1.7	......	43	......	......

NOTE.—Discharge based on a well-defined rating curve.

Monthly discharge of Thief River near Thief River Falls.

[Drainage area, 1,010 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
July	1,970	97	444	0.440	0.51	A
August	569	282	396	.392	.45	A
September	368	259	300	.297	.33	A
October	406	288	363	.359	.41	A
November	361	....	[a]290	.287	.32	C
December	....	....	[a]200	.198	.23	D
1910.						
January	....	....	[a]100	.099	.11	C
February	....	....	[a] 45	.045	.05	C
March	1,270	....	[a]330	.327	.38	B
April	1,440	837	1,150	1.14	1.27	A
May	814	233	438	.434	.50	A
June	228	77	160	.158	.18	A
July	196	50	108	.107	.12	A
August	109	22	44.2	.044	.05	A
September	27	.3	8.12	.0080	.009	B
October	0	.0	0.00	.000	.00	
November	0	.0	0.00	.000	.00	
December	0	.0	.00	.000	.00	
The year	1,440	.0	199	.197	2.67	
1911.						
January	....	....	0	0.000	0.00	....
February	....	....	0	.000	.00	....
March	78	....	12.2	.012	.01	C
April	114	11	46.2	.046	.05	B
May	82	1.0	6.88	.0068	.008	C
June	35	2.1	10.1	.010	.01	B
July	7.5	.2	1.34	.0013	.001	C
August	1.0	.0	.24	.00024	.0003	D
September	2.0	.0	.48	.00048	.0005	D
October	1.7	.9	1.13	.0011	.001	C
November	.9	....	.18	.00018	.0002	D
December	....	....	0	.000	.00	....
The year	114	0	6.53	.0065	.08	
1912.						
January	....	....	0.00	0.00000	0.0000	....
February	....	....	.00	.00000	.0000	....
March	....	....	.5	.00050	.0006	....
April	23	....	8.70	.0086	.01	C
May	16	1.4	4.85	.0048	.006	B
June	9.8	.6	2.53	.0025	.003	C
July	3.3	1.2	2.23	.0022	.003	C
August	1.8	.9	1.42	.0014	.002	C
September	119	1.0	24.3	.024	.03	B
October	90	8.8	41.4	.041	.05	B
November	84	....	32.7	.032	.04	C

[a] Estimated.

NOTE.—No flow from January 1 to March 12, 1911. Discharge estimated from March 13 to March 17. No flow from Nov. 10, 1911, to March 26, 1912. Discharge estimated from March 27 to April 7, and Nov. 16 to 30, 1912.

CLEARWATER RIVER AT RED LAKE FALLS.

Location.—At Great Northern Railway bridge at Red Lake Falls, about 1½ miles above the mouth of the river and 2 miles below the nearest tributary.

Records available.—June 18, 1909, to December 31, 1911, as the new gage has not yet been rated the 1912 estimates are not available.

Drainage area.—1,310 square miles.

Gage.—Vertical staff, about one-half mile farther downstream than the original gage. It was placed September 12, 1911, on account of the building of a dam which will cause several feet of backwater at the original section. The new gage was set to read 2.23 feet when the original gage read 5.83 feet. All readings prior to September 12, 1911, have been taken from the original gage. Readings after September 12 refer to the new gage.

Channel.—Permanent.

Discharge measurements.—Made from the railroad bridge or highway bridge 60 rods below, by wading at low stages.

Winter flow.—The river is frozen over from the middle of November to the first of April. Measurements are made through the ice to determine the winter discharge.

Regulation.—The operation of the power plant 40 rods above the present location causes fluctuations during the day, but the observations taken twice a day seem to eliminate this from the mean. The Healy Dam on the Red Lake River below the mouth of the Clearwater River can possibly back water at the gage, but only when extra flashboards have been used.

Accuracy.—As conditions at this station are good, the records should be reliable, unless sometimes affected by the dam below.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							268	1,210	832	286	420	
2							178	1,110	826	302	431	
3							140	1,050	703	286	400	
4							144	1,000	607	218	370	
5							135	936	493	218	318	
6							131	878	385	218	286	
7							120	897	385	218	286	
8							107	1,030	339	218	286	
9							103	936	310	218	250	
10							93	975	279	218	250	
11							74	1,280	279	224	250	
12							103	1,170	261	286	250	
13							103	1,620	250	448	250	
14							126	1,720	244	529	250	
15							155	1,580	244	505	250	
16							180	1,480	247	499	250	
17							166	1,450	250	529	250	
18						162	155	1,370	157	475	250	
19						157	155	1,260	234	448	250	
20						142	144	1,190	279	475	250	
21						112	166	1,120	326	395	250	
22						107	268	1,030	395	395	250	
23						103	1,040	1,040	470	464	250	
24						101	1,790	1,300	505	448	250	305
25						103	1,720	1,450	535	547	260	

Daily discharge, in second-feet, of Clearwater River at Red Lake Falls—Contd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
26						101	1,600	1,440	499	535	260	
27						97	1,410	1,250	395	499	270	
28						107	1,310	1,140	326	464	270	
29						565	1,240	1,060	286	475	274	
30						395	1,240	975	262	431	274	
31							1,240	910		370		
1910.												
1			100	1,790	949	166	32	40	37	37		
2			100	1,750	910	224	34	36	37	37		
3			100	1,680	858	247	33	37	37	37		
4		117	100	1,630	793	257	34	36	40	37		
5			100	1,570	715	272	34	36	43	37		
6			100	1,480	607	272	36	36	53	37		
7			100	1,420	470	272	36	37	48	46		
8			100	1,300	415	218	34	37	46	43		
9			100	1,190	366	146	33	36	48	43		
10			125	1,190	310	153	34	34	43	43		
11			125	1,140	282	157	32	36	38	43		
12			125	1,070	244	142	30	36	40	43		
13			150	1,030	212	144	32	32	38	44		
14			150	923	183	112	32	32	38	48		
15			200	910	178	89	36	34	41	51		
16			200	904	185	79	32	36	48	51		
17			200	884	171	54	32	36	48	49		
18			200	962	178	63	33	32	46	48		
19			250	1,240	171	63	34	32	45	54		51
20			300	1,710	168	63	34	34	46	52		
21			400	1,710	164	48	37	36	43	53		
22			1,960	1,620	157	34	36	37	40	54		
23			1,880	1,480	157	31	34	37	40	49		
24			1,720	1,410	148	27	36	40	38	53		
25			1,680	1,380	148	36	40	40	37	53		
26			1,640	1,320	155	38	43	43	33	43		
27			1,570	1,220	153	36	45	43	33	44		
28			1,550	1,150	148	34	44	43	34	48		
29			1,520	1,100	153	34	45	38	36	44		
30			1,540	968	142	33	40	38	36	44		
31			1,660		144		40	38		44		
1911.												
1				60	68	63	30	53	51	48		
2				70	63	65	30	65	46	44		
3				80	68	74	27	58	44	48		
4				100	55	144	20	53	44	49		
5				125	51	148	26	53	44	44		
6				175	44	118	27	58	43	44		
7				250	45	107	27	80	40	48		
8				400	46	234	29	77	37	52		
9				767	40	715	31	63	37	48		
10				722	32	685	33	46	40	44		
11				703	257	565	32	40	40	54		
12				571	244	448	28	44	51	45		
13				505	185	352	28	43	61	44		
14				390	155	268	29	43	57	45		
15				247	122	221	29	44	46	46		
16				234	95	178	30	46	44	52		
17				257	101	146	30	48	44	57		
18				207	103	126	32	53	48	53		
19				155	97	103	32	58	46	54		
20				126	87	90	30	63	43	54		
21				118	100	74	32	74	38	52		
22				105	101	68	32	87	37	44		
23				103	87	59	34	87	37	34		
24				105	90	60	37	87	40	33		
25				107	80	51	34	103	44	34		
26				101	77	55	29	112	48	35		
27				87	72	61	32	103	55	37		
28				77	63	63	38	122	63	40		
29				74	64	43	44	95	58	43		
30				77	77	30	48	80	48	51		
31					72		53	68		46		

Discharge computed from a well-defined rating curve, except March 1 to 21, 1910, when discharge is estimated.

Monthly discharge of Clearwater River at Red Lake Falls.

[Drainage area, 1,310 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (18-30)	565	97	173	0.132	0.06	A
July	1,790	74	510	.389	.45	A
August	1,720	878	1,190	.908	1.05	A
September	832	157	387	.295	.33	A
October	547	218	382	.292	.34	A
November	431	250	280	.214	.24	C
December			[a]260	.199	.23	D
1910.						
January			[a]220	.168	.19	C
February			[a]115	.088	.09	C
March	1,960	100	666	.508	.59	C
April	1,790	884	1,300	.992	1.11	A
May	949	142	324	.247	.28	A
June	272	27	118	.091	.10	B
July	45	30	35.7	.027	.03	C
August	43	32	36.7	.028	.03	C
September	53	33	41.0	.031	.03	C
October	54	37	45.5	.035	.04	C
November			[a]48.0	.037	.04	D
December			[a]50.0	.038	.04	D
The year			250	.191	2.57	
1911.						
January			[a]45.0	.034	.04	C
February			[a]45.0	.034	.04	D
March			[a]55.0	.042	.05	D
April	767	60	237.	.181	.20	B
May	257	32	91.6	.070	.08	A
June	715	30	180.	.137	.15	A
July	53	[b]20	32.0	.024	.03	A
August	122	40	67.9	.052	.06	A
September	63	37	45.8	.035	.04	A
October	57	33	45.9	.035	.04	A

[a] Estimated from a few discharge measurements, semi-weekly gage heights to the water surface, and climatological records.
[b] Estimated.

DEVELOPED WATER POWER.

The uniform flow of Red Lake River and the heavy fall between Thief River Falls and Crookston makes the river especially fitted for power development. There are four developed sites as follows:

RED LAKE RIVER.

Thief River Falls.—A timber crib dam of the A type, 10 feet high using 24 inch flashboards during the low water season creates a head varying from 10 to 12 feet. The dam is provided with a log way and sluice gates. At the right end of the dam are two plants which lease water from the owner of the dam. The Hansen and Barzen Milling Co. has a 45-inch Leffel Samson wheel of 129 horsepower capacity which is operated by a Woodward automatic governor. The water is conducted to the wheel by means of a wooden flume. This company has the first right to sufficient water to generate 100 horsepower, the average requirement. During the fall of the year this plant frequently operates 24 hours per day, but the average for the entire year will not be more than 12 hours. The Water and Light Department of Thief River Falls leases water from the owner of the dam, for use in supplying light and power to the city. The power plant is located near the Hansen and Barzen mill and consists of two 50-inch Samson Leffel wheels 200 horsepower capacity each. These wheels are set on two vertical shafts which are bevel geared to the same horizontal shaft, to which a 100 KW Triumph generator of 220 volts is belt connected. The main transmission line is 1600 feet long and consists of 4 pairs of 0000 wires, 1 pair of 00 wires and 1 pair of 0 wires. About 125 horsepower is the average developed. The plant operates continuously though with varying load. There is no auxiliary steam plant.

One mile above Red Lake Falls and 2 miles above Clearwater River.—At this point the Red River Power Co. has a 10-foot dam by which (with the aid of flashboards) a head of 12 feet is created. In the power house are two 66-inch American wheels of 295 horsepower capacity each, controlled by Lombard automatic governors. One wheel is connected to a 52 KW General Electric 2-phase alternating current generator of 52 volts, and the other is connected to a 104 KW General Electric 2-phase, alternating current generator of 1150 volts. The average power developed is 125 horsepower which is used in furnishing the city with light. The plant is operated about 12 hours per day. There is an auxiliary steam plant of 200 horsepower for emergency use.

One-half mile below Red Lake Falls and Clearwater River.—The Red River Power Co. has a 10-foot dam at this point on which 24 inch flashboards are used. At the south end of the dam is located a 54-inch New American wheel of 136 horsepower capacity to which the water is brought in a short flume. This wheel which is controlled by a hand wheel, is geared to a wheel of large diameter which transmits the power to the flour mill, 200 feet distant, by means of a wire cable. The plant operates 24 hours per day for eight months in the year. There is no auxiliary steam plant. The average power developed is 125 horsepower.

Crookston.—The Crookston Waterworks, Power and Light Co. has a 10-foot dam which has a cutoff wall of 6 by 12 inch tongue and grooved sheet piling with rock filled in on each side. The length of the dam is 152 feet. At the right end of the dam is located the power house. The turbines are set in open forebay and consist of three 61-inch Trump wheels of 228 horsepower capacity each, and one 72-inch Success turbine of 300 horsepower capacity. The Trump turbines are on vertical shafts bevel geared to one horizontal shaft and are operated by a Woodward automatic governor. The Success turbine has a hand wheel. Direct connected to the horizontal shaft to which the Trump wheels are geared are two 200 KW General Electric direct current generators of 125 volts each and one 240 KW General Electric, 3-phase, 60 cycle, alternating current generator of 230 volts. The generators and turbine gearing alternate on the shaft. An average of 800 horsepower are generated for use in furnishing Crookston with light and power. The plant operates continuously. There is an auxiliary steam plant of 100 horsepower capacity.

CLEARWATER RIVER.

Terrebonne.—At this point a head of 10 feet is utilized by a power plant consisting of a 48-inch American Victor turbine, and a 25-inch Flenniken turbine. The average power developed is 80 horsepower.

AVAILABLE HORSEPOWER.

From the records of flow of Red Lake River the following table has been compiled to show the available continuous horsepower at the developed sites:

Available horsepower at developed power sites.

Developed site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Thief River Falls	11	4	300	755	4	300	755
1 mile above Red Lake Falls	12	4	305	775	4	333	845
½ mile below Red Lake Falls	12	45	375	1,050	49	409	1,140
Crookston	10	50	435	1,270	45	395	1,150

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of Red Lake River from the outlet of Red Lake to Crookston was made in 1909-1910 to determine chiefly the availability for power development. The results of this survey are given on plates 57 to 62 inclusive of the atlas, and from these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Red Lake River from Crookston to Red Lake.

Stations.	Distance.		Elevation above sea level.	Ascent between Points.	
	From Crookston.	Point to Point.		Total	Per mile.
Crookston dam, foot	0.2		841.5		
Crookston dam, crest	0.2	0.0	851.5	10.0	
Upper end pond Crookston dam	5.0	4.8	852	0.5	0.1
Section line 27-34	9.0	4.0	856.5	4.5	1.1
Range line 45-46	14.6	5.6	866	9.5	1.7
Section line 7-8	18.7	4.1	874	8.0	2.0
Polk-Red Lake County line	23.3	4.6	883	9.0	2.0
Black River	25.8	2.5	887.5	4.5	1.8
	29.0	3.2	898.5	11.0	3.4
	32.0	3.0	920	21.5	7.2
Section line 17-18	35.2	3.2	927	7.0	2.2
Healy dam, foot	37.9	2.7	943	16.0	5.9
Healy dam, crest	37.9	0.0	955	12.0	
Upper end pond Healy dam	39.0	1.1	955	0.0	0.0
Marcus Johnson dam, foot	41.8	2.8	963	8.0	2.9
Marcus Johnson dam, crest	41.8	0.0	973	10.0	
Upper end pond Marcus Johnson dam.	43.5	1.7	973	0.0	0.0
Foot of rapids	44.6	1.1	977	4.0	3.6
Crest of rapids	46.3	1.7	1,002	25.0	14.7
Foot of rapids	46.7	0.4	1,003	1.0	0.2
Crest of rapids	47.4	0.7	1,015	12.0	17.1
	50.0	2.6	1,036	21.0	8.1
	53.0	3.0	1,049	13.0	4.3
Section line 17-20	56.2	3.2	1,061.5	12.5	3.9
St. Hilaire dam, foot	61.0	4.8	1,075	13.5	2.8
St. Hilaire dam, crest	61.0	0.0	1,080	5.0	
Upper end pond St. Hilaire dam	63.6	2.6	1,080	0.0	0.0
	68.0	4.4	1,090	10.0	2.3
	70.8	2.8	1,099	9.0	3.2
Thief River Falls dam, foot	72.3	1.5	1,102.5	3.5	2.3
Thief River Falls dam, crest	72.3	0.0	1,116	13.5	
Upper end pond Thief River Falls dam	75.0	2.7	1,116	0.0	0.0
Range line 42-43	77.3	2.3	1,119	3.0	1.3
Section line 8-9	81.7	4.4	1,126	7.0	1.6
Section line 23-24	87.8	6.1	1,134	8.0	1.3
Section line 17-18	92.2	4.4	1,138.5	4.5	1.0
	98.0	5.8	1,144	5.5	0.9
Range line 40-41	102.6	4.6	1,148.5	4.5	1.0
Township line 152-153	109.8	7.2	1,154	5.5	0.8
Section line 9-10	119.2	9.4	1,162.5	8.5	0.9
West boundary Red Lake Indian Reservation	123.9	4.7	1,165	2.5	0.5
	132.0	8.1	1,168.5	3.5	0.4
Outlet Red Lake	143.2	11.2	1,175	6.5	0.6

The section of river best suited for power development is that between Thief River Falls and Crookston. From Thief River Falls to Red Lake the slope of the river is very flat and the banks are low. From Crookston to Grand Forks there is a total fall of 58 feet or an average of about 1 foot per mile. As the banks are not high, this portion of the river is unsuited for development.

The survey of the river shows the following possible developments:

In sec. 20, T. 153 N., R. 43 W.—At mile 66.9 which is 5.5 miles below Thief River Falls, a 15-foot dam would back the water upstream nearly to the dam at the latter point, which is the controlling feature. The crest length of the dam would be **400 feet**, and as the banks are high, there would be little or no **overflow**.

In sec. 17, T. 152 N., R. 43 W.—A 17-foot dam at mile 56.8 which is 4 miles below St. Hilaire would back the water upstream to the top of the St. Hilaire dam, utilizing the head of this abandoned dam. The crest length of the dam would be 500 feet, and the overflowed area 200 acres.

In sec. 5, T. 151 N., R. 43 W.—At mile 50.9 the bluff lines approach sufficiently near to offer a site for a 20-foot dam, which would have a crest length of 700 feet. This dam would back the water 4.5 miles upstream, and would overflow 50 acres of land covered with brush.

In sec. 18, T. 151 N., R. 43 W.—A 30-foot dam at mile 45.6 which is 4 miles above the upper dam at Red Lake Falls would back the water 3 miles upstream. The crest length of the dam would be 800 feet and the area overflowed would be 75 acres of brush covered land. A pipe line 700 feet long across a bend of the river at the dam site, would give an additional head of 9 feet, making the total head 39 feet.

In sec. 28, T. 151 N., R. 45 W.—Between Red Lake Falls and Huot the most feasible power site is just above Huot and below the mouth of Black River at mile 25.7. Here a 42-foot dam could be built that would vary in length from 300 feet at the water surface to 1000 feet at the crest. In addition, a 10-foot dike 800 feet long would be required at the right end of the dam.

In sec. 25, T. 150 N., R. 46 W.—Below Huot the valley widens out to such an extent that dam sites for developments of greater height than that afforded by the river banks themselves, are practically missing, with the exception of a site at mile 12.0. Here an 18-foot dam would back the water 10.5 miles upstream, overflowing very little land.

AVAILABLE HORSEPOWER.

Records of flow of Red Lake River are available at different points from 1899 to 1912. From these it is seen that the low flow during the latter part of 1911 and the first of 1912 was an extreme flow very much less than that for an ordinary low year. It is fortunate that the long time records on this river are available, as records for 1911 and 1912 alone, would give a wholly erroneous impression of the value of Red Lake River for power development.

The following estimates of available power at the various sites has been based on the existing records of flow:

Undeveloped horsepower on Red Lake River.

Site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Sec. 20, T. 153 N., R. 43 W.	15	4	300	755	5	410	1,029
Sec. 17, T. 152 N., R. 43 W.	17	4	300	760	6	464	1,175
Sec. 5, T. 151 N., R. 43 W.	20	4	305	765	7	555	1,391
Sec. 18, T. 151 N., R. 43 W.	39	4	305	770	14	1,081	2,730
Sec. 28, T. 151 N., R. 45 W.	42	49	410	1,115	187	1,565	4,257
Sec. 25, T. 150 N., R. 46 W.	18	50	435	1,270	82	712	2,078

STORAGE STUDY OF RED LAKE.

The largest site in Red Lake River basin is Red Lake, the source of the river and by far the most important storage site.

Topography.—Red Lake is divided into the upper and lower lakes by narrow strips of land that extend from the eastern and western shores to within 1.5 miles of each other. The total area of both lakes is 441 square miles. The upper lake is bordered by a tamarack swamp which extends from Manomin Creek nearly around to the east side. The general elevation of the swamp is about 5 feet above the low water of 1911 which was taken as the datum for the survey. On the east side of the upper lake the land is somewhat higher and the swamp area becomes less. On the south shore the land gradually rises in elevation until at a point near the narrows, the bluffs attain a height of 35 feet.

In general the banks of the lower lake are higher than those of the upper. The high bluffs found near the narrows on the upper lake, extend along the north shore of the lower lake, gradually becoming lower until at the northeast corner of the lake the banks are only 10 feet high. At the east end of the lake there is a series of barrier beaches from 5 to 10 feet high which extend around the southern shore nearly to Redby. Behind these beaches, there are considerable areas of tamarack swamp having an elevation of less than 5 feet above the lake level. At a point 2 miles east of Redby the banks become high, and maintain an elevation of 25 feet or more to a point 5 miles west of the Indian Agency. Beyond that point, the banks become low again. From Sandy River to Mosquito Creek low barrier beaches are found, and behind these the tamarack swamp has an elevation ranging from 3 to 5 feet. From Mosquito Creek to the western end of the narrows the banks have an elevation of 5 feet or more.

Capacity of the reservoir.—A survey of the lake to determine its storage capacity was made in 1911. The results of this survey are given on plates 55 and 56 of the atlas, and from these the following table of capacities has been computed:

Capacity of Red Lake reservoir.

Contour.	Area square miles.	Capacity of Section, acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
−5[a]	413.84			
Shore line	441.09	1,367,900	1,367,900	40,216,000,000
+3	447.11	852,700	2,220,600	96,729,000,000

[a] As determined by the low water of 1911.

Runoff from Red Lake.—There are available at different points on Red Lake River records of runoff extending from 1899 to date. As the longest records are those at Crookston, they have been used as the basis of estimate. Comparison of the runoff above Thief River with that at Crookston shows that the average runoff per square mile is 5 per cent greater above Thief River and therefore the runoff per square mile of the Crookston records has been increased by that amount. This factor has been applied to the drainage area at the outlet of Red Lake, which is 1950 square miles.

A mass curve showing the total runoff since May, 1899, is given on plate XIII. The runoff is regulated naturally to such an extent that it would not be feasible, in general, to store water for a longer period than a year. The lines of uniform draft on the mass curve show that the greatest storage capacity needed to regulate entirely the flow for any one year would be 9 billion cubic feet in 1904, and 8.8 billion cubic feet in 1910. As the capacities of Red Lake are far in excess of these quantities it is evident that a draft of 1 foot or less would be ample to supply the needed storage.

To improve navigation on Red Lake by increasing the depth near shore and through the narrows, it is probable that a dam would be built to raise the water level three feet. The shore elevations are such that very little land would be overflowed, and the extra 2 feet depth beyond the requirements for storage would aid navigation greatly. A dam at the outlet of Red Lake into Red Lake River would have a length of 400 feet at the water surface, 950 feet at 2 feet elevation, and 1050 feet at 4 feet.

Benefits of reservoir regulation.—The benefits of the regulation of Red Lake River would be to water power development, navigation, and flood control and prevention.

There are four developed and six undeveloped water powers on Red Lake River having a total head of 197 feet. The following table shows the resulting increase flow during the low water months, had the reservoir been in operation during the period from 1899 to 1911, and the resulting increased horsepower. From 1902 to 1904 the natural flow during the winter months has been assumed and may be somewhat in error.

Increased horsepower due to operation of Red Lake as a reservoir.

Month.	Natural Flow.	Regulated Flow.	Increased Flow.	Increased Horsepower 197 feet head.
1899.				
November	433	560	127	2,280
December	387	560	173	3,100
1900.				
January	359	560	201	3,600
February	365	560	195	3,490
March	355	560	205	3,670
April	488	560	72	1,290
May	330	560	230	4,120
June	369	560	191	3,420
July	343	790	447	8,000
1901.				
January	632	790	158	2,830
February	628	790	162	2,900
March	652	790	138	2,470
September	521	790	269	4,810
October	597	790	193	3,460
November	470	790	320	5,730
December	400	790	390	6,990
1902.				
January	350	790	440	7,870
February	350	595	245	4,390
August	447	595	148	2,650
September	398	595	197	3,530
October	455	595	140	2,500
November	521	595	74	1,320
December	400	595	195	3,490
1903.				
January	350	595	245	4,390
February	350	595	245	4,390
March	350	595	245	4,390
April	500	595	95	1,700
July	382	595	213	3,820
August	258	595	337	6,140
September	535	595	60	1,070
November	490	595	105	1,880
December	574	595	21	376
1904.				
January	400	595	195	3,490
February	350	595	245	4,380
March	350	790	440	7,880
July	701	790	89	1,590
August	361	790	429	7,690
September	394	790	396	7,090
October	394	790	396	7,090
November	344	790	446	7,990
December	408	790	382	6,840
1905.				
January	350	790	440	7,880
February	350	790	440	7,880
March	375	750	375	6,720
November	648	750	102	1,830
December	617	750	133	2,380
1906.				
January	577	750	173	3,100
February	396	750	354	6,340
March	578	750	172	3,080
July	693	750	57	1,020
August	587	750	163	2,920
September	486	750	264	4,720
October	378	750	372	6,660
November	322	750	428	7,810
December	271	750	479	8,590
1907.				
January	250	750	500	8,950
February	175	750	575	10,300
July	470	500	30	540
August	329	500	171	3,060
September	382	500	118	2,110
October	400	500	100	1,790
November	258	500	242	4,330
December	242	500	258	4,620

Increased horsepower due to operation of Red Lake as a reservoir—Continued.

Month.	Natural Flow.	Regulated Flow.	Increased Flow.	Increased Horsepover 197 feet head.
1908.				
January	181	500	319	5,710
February	195	500	305	5,460
March	240	560	320	5,720
July	517	560	43	770
August	459	560	101	1,810
September	454	560	106	1,900
October	332	560	228	4,080
November	310	560	250	4,480
December	168	560	392	7,010
1909.				
January	185	560	375	6,710
February	148	560	412	7,380
March	254	560	306	5,480
June	377	560	183	3,380
September	517	560	43	770
November	510	560	50	895
December	402	560	158	2,830
1910.				
January	291	560	269	4,810
August	134	200	66	1,180
September	129	200	71	1,270
October	113	200	87	1,560
November	84	200	116	2,080
December	84	200	116	2,080
1911.				
January	70	200	130	2,330
February	54	200	146	2,610
March	86	200	114	2,040
May	166	200	34	609
June	35	200	165	2,950
July	37	200	163	2,920
August	18	200	182	3,260
September	16	200	184	3,300
October	19	200	181	3,240
November	8	200	192	3,440
December	6	200	194	3,470

The benefit to navigation by the regulation of the flow of Red Lake River would be felt not only on Red Lake itself but also on Red Lake River between Thief River Falls and Red Lake, and on Red River below Grand Forks.

As no records of the stage of the river above Thief River Falls are available, the increased depth in this portion of the river during the low water navigation months cannot be accurately determined. At Grand Forks both records of stage and discharge of the river are available making it possible to determine the increased depth in Red River at Grand Forks during the months of July, August, September and October.

Increased stage of Red River at Grand Forks.

Month.	Increased flow in second-feet.	Increased stage, feet.
1902.		
August	148	0.3
September	197	.4
October	140	.3
1903.		
July	213	.4
August	337	.7
September	60	.2
1904.		
July	89	.1
August	429	.6
September	396	.7
October	396	.7
1905.		
No	increase.	
1906.		
August	163	.3
September	264	.5
October	372	.7
1907.		
August	171	.4
September	118	.2
October	100	.2
1908.		
July	43	.1
August	101	.2
September	106	.2
October	228	.5
1909.		
Practically	no increase.	
1910.		
August	66	.3
September	71	.3
October	87	.4
1911.		
July	163	.6
August	182	.9
September	184	.9
October	181	.8

The value of the Red Lake reservoir would be very much less for flood prevention than for either power or navigation. The large area of the lake controls the flow of Red Lake River to such an extent that serious floods do not occur. At Grand Forks, where the Red Lake empties into Red River, the combined flow of the two rivers represents the runoff from 25,000 square miles, of which only 1,950 is controlled by Red Lake. As this flow is naturally regulated to a great degree any further regulation would not have a marked effect at Grand Forks, especially as ice gorging in the spring is the cause of many of the floods.

SANITARY STATISTICS.

To show the sanitary quality of the water in Red Lake River and the extent to which it is used for municipal purposes, data showing the source of municipal supply, and disposal of sewage, have been compiled for all towns of 500 inhabitants or more, located on the river. These data are given in the following table, in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on Red Lake River.

Town.	Distance above mouth	Population 1910	Water Works Systems.			Sewerage Systems.		Rural Population in basin per square mile.
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
Red Lake River.								
Thief River Falls	117	3,714	well and river	no	50,000	river	no	2.7
Red Lake Falls	83	1,757	none	.....	....	none	....	....
Mouth Clearwater R.	83		....	....	....	....	....	3.1
Crookston	45	7,559	river and wells	yes	350,000	river	no	....
Grand Forks, N. Dak.	0	12,478	river	yes	750,000	Red river	no	....
East Grand Forks	0	2,533	river	yes	100,000	Red river	no	5.5
Clearwater River.								
Bagley	112	801	shallow wells	no	50,000	none	....	9.8

From the preceding table it appears that no urban sewage enters the river above Thief River Falls. The rural population of the upper basin is extremely sparse, being only 2.7 per square mile. The basin is so very level and swampy that it is probable that little or no rural sewage reaches Thief River Falls. The average slope of the river from Red Lake to Thief River is 0.8 foot per mile.

Between Thief River and the mouth of the Clearwater at Red Lake Falls, a distance of 34 miles, the river has an average slope of 4.3 feet per mile, which insures sewage bacteria from Thief River Falls reaching Red Lake Falls.

At the mouth of the Clearwater is received the drainage from 1,310 square miles, having a rural population of 9.8 per square mile. No urban sewage is carried by the Clearwater.

From the Clearwater to the mouth of the river, a distance of 83 miles, the river receives untreated sewage from Crookston, representing a population of 7,559. In this section, the river water is filtered and used for municipal purposes by Crookston, Grand Forks and East Grand Forks. The average slope of the river between Crookston and the mouth is 1.3 foot per mile, which insures the contamination of the river at the mouth from Crookston's sewage bacteria.

RAINY RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Rainy River connects Rainy Lake with Lake of the Woods, but above Rainy Lake is a succession of lakes connected by rapids, at the head of which, in T. 65 N., R. 2 W., on the international boundary, is North Lake. From North Lake a stream flows westward, passing through Gunflint, Pine, Granite, Saganaga, Otter Track, Knife, Sucker, Basswood, Crooked, Iron and Lac La Croix lakes, and Namekan River into Rainy Lake. With the exception of the Namekan River, whose course lies in Ontario, these waters form a portion of the boundary between Minnesota and Canada, but no general term other than "boundary waters" has been applied to the chain above Rainy Lake.

The principal American tributaries of the boundary waters are Cross River, which flows through Kaskadinna, Sucker and Ham lakes into Gunflint Lake; a line of drainage passing through Charley, Bashitanaqueb, Greenwood, East and West, Little Saganaga, Gabimichigama, Ogishke-Muncie, Frog Rock, West Sea Gull and Sea Gull lakes and emptying into Saganaga Lake; Kawishiwi River which rises in Syenite Lake and flows through Polly, Boulder, Alice, Wilder, Crab, Copeland, Birch, White-Iron, Garden, Fall and Newton lakes into Basswood Lake; Loon River, which enters Loon

Lake and flows through Little Vermilion and Sand Point lakes into Namekan Lake; Vermilion River, which flows through Crane and Sand Point lakes into Namekan Lake; Ash River which flows through Kabetogama Lake into Namekan Lake; Rat Root River, which flows into Rainy Lake; and Little Fork, Big Fork, Black Rapid and Winterroad, rivers, which discharge into Rainy River.

The chief Canadian tributaries are a line of drainage through Weikwabinonaw, Koss and Northern Light lakes into Saganaga Lake; Maligne River which drains a region thickly dotted with lakes (the largest being Pickerel and Sturgeon lakes) and discharges into Lac La Croix; Pipestone, Manitou, Turtle and Otukamamoan, lake outlets, which enter Rainy Lake and La Valle and Pine rivers, which enter Rainy River.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

Above Rainy Lake the drainage area is rough and hilly and thickly dotted with lakes which lie in rock-bound basins and have outlet over rocky rims that have been little eroded. The southern boundary of this part of the drainage area is a broad undulating plateau which rises 1,800 to 1,900 feet above sea level. This is the region of light glacial drift or bare rocks, the latter comprising granites, gneisses, mica-schists, gabbros and greenstones. The valleys of the Vermilion and other rivers show a thin layer of fine clay, probably deposited by a glacier-dammed lake.

West of Rainy Lake the basin is deeply covered with glacial drift, lakes are rare and the country is, for the most part, flat with a few hills rising 50 to 75 feet above the plain. During the glacial period this part of the basin was covered by a lake, now called Lake Agassiz, and in consequence the surface is very smooth. The northward slope of the area south of Rainy River is insufficient to afford good drainage and extensive tracts are swampy. In general dry land is only found along the banks of the streams which flow in very tortuous channels cut 5 to 40 feet below the general surface level. Settlers are few except along the streams, as the infrequent roads are almost impassible during the open season.

Between the southern end of Bow String Lake and Lake Winnibigoshish is a continuous river valley that during high stages affords water connection between Mississippi River and Hudson Bay. In the eastern portion of the area there is probably a connection between North Lake in the Hudson Bay drainage area and South Lake in the Lake Superior drainage area. Altitudes in the Rainy River basin range from 1,025 to 2,000 feet above sea level.

The portion of the drainage area in Minnesota and probably also that in Ontario lies within the forested region and contains very little cleared land. East of Rat Root River are tracts of dense timber interspersed with patches of thin timber. The western part of the basin is covered with dense, heavy forests, in which white and Norway pine, spruce, cedar, balsam and tamarack are the principal growths. In the extreme western end of the basin, south of Lake of the Woods, are extensive areas of muskeag which are covered with short, scrubby, fairly dense growths of black spruce.

RAINFALL.

As no rainfall records have been kept in the Rainy River area for any considerable time, except at Kenora, Ontario, the rainfall is not known accurately, but stations outside the basin indicate a probable mean annual precipitation of 30 inches or more in the extreme eastern portion with a decrease to some 23 inches at Lake of the Woods. The annual snowfall equals about 5½ inches of the precipitation. It is probable that 1910 was the driest for many years. The records at International Falls denoted a rainfall of about 18.7 inches.

FLOODS AND REGULATION OF FLOW.

The many lakes in the basin drained by Rainy River (the largest of which is Rainy Lake having an approximate area of 344 square miles) have so regulated the flow of the lower river that since 1907 when records have been available the extreme range of stage has not exceeded 12 feet. As the banks are much higher than this, there has been no overflow. From 1910 to 1912 during which period records of stage are available the range in Rainy Lake has been 8.3 feet. Since the completion of the power plant at International Falls the dam can back water on Rainy Lake to a depth of about 4 feet. Although the area covered by Rainy Lake is 344 square miles, the areas of the many islands in the lake will total about 34 square miles, leaving a net water area of 310 square miles. This gives an available storage of approximately 69,500,000,000 cubic feet.

Power regulation unlike that for logging purposes tends to equalize the flow by storing the flood waters for use during the low water period.

NAVIGATION.

Except where used by log booms, Rainy River is navigable for small steamers from International Falls to Lake of the Woods and above the dam, from International Falls to the upper end of Rainy Lake where the channel is barred by Kettle Falls, where there is a rise of about 9 feet.

There is a log sluice at the dam, but no locks for vessels. The Canadian Government has recently investigated the lower river with a view to improving navigation by building locks at the Long Sault and Manitou Rapids. Logs are driven down Vermilion River into Rainy Lake and thence either to International Falls or to Baudette and Spooner where are located large saw mills. Logs are also driven to the latter mills from points on Little Fork and Big Fork rivers.

DRAINAGE.

Although it is estimated there are about 2,000,000 acres of swamp land in the Minnesota portion of the basin, very little drainage work has been done as the country is very sparsely settled. The state has provided main outlet ditches which benefit 81,300 acres in Little Fork and Big Fork basins.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Rainy River basin.

River.	Above.	Drainage area.
Boundary Waters	Saganaga Lake	945
Do	Knife Lake	1,100
Do	Sucker Lake	1,260
Do	Basswood Lake	3,550
Do	Crooked Lake	3,790
Do	Iron Lake	3,860
Rainy	Kettle Falls	7,320 square miles
Do	International Falls	[a]14,600
Do	Lake of the Woods Inlet	[a]20,800
Cross	Mouth	61
Echo Lake outlet	Mouth	102
Ash	do	146
Rat Root	do	283
Black	West Fork	288
Do	Mouth	408
Rapid	East Fork	182
Do	Mouth	455
East Fork Rapids	do	268
Beaudette	do	95
Winter Road	do	150
Warroad	do	256

[a] Revised since 1910 report.

GAGING STATION RECORDS.

RAINY LAKE AT RANIER.

Location.—At the foot of Rainy Lake at the foot of the Ranier wharf.

Records available.—January 1, 1910, to December 31, 1912.

Gage.—Vertical staff. Prior to August 19, 1911, the gage heights were taken at the upper gage of the Minnesota & Ontario Power Co., just above the dam at International Falls, 2 miles below Ranier. This dam controls the level of Rainy Lake which has an area of approximately 344 square miles. Owing to the great number of small islands in the lake its effective capacity is somewhat uncertain, as the existing maps are too small to show this accurately. Beginning August

19, 1911, the gage heights refer to the gage established by the Canadian Department of Public Works. This gage has its datum 489.00 feet above that of the Minnesota & Ontario gage. Readings of the two gages indicate a slope of 0.50 feet between the two points. Thus to make the records at the two points comparable the readings on the Minnesota & Ontario gage have been reduced by 488.50.

The records at this station, by indicating the change of water level, show the gain or loss in storage due to the control of the flow at the International Falls dam, and when used in connection with the records of flow of the Rainy at International Falls are of value in determining the natural run-off.

Daily gage height, in feet, of Rainy Lake at Ranier.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1	7.45	6.90	5.55	4.90	6.15	6.05	4.85	4.55	3.75	2.95	1.30	0.30
2	......	6.90	5.55	4.90	6.15	5.90	4.65	4.50	3.80	......	1.20	0.20
3	7.48	6.85	5.55	5.00	6.15	6.05	4.65	4.25	3.80	2.80	1.15	0.10
4	......	6.85	5.55	5.05	6.15	6.20	4.65	4.35	3.80	2.75	1.07	......
5	7.47	6.80	5.55	5.15	6.15	6.20	4.65	4.35	3.80	2.45	0.95	0.00
6	7.47	......	5.55	5.25	6.15	6.15	4.55	4.35	3.80	2.51	......	0.30
7	7.42	6.65	5.45	5.25	6.15	5.75	4.75	4.35	3.75	2.49	0.90	+0.10
8	7.40	6.65	5.35	5.35	6.15	5.95	4.80	4.15	3.75	2.35	0.80	-0.14
9	......	6.55	5.25	5.35	6.10	5.55	4.85	4.25	3.75	2.35	0.80	-0.15
10	7.38	6.50	5.25	5.35	5.95	5.35	4.95	4.35	3.75	2.35	0.70	-0.27
11	7.37	6.45	5.00	5.45	5.85	5.35	4.85	4.35	3.75	2.35	0.66	0.00
12	7.35	6.45	5.00	5.45	5.65	5.35	4.90	4.35	3.75	2.50	0.60	0.00
13	7.35		5.00	5.45	6.30	5.30	4.85	4.35	3.65	2.35	......	+0.20
14	7.30	6.35	4.97	5.45	6.30	5.20	4.75	4.35	3.45	2.35	0.60	+0.22
15	7.25	6.30	4.93	5.55	6.30	5.25	4.75	4.35	3.35	1.85	0.50	-0.15
16	......	6.25	4.75	5.55	6.25	5.25	4.90	4.25	3.30	2.75	0.35	-0.10
17	7.28	......	4.75	5.75	6.25	5.25	4.90	4.25	3.25	2.55	0.30	-0.10
18	7.25		4.70	5.75	6.10	5.65	4.75	4.20	3.15	2.10	0.20	......
19	7.25		4.65	5.90	6.15	5.65	4.60	4.10	3.15	2.40	0.30	+0.08
20	7.24	......	4.65	6.05	6.45	5.55	4.55	4.10	3.15	2.11	......	-0.25
21	7.25	5.95	4.65	6.05	6.35	5.50	4.55	4.10	3.15	2.07	0.50	-0.25
22	7.15	5.90	4.75	5.95	6.35	5.25	4.65	4.65	3.15	2.00	0.05	-0.20
23	......	5.85	4.75	5.95	6.25	5.30	4.70	4.05	3.20	......	0.60	0.00
24	7.10	5.85	4.65	5.95	6.10	5.15	4.70	4.05	3.15	2.32	0.50	0.00
25	7.10	5.85	4.65	6.10	6.35	5.05	4.75	4.00	3.25	1.74	0.40	......
26	7.05	5.75	4.70	6.15	6.35	5.05	4.55	3.85	3.05	1.71	0.40	+0.10
27	......	......	4.70	6.25	6.10	5.05	4.75	3.90	3.05	1.61	......	-0.15
28	7.00	5.65	4.65	6.10	5.85	5.00	4.65	3.90	3.00	1.60	0.60	-0.35
29	6.95	......	4.75	6.15	5.95	5.00	4.45	3.90	3.05	1.55	0.60	-0.35
30	6.90	......	4.85	6.25	6.00	4.90	4.50	3.65	2.95	......	0.20	-0.35
31	6.90	......	4.90		6.25	......	4.50	3.75	......	1.57	......	-0.35
1911.												
1	+0.15	-0.15	-0.35	-0.90	0.55	1.35	......	4.53	4.56	4.20	3.92	3.58
2	-0.05	-0.20	-0.45	-0.68	0.55	1.43	3.75	4.58	4.55	4.20	3.82	3.56
3	-0.10	-0.20	-0.55	-0.65	0.65	......	......	4.58	4.53	4.20	3.82	3.54
4	-0.10	......	......	-0.65	0.70	1.75	3.80	4.50	4.53	4.20	3.85	3.52
5	-0.15	-0.05	-0.45	-0.67	0.70	1.50	3.75	......	4.53	4.20	3.86	3.50
6	-0.45	-0.15	-0.60	-0.65	......	1.65	3.75	4.72	4.52	4.20	3.86	3.50
7	......	-0.20	......	......	0.80	1.85	4.00	4.70	4.50	4.20	3.82	3.50
8	-0.10	-0.30	......	-0.70	0.75	1.86	......	4.68	4.48	4.20	3.83	3.50
9	-0.25	-0.25	......	-0.65	0.67	2.00	3.90	4.61	4.46	4.20	3.79	3.50
10	-0.25	-0.30	-0.75	-0.60	0.29	......	3.80	4.63	4.44	4.20	3.70	3.48
11	-0.45	......	......	-0.37	0.35	2.65	......	4.60	4.40	4.20	......	3.46
12	-0.35	-0.15	-0.75	-0.45	0.76	2.35	4.05	4.80	4.40	4.20	3.64	3.44
13	-0.40	......	......	-0.35	......	2.40	4.07	4.60	4.40	4.20	3.71	3.42
14	......	......	-0.85	......	1.23	2.50	4.10	4.65	4.38	4.20	3.76	3.40
15	-0.02	......	......	0.10	.81	2.45	......	4.65	4.35	4.18	3.80	3.38
16	-0.15	......	-0.55	-0.10	.60	2.53	4.20	4.65	4.35	4.18	3.80	3.36
17	-0.35	......	-0.65	-0.10	1.05	......	4.25	4.54	4.34	4.18	3.80	3.35
18	-0.20	......	......	0.00	.73	2.75	4.30	4.55	4.26	4.16	3.80	3.35
19	-0.05	......	-0.65	+0.05	.63	2.79	4.35	4.62	4.28	4.13	3.80	3.33
20	-0.22	......	-0.65	+0.17	......	2.84	4.35	4.60	4.29	4.08	3.76	3.31

Daily gage height, in feet, of Rainy Lake at Ranier—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
21	......	......	−0.75	+0.30	.97	2.90	4.35	4.60	4.28	4.12	3.74	3.29
22	−0.15	......	−0.85	+0.33	.80	3.00	......	4.59	4.29	4.12	3.73	3.27
23	−0.10	......	−0.65	+0.37	.72	......	4.45	4.58	4.29	4.09	3.72	3.25
24	−0.05	−0.25	−0.65	+0.40	.85	......	4.47	4.52	4.26	4.08	3.71	3.23
25	−0.10	......	−0.65	+0.55	1.00	3.24	4.28	4.52	4.25	4.03	3.70	3.22
26	−0.15	−0.25	−0.65	+0.60	1.00	3.25	4.25	4.54	4.20	4.03	3.68	3.20
27	−0.20	−0.40	−0.65	......	......	3.34	4.32	4.60	4.20	4.00	3.66	3.18
28	......	−0.35	−0.55	......	1.20	3.55	4.28	4.61	4.20	3.89	3.64	3.17
29	−0.05	......	−0.60	+0.65	1.14	3.57	......	4.60	4.21	3.92	3.62	3.16
30	−0.20	......	−0.65	......	1.20	3.60	4.43	4.61	4.20	3.92	3.60	3.15
31	−0.20	......	......	......	1.25	......	......	4.60	......	......	......	......
1912.												
1	3.12	2.36	1.74	0.91	1.41	3.91	6.45	7.38	7.34	7.28	......	......
2	3.10	2.32	1.72	.87	1.48	4.06	6.50	7.34	7.33	7.26	......	......
3	3.08	2.30	1.70	.83	1.56	4.12	6.56	7.31	7.36	7.26	......	......
4	3.06	2.28	1.68	.81	1.61	4.24	6.61	7.29	7.36	7.27	......	......
5	3.04	2.26	1.64	.80	1.71	4.34	6.66	7.30	7.38	7.27	......	......
6	3.02	2.24	1.62	.78	1.75	4.42	6.68	7.32	7.39	7.25	......	......
7	3.00	2.22	1.59	.78	1.77	4.54	6.78	7.31	7.34	7.25	......	......
8	2.98	2.20	1.56	.79	1.89	4.62	6.83	7.29	7.41	7.26	......	......
9	2.96	2.20	1.54	.75	2.01	4.71	6.86	7.28	7.32	7.27	......	......
10	2.94	2.19	1.52	.75	2.08	4.81	6.88	7.26	7.30	......	......	......
11	2.92	2.18	1.50	.75	2.16	4.92	6.91	7.24	7.29	......	......	......
12	2.90	2.18	1.48	.75	2.24	5.00	6.98	7.18	7.28	......	......	......
13	2.88	2.16	1.45	.76	2.31	5.05	7.02	7.15	7.28	......	......	......
14	2.86	2.12	1.41	.78	2.37	5.12	7.03	7.20	7.26	......	......	......
15	2.84	2.10	1.37	.78	2.46	5.21	7.02	7.20	7.27	......	......	......
16	2.81	2.08	1.33	.82	2.55	5.28	7.06	7.22	7.56	......	......	......
17	2.76	2.06	1.31	.87	2.57	5.38	7.08	7.27	7.24	......	......	......
18	2.72	2.05	1.30	.90	2.66	5.48	7.08	7.24	7.20	......	......	......
19	2.69	2.04	1.27	.91	2.80	5.58	7.09	7.23	7.21	......	......	......
20	2.64	2.03	1.23	.91	2.88	5.65	7.16	7.22	7.17	......	......	......
21	2.63	2.02	1.20	.93	2.96	5.72	7.19	7.19	7.17	......	......	......
22	2.62	2.00	1.18	.95	3.02	5.78	7.23	7.20	7.09	......	......	......
23	2.60	1.98	1.16	.97	3.10	5.83	7.28	7.22	7.11	......	......	......
24	2.56	1.96	1.14	.99	3.21	5.90	7.28	7.27	......	......	......	......
25	2.54	1.91	1.11	1.03	3.26	6.00	7.28	7.27	......	......	......	......
26	2.50	1.86	1.07	1.10	3.42	6.06	7.29	7.27	7.24	......	......	......
27	2.48	1.81	1.03	1.20	3.55	6.14	7.29	7.26	7.26	......	......	......
28	2.45	1.78	1.00	1.22	3.66	6.19	7.40	7.30	7.26	......	......	......
29	2.42	1.76	0.98	1.29	3.71	6.27	7.39	7.31	7.27	......	......	......
30	2.40	......	0.96	1.35	3.76	6.42	7.38	7.33	7.27	......	......	......
31	2.38	......	0.93	......	3.81	......	7.38	7.33	......	......	......	......

NOTE.—1912 gage heights as published above refer to the same datum, the readings September 21 to October 9 having been corrected by (—.23) 0.23 foot in accordance with the fact that the original elevation of the datum of the gage was 489.00 feet and the gage observer's notes, which are as follows:

Sept. 21: "Elevation changed to 488.77 feet."
Oct. 10: "No readings—gage out of commission."

RAINY RIVER AT INTERNATIONAL FALLS.

Location.—At the steamboat dock one-half mile below the dam at International Falls.

Records available.—March 1, 1907, to December 31, 1912.

Drainage area.—14,600[a] square miles.

[a] Revised since previous report.

Gage.—Vertical staff. Prior to April 20, 1911, the gage heights were furnished through the courtesy of the Minnesota and Ontario Power Co. They were referred to a gage located just below the dam, first on the American side, but later on the Canadian. On the above date a gage was installed by the United States Geological Survey at the American Steamboat Dock below the falls. The zero of the latter gage is 460.99 feet above that of the power company gage when the slope of the river between the two points is considered.

Channel.—Permanent, except during extreme high water in Little Fork and Big Fork which causes temporary backwater.

Discharge measurements.—Discharge measurements for the purpose of rating the section have been made by the Geological Survey since 1909, by means of a boat and cable at a section several hundred yards below the station, where an island divides the river into two channels. Additional measurements referred to the same gage have been made by Canadian Government engineers and furnished through their courtesy.

Winter flow.—Although the dam prevents ice forming at the power company gage, which is used during the winter months, ice forms on the rapids several miles below, causing serious backwater at the gage. Since 1909 and 1910 the monthly estimates during the frozen period have been based indirectly on records of flow through the turbines as kept by the power company, and upon a few discharge measurements. Previous to 1910 the winter estimates can only be considered approximate.

Regulation.—The low-water flow at the station is controlled by the operation of the power plants at the dam, as shown by the drop in gage heights on Sundays during portions of 1910 and 1911. The flow during the summer and fall months of 1911 does not represent the natural run-off from the drainage basin, as during that period the water level above the dam rose 5 feet. As the dam backs up the water in Rainy Lake, this rise represents a large increase in storage.

Accuracy.—Although the channel is permanent, the conditions for measuring the flow are not of the best, and therefore the results of the measurements are somewhat erratic. However, it is believed that estimates based on them will be within 5 to 10 per cent of the true value.

Daily discharge, in second-feet, of Rainy River at International Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1	......	......	......	5,840	6,270	10,500	11,700	13,200	17,200	17,800	16,400	......
2	......	......	......	5,270	6,490	10,300	11,900	13,200	17,200	17,800	16,400	......
3	......	......	......	5,270	6,720	10,100	12,200	13,200	17,200	17,800	16,200	......
4	......	......	......	5,130	7,020	9,820	12,300	13,200	17,200	17,700	16,200	......
5	......	......	......	4,990	7,170	9,660	12,400	13,300	17,200	17,700	16,200	......
6	......	......	......	4,990	7,320	9,500	12,500	13,300	17,200	17,800	16,200	......
7	......	......	......	5,130	7,240	9,580	12,600	13,300	17,200	17,800	16,100	......
8	......	......	......	5,270	7,160	9,660	12,700	13,500	17,200	17,800	16,100	......
9	......	......	......	5,130	7,320	9,580	12,700	13,500	17,300	17,700	16,100	......
10	......	......	......	5,130	7,160	9,500	12,800	13,500	17,300	17,800	16,000	......
11	......	......	......	5,270	7,320	9,500	12,800	14,700	17,300	17,700	15,900	......
12	......	......	......	5,130	7,320	9,600	12,900	15,900	17,200	17,700	15,700	......
13	......	......	......	5,130	7,320	9,740	12,900	16,100	17,300	17,700	15,600	......
14	......	......	......	5,130	7,160	9,820	13,000	16,100	17,300	17,700	15,400	......
15	......	......	......	4,990	7,550	9,870	13,000	16,100	17,300	17,500	15,400	......
16	......	......	......	4,860	7,940	9,820	13,000	15,900	17,300	17,300	15,400	......
17	......	......	......	4,860	8,710	9,980	13,100	15,600	17,300	17,300	15,200	......
18	......	......	......	5,130	9,180	9,980	13,200	15,600	17,300	17,300	15,200	......
19	......	......	......	5,270	9,660	10,100	13,300	16,100	17,300	17,300	15,100	......
20	......	......	......	5,270	9,820	10,100	13,400	16,100	17,700	17,200	15,100	......
21	......	......	......	5,340	9,820	10,200	13,500	16,200	17,700	17,000	14,900	......
22	......	......	......	5,410	9,660	10,400	13,600	16,200	17,900	16,800	14,800	......
23	......	......	......	5,900	9,660	10,600	13,700	16,200	18,100	16,700	14,600	......
24	......	......	......	6,400	9,820	10,800	13,700	16,200	18,100	16,500	14,600	......
25	......	......	......	6,860	9,820	10,900	13,600	16,300	18,100	16,500	14,600	......

Daily discharge, in second-feet, of Rainy River at International Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
26				6,860	9,980	11,000	13,600	16,400	18,100	16,500	14,500	
27				7,020	10,100	11,100	13,500	16,500	18,100	16,400	14,500	
28				6,560	10,800	11,200	13,500	16,500	18,100	16,400	14,400	
29				6,560	10,800	11,300	13,400	16,600	18,000	16,500	14,400	
30				6,420	10,600	11,500	13,300	16,700	18,000	16,500	14,400	
31					10,600		13,300	17,200		16,500		
1908.												
1							13,200	14,500	12,800	10,900	8,630	
2							13,200	14,500	12,600	10,800	8,560	
3						12,400	13,200	14,400	12,500	10,800	8,400	
4			10,600				13,200	14,300	12,400	10,700	8,240	
5							13,200	14,200	12,300	10,600	8,240	
6							13,200	14,100	12,200	10,500	8,090	
7				4,580			13,400	14,100	12,100	10,400	7,940	
8							13,500	14,000	12,100	10,300	7,860	
9						14,600	13,400	14,000	12,000	10,200	7,780	
10							13,400	14,000	12,000	10,100	7,780	
11			9,980				13,300	14,000	11,900	10,000	7,620	
12							13,400	14,000	11,800	9,930	7,620	
13						15,300	13,500	14,000	11,700	9,840	7,620	
14							13,500	14,000	11,600	9,750	7,620	
15					11,400		13,600	14,000	11,500	9,660	7,470	
16							13,700	14,600	11,400	9,660	7,320	
17							14,200	14,000	11,400	9,500	7,320	
18				7,470		12,500	14,700	14,000	11,400	9,420	7,320	
19			9,820				15,100	13,900	11,400	9,340	7,320	
20							15,400	13,800	11,200	9,260	7,320	
21							15,300	13,700	11,100	9,180	7,160	
22							15,200	13,500	11,100	9,120	7,090	
23							15,100	13,200	11,000	9,070	7,020	
24							15,000	12,900	11,000	9,020	7,020	
25							14,900	12,700	11,000	9,020	6,860	
26						13,000	14,800	12,500	10,900	9,020	6,860	
27					14,000		14,700	12,500	10,900	8,940	6,860	
28							14,600	12,600	10,900	8,860	6,860	
29							14,600	12,700	10,900	8,860	6,790	
30			6,720	12,900			14,600	12,800	10,900	8,710	6,720	
31							14,500	12,900		8,710		
1909.												
1				5,550	2,380	976	10,900	9,340	8,710	8,710	8,860	
2				5,270	2,500	1,900	10,900	9,340	8,240	8,560	8,510	
3				5,130	2,530	3,140	11,100	9,500	8,710	8,560	8,130	
4				5,060	2,560	4,720	11,000	10,100	9,340	8,560	7,750	
5				4,990	2,590	5,270	10,900	9,820	9,420	8,560	7,370	
6				4,450	2,630	5,690	11,100	9,980	9,500	9,820	6,990	
7				4,380	3,010	4,580	10,900	10,100	8,400	9,820	6,610	
8				4,320	3,390	4,860	11,100	10,200	7,940	9,820	6,230	
9				4,180	3,780	5,980	11,100	10,300	9,020	9,820	5,750	
10				4,050	3,920	6,120	11,000	10,800	9,500	9,900	5,480	
11				3,920	3,920	6,420	10,800	11,100	10,100	9,980	5,100	
12				3,780	3,920	6,120	10,800	11,100	10,200	10,100	4,720	
13				2,380	4,860	6,490	9,820	12,900	10,300	10,300	3,920	
14				2,260	7,160	6,860	9,980	13,700	10,100	10,100	3,990	
15				2,260	7,500	7,020	9,820	13,600	10,100	9,050	4,050	
16				2,260	7,500	7,100	10,300	13,500	10,100	8,530	4,140	
17				2,140	7,300	7,020	10,300	13,000	10,100	8,020	4,230	
18				1,780	7,000	7,160	10,800	12,400	10,100	7,520	4,320	
19				1,430	6,860	7,160	11,300	12,100	9,330	7,020	4,320	
20				1,430	5,980	7,160	11,300	11,900	8,560	7,160	4,450	
21				431	4,990	7,160	11,300	12,400	8,560	7,620	4,600	
22				1,200	4,180	8,400	11,300	12,000	8,710	8,240	4,720	
23				1,320	3,520	8,560	10,900	11,700	8,710	8,560	5,130	
24				1,550	3,010	9,020	10,500	10,800	8,860	9,180	4,320	
25				1,660	2,500	9,340	10,300	10,000	8,860	9,340	3,520	
26				1,780	1,900	9,500	10,100	7,320	8,860	9,820	3,920	
27				1,900	1,550	9,980	9,020	7,470	8,860	9,980		
28				1,780	1,200	10,300	9,660	7,680	8,860	9,660		
29				1,900	865	10,600	9,820	7,880	8,860	9,660		
30				2,140	646	10,900	9,500	8,090	8,710	9,340		
31					735		9,500	7,940		9,180		

Daily discharge, in second-feet, of Rainy River at International Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1					11,700	8,660	9,620	4,010	5,370	4,950	6,660	
2					11,900	10,300	9,780	6,080	5,090	2,500	3,460	
3					11,900	8,660	9,780	6,080	5,090	4,810	6,520	
4					11,700	8,660	9,680	6,370	5,090	4,810	6,820	
5					11,700	8,660	8,040	6,150	5,090	4,810	6,820	
6					11,700	9,140	8,980	6,150	5,090	4,810	2,500	
7					11,700	10,900	8,660	4,140	5,090	5,910	3,420	
8					11,700	10,300	7,270	5,370	5,090	5,510	6,600	
9					11,700	11,900	7,040	6,230	5,090	5,510	6,600	
10					12,000	11,500	6,370	5,510	5,090	2,420	6,620	
11				10,600	12,200	11,900	7,120	4,810	5,060	5,790	6,600	
12				10,660	12,500	11,900	6,670	5,230	5,090	5,790	6,740	
13				10,400	12,500	11,100	6,970	5,370	5,230	6,010	2,000	
14				10,400	9,620	11,900	6,820	4,410	4,950	6,230	5,510	
15				10,600	9,620	11,400	6,670	4,410	4,950	6,370	6,600	
16				10,600	9,780	11,500	6,370	4,410	4,950	2,340	6,740	
17				10,700	9,780	11,400	6,370	5,090	4,950	3,480	6,970	
18				11,700	10,400	8,590	3,610	5,090	5,090	5,300	7,120	
19				13,600	10,900	8,590	6,150	5,230	5,090	6,010	7,660	
20				13,600	7,970	8,660	6,080	5,230	5,090	6,080	2,500	
21				13,600	8,900	8,660	5,940	5,230	5,090	6,010	6,970	
22				13,600	8,040	9,460	5,510	5,230	5,090	6,150	8,660	
23				13,600	11,100	9,300	4,950	3,740	5,090	2,500	8,040	
24				12,900	11,100	10,400	4,950	5,230	5,090	3,600	7,580	
25				12,300	10,300	10,300	4,870	5,370	5,090	6,640	7,730	
26				12,300	8,660	10,300	4,680	5,370	5,230	6,640	7,420	
27				11,700	9,780	9,460	4,460	5,490	4,950	6,600	2,000	
28				11,700	9,780	9,460	4,460	6,820	5,090	6,500	4,140	
29				11,700	9,680	9,460	5,650	3,740	5,090	6,520	6,370	
30				11,400	9,280	8,980	5,940	5,650	4,950	2,500	7,120	
31					9,280		6,080	5,510		5,480		
1911.												
1				2,600	2,740	6,270	3,970	6,640	6,880	5,270	5,240	
2				2,600	3,850	6,180	2,500	6,620	6,860	4,380	5,270	
3				2,800	4,020	6,180	1,900	6,860	6,860	5,410	5,130	
4				2,800	3,940	4,250	1,900	6,790	6,360	5,620	4,790	
5				3,000	3,970	4,250	3,590	6,490	6,500	5,620	4,020	
6				3,000	3,840	6,720	4,150	3,570	6,780	5,690	4,450	
7				3,200	3,120	6,840	4,050	6,340	6,620	5,480	4,920	
8				3,200	2,970	6,800	4,110	6,720	6,720	4,880	4,880	
9				3,400	4,070	6,740	3,850	6,780	6,560	4,560	4,990	
10				3,400	4,370	7,620	3,920	6,920	6,360	4,960	5,380	
11				3,600	5,350	4,720	4,320	7,090	6,420	5,610	4,790	
12				3,600	5,270	6,790	3,980	7,680	6,420	5,680	6,070	
13				3,800	4,380	8,710	4,050	3,940	6,300	5,660	5,900	
14				4,000	2,790	8,930	4,100	6,640	6,360	5,400	5,800	
15				4,200	4,130	9,030	4,320	7,090	6,420	4,380	5,750	
16				4,400	4,750	8,830	3,520	6,920	5,970	4,470	5,700	
17				4,600	5,990	7,550	3,930	6,920	4,920	5,240	5,550	
18				4,800	5,140	4,450	3,970	7,220	4,730	5,520	5,100	
19				4,460	5,810	4,770	3,820	7,020	5,840	5,680	5,270	
20				4,500	5,720	6,800	3,080	5,760	6,050	5,890	5,200	
21				4,380	2,820	7,160	3,030	6,420	5,840	5,480	5,400	
22				4,370	4,530	7,080	3,030	6,920	5,140	4,710	5,700	
23				3,520	5,920	6,390	2,200	6,920	5,850	4,470	5,600	
24				3,816	6,070	5,550	2,200	7,200	4,790	4,520	5,700	
25				3,890	6,080	5,550	4,070	6,900	3,950	5,480	5,800	
26				3,650	5,620	5,280	5,990	7,140	5,410	5,610	5,900	
27				3,520	6,020	5,410	6,280	5,720	5,410	5,720	5,980	
28				3,340	3,120	5,340	6,600	6,420	5,580	5,610	5,970	
29				3,190	4,150	5,120	6,810	6,610	5,690	5,100	5,950	
30				2,770	5,980	4,110	4,870	6,880	5,720	4,320	5,900	
31					6,210		5,000	6,860		4,990		
1912.												
1	4,490	5,085	4,856	3,953	5,880	6,650	5,300	10,200	6,330	7,990	6,970	
2	5,695	5,440	4,888	5,022	5,885	6,020	5,720	10,400	5,870	7,810	6,970	
3	5,665	5,845	4,197	5,028	5,915	6,490	5,720	10,400	6,490	7,640	6,020	
4	5,695	4,620	4,102	4,997	6,190	6,490	5,230	9,480	8,170	7,470	5,870	
5	5,640	3,995	5,101	5,092	5,250	6,490	5,440	9,290	8,350	7,640	7,130	

Daily discharge, in second-feet, of Rainy River at International Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6	5,815	5,105	5,037	4,984	4,795	6,490	5,720	9,670	8,720	6,810	7,130	......
7	4,450	5,090	5,090	3,725	6,185	6,490	5,100	10,000	8,350	6,970	7,130	......
8	3,905	5,050	5,102	3,616	6,570	6,330	5,580	9,860	7,990	7,130	7,130	......
9	5,725	4,985	5,063	5,049	6,600	5,870	6,650	9,670	7,990	7,300	6,970	......
10	5,720	4,870	4,205	5,068	6,692	6,020	6,970	9,670	8,530	7,300	6,020	......
11	5,725	4,105	4,108	5,096	6,734	6,330	7,810	8,720	8,350	7,300	6,020	......
12	5,940	3,990	5,105	5,119	5,435	6,330	7,640	8,350	7,990	7,470	6,650	......
13	6,220	5,030	5,060	5,052	4,800	6,170	7,810	8,170	7,990	6,490	6,970	......
14	3,700	5,035	5,025	4,031	6,690	6,170	7,130	8,170	7,990	6,970	6,970	......
15	5,030	5,000	5,046	4,409	6,695	6,020	7,300	7,990	6,970	7,130	6,970	......
16	5,855	5,009	4,960	5,100	6,690	5,580	8,350	6,810	7,300	7,130	6,810	......
17	5,930	5,017	3,828	5,060	6,350	5,720	8,720	7,300	7,640	6,970	6,020	......
18	5,909	4,119	3,890	5,045	6,355	5,870	7,990	7,130	7,300	6,970	6,330	......
19	5,915	3,976	4,812	5,055	4,855	5,870	6,810	7,470	6,810	7,130	6,970	......
20	5,915	5,035	5,045	5,048	5,200	6,020	7,640	8,170	6,810	6,490	6,970	......
21	4,700	5,044	5,096	4,130	6,730	6,020	8,350	7,810	6,330	6,020	7,300	......
22	4,320	5,057	5,095	3,950	6,743	6,330	8,350	6,970	6,170	6,810	7,130	......
23	5,915	5,063	5,004	5,045	6,720	5,720	8,720	6,650	6,170	6,970	6,970	......
24	5,920	5,014	3,560	5,055	6,770	5,720	8,910	6,810	6,650	6,970	6,170	......
25	5,875	4,169	4,429	5,385	6,577	6,020	8,910	6,170	7,640	6,970	6,170	......
26	5,760	4,080	5,070	5,800	4,892	5,720	8,910	6,650	9,860	6,970	6,810	......
27	5,495	5,068	5,022	5,900	5,175	5,720	8,910	6,330	9,100	5,870	6,970	......
28	4,255	5,066	5,057	4,597	6,680	5,580	8,720	6,650	8,170	5,870	6,970	......
29	3,935	5,056	5,090	4,348	6,495	5,580	10,200	6,650	7,640	6,810	6,970	......
30	5,080	......	4,910	5,865	6,350	5,030	10,200	6,970	7,990	6,970	6,810	......
31	5,085	......	4,012	......	5,776	......	10,200	6,810	......	6,970	......	......

NOTE.—The daily discharges have been computed from a fairly well-defined rating curve. The daily discharges from January 1 to May 31, 1912, were based on the flow through the power house and were furnished by the courtesy of Mr. S. B. Johnson, of the Canadian Department of Public Works.

Monthly discharge[a] *of Rainy River at International Falls.*

[Drainage area, 14,600[a] square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1907.						
March			[b]5,500	0.377	0.43	C
April	7,020	4,800	5,550	.380	.42	B
May	10,800	6,270	8,500	.582	.67	A
June	11,500	9,500	10,200	.699	.78	A
July	13,700	11,700	13,000	.890	1.03	B
August	17,200	13,200	15,200	1.04	1.20	A
September	18,100	17,200	17,500	1.20	1.34	A
October	17,800	16,400	17,200	1.18	1.36	A
November	16,400	14,400	15,400	1.05	1.17	A
December			[b]13,000	.890	1.03	B
1908.						
January			[b]12,000	.822	.95	C
February			[b]11,100	.753	.78	C
March			[b]9,280	.636	.73	B
April			[b]7,940	.544	.61	B
May			[b]12,700	.870	1.00	B
June			[b]13,600	.932	1.04	B
July	15,400	13,200	14,100	.966	1.11	A
August	14,500	12,500	13,700	.938	1.08	A
September	12,800	10,900	11,600	.795	.89	A
October	10,900	8,710	9,680	.663	.76	A
November	8,630	6,720	7,510	.514	.57	A
December			6,500	.445	.51	B
The year			10,800	.740	10.03	

[a] Revised since publication of "Report on Water Resources Investigation of Minnesota during 1909-1910."
[b] Estimated.

Monthly discharge[a] *of Rainy River at International Falls*—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile		
1909.						
January	....	....	[b]6,000	.411	.47	C
February	....	....	[b]5,500	.377	.39	C
March	....	....	[b]5,500	.377	.43	C
April	5,550	431	2,890	.198	.22	A
May	7,500	646	3,760	.258	.30	A
June	10,900	976	6,850	.469	.52	A
July	11,300	9,020	10,600	.726	.84	A
August	13,700	7,320	10,600	.726	.84	A
September	10,300	7,940	9,250	.634	.71	A
October	10,300	7,020	9,050	.620	.71	A
November	8,860	3,520	5,400	.370	.41	A
December	....	....	[b]5,000	.342	.39	B
The year	13,700	431	6,700	.459	6.23	
1910.						
January	....	....	[b]4,500	.308	.36	C
February	....	....	[b]4,500	.308	.32	C
March	....	....	[b]5,000	.342	.39	C
April	13,600	6,000	10,600	.726	.81	B
May	12,500	7,970	10,600	.726	.84	B
June	11,900	8,590	10,000	.685	.76	B
July	9,780	3,610	6,630	.454	.52	B
August	6,820	3,740	5,280	.361	.42	B
September	5,370	4,950	5,080	.348	.39	B
October	6,640	2,340	5,120	.351	.40	B
November	8,660	2,000	6,020	.412	.46	B
December	....	....	[b]4,300	.295	.34	B
The year	13,600	....	6,470	.443	6.01	
1911.						
January	....	....	[c]2,860	.196	.23	C
February	....	....	[c]2,380	.163	.17	C
March	....	....	[c]2,530	.173	.20	C
April	4,800	[b]2,600	3,620	.248	.28	B
May	6,210	2,740	4,600	.315	.36	A
June	9,060	1,110	6,320	.433	.48	A
July	6,840	1,900	3,970	.272	.31	A
August	7,220	3,570	6,560	.449	.52	A
September	6,880	4,730	5,990	.410	.46	A
October	5,890	4,320	5,210	.357	.41	A
November	6,070	4,020	5,410	.371	.41	A
December	....	....	[c]5,900	.404	.47	B
The year	9,060	....	4,610	.316	4.30	
1912.						
January	6,220	3,700	5,330	.365	.42	....
February	5,840	3,980	4,830	.331	.36	....
March	5,100	3,560	4,740	.325	.37	....
April	5,900	3,620	4,850	.332	.37	....
May	6,770	4,800	6,090	.417	.48	....
June	6,650	5,030	6,030	.413	.46	A
July	10,200	5,100	7,580	.519	.60	A
August	10,400	6,170	8,110	.555	.64	A
September	9,860	5,870	7,590	.520	.58	A
October	7,990	5,870	7,010	.480	.55	A
November	7,300	5,870	6,740	.462	.52	A

[a] Revised since publication of "Report on Water Resources Investigation of Minnesota during 1909-1910."

[b] Estimated.

[c] Estimate based on record of M. & O. Power Co.

NOTE.—Monthly discharge from January 1 to May 31, 1912, was based on the flow through the power house as furnished by the Canadian Department of Public Works.

DEVELOPED WATER POWER.

There is one development of power on Rainy River which is one of the largest in the state.

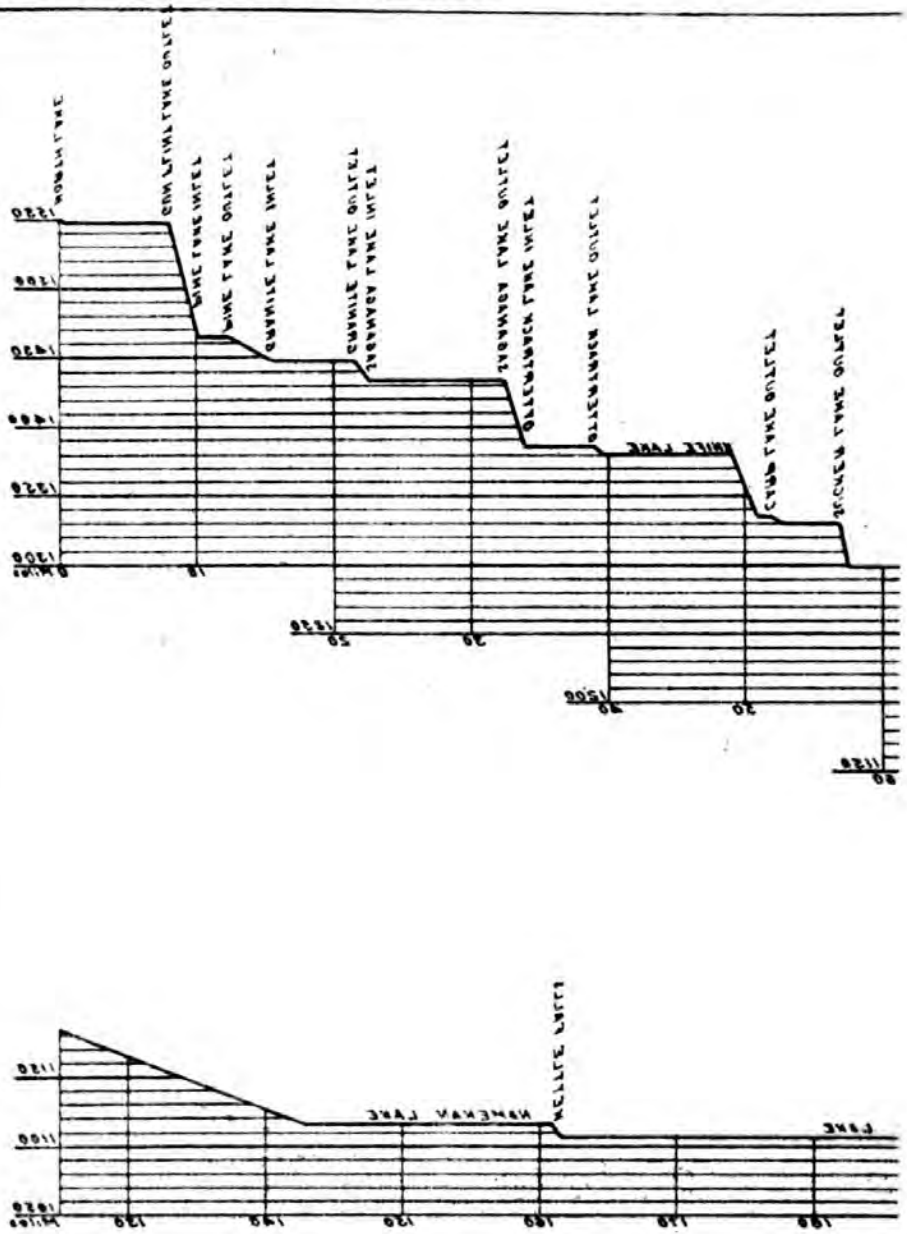
At International Falls the Minnesota and Ontario Power Company utilizes the Koochiching Falls in Rainy River by an arched masonry dam, which develops a head of 30 feet. This head is kept nearly constant by reducing the number of wheels when necessary. Under the terms of the charters obtained from the Canadian and Minnesota governments it was necessary to develop the power equally on both sides of the river, although 6,000 horsepower of the Canadian power could be exported to Minnesota if not needed in Ontario. Accordingly, two plants have been built, one at either end of the dam. The Minnesota plant has twenty-four 39-inch S. Morgan Smith wheels arranged in 6 units of 4 wheels each. They are set on horizontal shafts in open forebay. Each unit is direct connected to a wood grinder in the M. & O. paper mill. There are no governors as the wheels are regulated by the grinders. The installed horsepower is between 12,000 and 13.000, which will ultimately be increased to 15,000 or 18,000 horsepower.

The Ontario plant, which is located at the Canadian end of the dam in Fort Frances, has eight 36-inch and eight 39-inch Hercules wheels installed. These wheels ar set in open forebay on vertical shafts, arranged in 4 units of 4 wheels each. Each unit is direct connected to a 1,250 KW Westinghouse generator at 6,600 volts. Improved Holyoke automatic governors are used. At the present time much of the power is transmitted to Minnesota for use in running the paper mill and lighting International Falls. There are wheel pits for 5 additional units, which will be installed later, bringing the entire installation up to about 18,000 horsepower.

Since 1907 the lowest monthly flow has been 2,380 second feet which corresponds to 6,490 horsepower at 80 per cent efficiency. From the discussion of storage on Rainy Lake on p. 458, it appears that it would be possible to obtain a uniform continuous flow of 6,050 second feet during the lowest two years covered by the records. This would correspond to 16,500 horsepower.

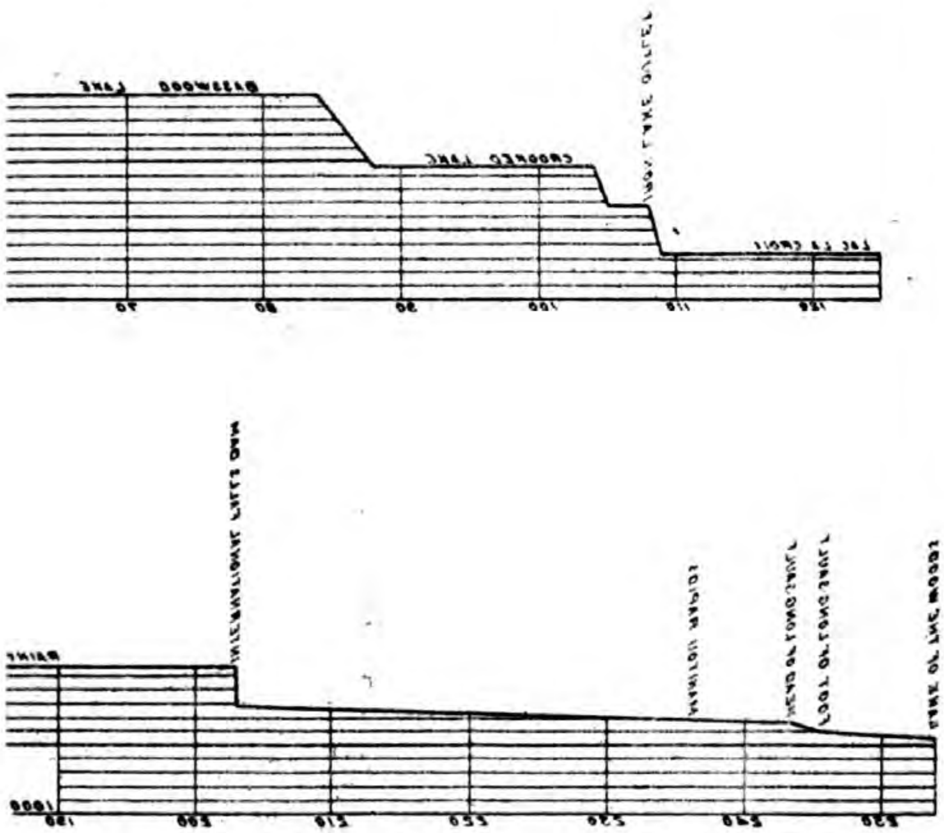
UNDEVELOPED WATER POWER.

Although no topographic survey of Rainy River and the Boundary Waters has been made, there are available elevations at various points along the waterway. Above Basswood Lake these elevations are only approximate, being chiefly aneroid readings taken from the final report of the Geological and Natural History Survey of Minnesota. From Basswood Lake to Lake of the Woods the elevations are based on a survey made by E. B. Banks, city engineer of



PROFILE OF RAINY RIVER AND BOUNDARY WATERS.

NOTE: ABOVE BASSWOOD LAKE THE ELEVATIONS CAN ONLY BE CONSIDERED APPROXIMATE.



Superior, Wisconsin, and furnished through his courtesy. From these data the profile on plate XIV. has been compiled. The following table of elevations and distances are based on the foregoing data:

Elevations and distances along Rainy River and boundary waters from North Lake to Lake of the Woods.

Point	Distance in Miles		Elevation in feet above sea level	Descent in feet between points	
	Below North Lake	Point to Point		Total	Per Mile
North Lake	0	....	1,550	....	....
Gun Flint Lake, inlet	0.5	0.5	1,547	3	6
outlet	8	7.5	1,547	0	0
Pine Lake, inlet	10	2	1,465	82	41
outlet	12.5	2.5	1,465	0	0
Granite Lake, inlet	15.5	3	1,448	17	5
outlet	21.5	6	1,448	0	0
Saganaga Lake, inlet	22.5	1	1,434	14	14
outlet	32.5	10	1,434	0	0
Ottertrack Lake, inlet	34	1.5	1,385	49	33
outlet	39	5	1,385	0	0
Knife Lake, inlet	39.5	0.5	1,381	4	8
outlet	49	9.5	1,381	0	0
Carp Lake, inlet	51	2	1,335	46	23
outlet	52	1	1,335	0	0
Sucker Lake, inlet	53	1	1,330	5	5
outlet	57	4	1,330	0	0
Basswood Lake, inlet	57.5	0.5	1,299	31	62
outlet	84	26.5	1,299	0	0
Crooked Lake, inlet	88	4	1,246	53	13
outlet	101	16	1,246	0	0
Iron Lake, inlet	105	1	1,217	29	29
outlet	108	3	1,217	0	0
Lac la Croix, inlet	109	1	1,183	34	34
outlet	125	16	1,183	0	0
Namekan Lake, inlet	143	18	1,115	68	4
outlet. } Kettle Falls.	161	18	1,115	0	0
Rainy Lake, inlet } Kettle Falls.	161.5	0.5	1,106	9	18
outlet	201	39.5	1,106	0	0
International Falls dam, headwater	203	2	1,106	0	0
tailwater	203	0	1,077	29	....
Head of Manitou Rapids	236	33	1,069	8	0.2
Foot of Manitou Rapids	236.5	0.5	1,068	1	2
Head of Long Sault	243.5	7	1,066	2	0.3
Foot of long Sault	245.5	2	1,060	6	3.0
Lake of the Woods	254	8.5	1,054	6	0.7

In the absence of topographic maps there is no definite information regarding dam sites, but as most of the lakes have rock rims around their outlets, it is probable that suitable sites for low dams will be found at each outlet. The table shows that the fall above Rainy Lake is concentrated chiefly between the various lakes, thus determining the location of the power sites.

To determine the available horsepower at each site, there are available the records of flow of Rainy River at International Falls. Although the flow at this point is controlled by the dam at the outlet of the lake, the many lakes composing the boundary waters regulate the flow naturally to a great extent. This fact, together with the additional one that the rainfall in the upper basin is heavier than in the lower, makes it fair to assume that the runoff per square mile will not differ greatly from that at International Falls.

From the foregoing data the following table has been compiled to show the available horsepower at the various power sites:

Undeveloped horsepower on Rainy River and boundary waters.

Site	Distance in miles	Head in feet	Minimum Run-off[a]			Horsepower (80% Efficiency)		
			Lowest month	Lowest month average low year	6 Highest months average low year	Lowest month	Lowest month average low year	6 Highest months average low year
Between Saganaga and Ottertrack lakes....	1.5	49	208	284	378	926	1,260	1,680
Between Knife and Carp Lakes........	2	46	242	330	440	1,010	1,380	1,840
Between Sucker and Basswood lakes....	0.5	31	252	340	446	710	956	1,310
Between Basswood and Crooked lakes......	4	53	650	800	1,150	3,130	3,850	5,540
Between Crooked and Iron lakes.........	1	29	720	950	1,330	1,900	2,500	3,500
Between Iron and Lac la Croix............	1	34	733	965	1,350	2,270	2,980	4,170
Between Namekan and Rainy lakes........	0.5	9	1,390	1,830	2,560	1,140	1,500	2,090
Between foot of dam at International Falls and Lake of the Woods............	51	23	2,600	[b]6,300	....	5,440	[b]13,170	....

[a] Flow based on mean area for the section.
[b] Complete regulation of flow at Rainy Lake.

STORAGE STUDY OF RAINY LAKE.

The many lakes in the basin of Rainy River regulate the flow of Rainy River to such an extent that sudden changes in stage are eliminated.

The best reservoir site in the basin is Rainy Lake. From the best available maps the net area of this lake, exclusive of the many islands, is found to be about 310 square miles. As no topographic survey has been made of the lake it is not known to what depth water may be stored in the lake. But the records of stage at Ranier for 1910 and 1911 show that during that period the water level in the lake had a range of 8.3 feet. With a mean area of 300 square miles, this represents a storage capacity of 69,500,000,000 cubic feet.

To determine the amount of storage needed to insure uniform flow at International Falls a mass curve was constructed from the runoff records. With a maximum storage of sixty billion cubic feet it would have been possible to obtain the following discharge:

March 1, 1907 to March 31, 1908....13,200 second feet
April 1, 1908, to April 30, 1909..... 8,650 second feet
May 1, 1909, to Dec. 31, 1911...... 6,050 second feet

The chief value of this regulated flow would have been to power development at International Falls and in the portion of Rainy

River between International Falls and Lake of the Woods. Navigation would also have been benefited, especially at the rapids between Rainy Lake and Lake of the Woods.

SANITARY STATISTICS.

To show the sanitary quality of the water in Rainy River and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage for all towns located on Rainy River have been compiled and are given in the following table:

Municipal water supply and sewage disposal of towns on Rainy River.

Town	Distance above Lake of the Woods	Population 1910	Water Works Systems			Sewerage Systems		Rural population per square mile
			Source of Supply	Filtered	Amount gallons 24 hours	Outlet	Treated	
International Falls....	89	1,487	river	calcium hypochlorite	....	river	no	....
Fort Frances....	89	......	Rainy Lake and river	no	300,000	river	no	....
Rainy River....	12	1578	river	yes	3,000,000	river	septic tank	
Baudette....	12	897	river	calcium hypochlorite	20,000	river	septic tank	....
Spooner....	12	668	none	....	....	Baudette River	no	....

From the preceding table it appears that above International Falls no urban sewage enters the boundary waters. The population is very sparse—about 3 per square mile on the Minnesota side and probably about the same in Ontario—although no data are available regarding the population on the Canadian side. The many lakes in the basin above International Falls, the largest being Rainy Lake with an area of 344 square miles, afford such excellent settling basins that sedimentation will remove practically all of the pollution from rural sewage which may enter the streams.

Between International Falls and Lake of the Woods, a distance of 51 miles, Rainy River receives untreated sewage from International Falls, Fort Frances and Spooner. Although the average fall in this stretch of river is only .5 foot per mile it is probable that sewage pollution will be found throughout. In many places the river is deep and the sunlight does not have opportunity to kill the bacteria that it would have otherwise.

With the exception of Fort Frances, none of the towns use raw river water for municipal purposes. The rural population below International Falls is about 2 per square mile.

[a] KAWISHIWI RIVER.

[a] Pronounced "Kashaway."

SOURCE, COURSE AND TRIBUTARIES.

Kawishiwi River rises in Syenite Lake in the eastern part of township 62 north, range 6 west in Lake County, and flows north and west through a chain of lakes, the chief ones being Polly, Boulder, Alice, Wilder and Crab lakes. In the southeast corner of township 63 north, range 10 west, the river divides, one fork known as the North Kawishiwi, continuing westward through Friday, and Farm lakes into Garden (or Eve) Lake. The other fork known as the South Kawishiwi or Birch River flows southwest through Copeland Lake into Birch Lake where it turns northward and flows through White Iron Lake into Garden Lake, joining the North Kawishiwi. From Garden Lake, the Kawishiwi flows northward through Fall, and Newton lakes into Basswood Lake, a tributary of Rainy River. The South Kawishiwi is the larger of the two forks.

There are no important tributaries above the upper forks nor are there any entering the North Kawishiwi. Isabella, Stony, Dunka and Beaver rivers enter the South Kawishiwi, and Long Lake outlet enters the Kawishiwi through Fall Lake. There are no tributaries below this point.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The drainage area is rugged, and thickly dotted with lakes which lie in rock bound basins, and have their outlets over the rocky rims which have not been eroded to any extent. The southern boundary is a broad undulating plateau which rises to an altitude of 1,800 to 1,900 feet above sea level. This is the region of light glacial drift or bare rocks, the latter comprising granites, gneisses, mica-schists, gabbros and greenstones of the Cambrian and Archean systems. The soil of the basin is very scare, and is almost entirely decomposed vegetable matter.

The entire area is covered with timber and much of it is included within the Superior National Forest. The portion of the national forest including the Kawishiwi basin lies within an area bounded approximately as follows: Beginning near the middle of the western edge of T. 63 N., R. 10 W., thence in a general northeasterly direction to sec. 25, T. 64 N., R. 2 W.; thence south to sec. 6, T. 63; thence west to the northwest corner of T. 62 N., R. 4 W.; thence south to sec. 36, T. 59 N., R. 5 W.; thence west 6 miles; thence in a general westerly direction to the southwest corner of T. 61 N., R. 11 W.; thence north 6 miles, east 6 miles and north 8 miles to the initial point. The lower portion of the basin has been burned over so extensively that the forest cover is very broken and the soil nearly destroyed. Here jack pine is the chief species, as it will take years before the valuable woods can be grown. In the remainder of the basin there is a dense growth of birch, poplar and jack pine and the forest floor is covered with a heavy litter of humus.

RAINFALL.

No rainfall records have been kept within the basin for any length of time, the nearest record being that at Tower which was maintained continuously from 1896 to 1903. This record showed a mean annual rainfall of 29 inches for the period from 1896 to 1903. However, it is probable from the lines of equal rainfall for the northeastern part of the state that the mean rainfall for the basin is about 30 inches. The wettest year recorded at Tower was 1899 with a rainfall of 35.8 inches. The driest year was 1910 with a record of 17.8 inches as recorded at Stephens Mine.

REGULATION OF FLOW AND LOGGING.

The many lakes through which the Kawishiwi and its tributaries flow, act as natural regulators of the flow, tending to make it uniform. This natural effect, however, is more than offset by the operation of logging dams. One of them is located at the outlet of Garden Lake for the purpose of storing water to sluice the logs over the falls between Garden and Fall lakes. This dam, which is a timber structure, raises the water 14 feet on Garden Lake, and its influence is felt as far as White Iron Lake where the water is held to a depth of 2 feet. There is a logging dam at the outlet of Birch Lake in sec. 31, T. 62 N., R. 11 W., which raises the water 6 feet on Birch Lake, creating a reservoir with a capacity of 1.7 billion cubic feet. There is a rubble rock ridge located above the dam which has its crest 2 feet above the floor of the sluices of the dam, thus preventing the lake level from being drawn down to the bottom of the sluice ways. There is a third dam on Stony River in sec. 8, T. 60 N., R. 11 W.

These dams hold back the flow during the winter time, which is the natural period of low water, for the purpose of increasing the flow during the spring and early summer, when the logs are driven into Fall Lake. Thus the natural inequality of flow is greatly increased by the operation of these dams. It is estimated by the U. S. Forest Service that the annual log drive down the Kawishiwi is about 20,000,000 feet, B. M. It is further estimated that the log drives for the next five years will continue at this figure after which time logging will practically cease. At the present time the timber comes from the South Kawishiwi and its tributaries, as the North Kawishiwi was cut over several years ago.

Beside the logging dams there is a dam at the entrance to Fall Lake which does not control the flow, but simply forms a pool and sluiceway to aid logs over the lower falls. There is also a low dam between Fall and Newton lakes which does not control the flow, but simply raises the water level in Fall Lake.

DRAINAGE AREAS.

The following drainage areas in the Kawishiwi River basin have been measured:

Drainage areas in Kawishiwi River basin.

River.	Drainage area above.	Square Miles.
Kawishiwi	Forks in sec. 25, T. 63 N., R. 10 W.	242
Do	Garden Lake Outlet	1,200
Do	Mouth	1,410
Stony	Mouth	254
Burntside	Mouth	146

GAGING STATION RECORDS.

KAWISHIWI RIVER NEAR WINTON.

Location.—At the logging dam at the outlet of Garden Lake in Sec. 20, T. 62 N., R. 11 W., about 3 miles east of Winton.

Records available.—June 21, 1905, to June 30, 1907. These records are furnished through the courtesy of the Minnesota Canal and Power Company by whom they were compiled.

Drainage area.—1,200 square miles.

Gage.—Vertical staff read at 8 a. m. and 5 p. m.; the mean is taken as the mean for the day.

Method of compiling records.—Obtained by recording the flow through the five sluiceways of the logging dam, which were closed by Taintor gates. The coefficient for each sluiceway was obtained by current meter.

Regulation.—The flow at Garden Lake outlet is almost wholly controlled by logging reservoirs, and the daily records do not represent the natural variation in runoff.

Daily discharge, in second-feet, of Kawishiwi River near Winton.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1							1,693	2,320	0	3,426	1,238	1,083
2							2,650	2,342	228	3,244	1,210	1,083
3							2,070	1,645	910	2,899	1,210	1,109
4							1,900	2,650	988	1,458	1,158	1,109
5							3,192	1,613	1,180	1,898	1,134	1,134
6							3,192	1,877	1,134	2,659	1,134	1,158
7							3,766	3,018	1,159	2,123	1,109	1,158
8							4,131	2,901	2,286	1,350	1,083	1,158
9							3,737	1,693	2,200	1,361	1,060	1,158
10							3,736	2,118	1,302	1,768	1,060	1,158
11							3,459	2,550	1,400	2,339	1,039	1,158
12							2,985	1,840	1,897	1,711	972	1,185
13							2,818	2,315	2,534	1,341	850	1,158
14							2,562	846	2,650	1,083	888	1,158
15							3,088	203	2,294	934	908	1,158
16							3,370	1,172	2,008	843	928	1,099
17							3,097	2,605	193	775	928	1,070
18							2,386	2,194	850	734	928	1,070
19							422	1,887	2,435	775	820	1,070
20							1,800	1,606	2,387	820	629	1,050
21						1,340	3,243	1,406	2,353	887	671	1,024
22						1,912	2,608	1,288	2,332	964	700	1,024
23						1,960	2,422	738	2,656	1,083	903	1,024
24						1,994	887	0	3,426	1,109	1,288	998
25						2,237	1,025	0	3,426	1,158	1,185	975
26						2,174	1,878	130	3,554	1,210	1,134	951
27						1,082	912	622	3,719	1,265	1,109	931
28						2,903	2,102	622	3,790	1,288	1,083	931
29						2,921	2,000	492	3,719	1,265	1,060	910
30						2,000	1,149	0	3,581	1,265	1,060	880
31							2,300	0		1,238		880
1906.												
1	856	506	360	276	1,682	2,585	2,276	455	400	276	400	660
2	837	506	360	289	1,840	2,920	1,152	1,150	360	276	400	642
3	837	523	360	289	1,836	2,444	1,095	214	400	276	416	621
4	837	506	360	289	1,889	2,353	1,005	750	400	263	416	600
5	810	506	360	300	1,930	2,911	1,860	524	400	250	400	579
6	783	506	360	300	2,105	3,146	830	0	380	263	400	579
7	760	491	345	315	2,650	3,146	880	795	380	276	400	579
8	731	491	345	315	2,057	3,096	920	0	416	276	416	540
9	731	474	345	330	2,172	3,074	930	848	435	300	435	523
10	731	474	345	330	2,880	3,020	950	1,275	435	330	435	506
11	713	474	345	345	2,706	3,094	962	1,070	435	330	435	506
12	695	474	330	360	2,150	3,327	985	830	416	330	491	491
13	695	458	330	416	2,370	2,764	1,050	780	400	330	540	474
14	676	458	330	474	1,795	3,144	1,275	708	400	315	592	474
15	660	435	330	506	1,836	2,685	985	702	360	300	680	474
16	660	435	330	579	2,057	2,843	950	525	345	300	783	474
17	660	435	330	660	2,913	3,070	1,546	550	330	289	931	474
18	642	416	320	760	3,087	2,846	830	600	315	289	975	474
19	642	416	315	856	3,212	2,940	810	560	300	276	998	435
20	621	400	315	931	3,055	2,378	830	523	289	289	998	435
21	621	400	315	1,024	3,008	2,830	840	523	289	300	975	458
22	600	400	300	1,158	2,987	2,062	840	523	276	330	931	416
23	600	400	300	1,265	3,091	1,344	830	523	276	330	910	400
24	579	380	300	1,491	3,113	2,259	800	523	263	330	837	400
25	579	380	300	1,730	3,005	2,387	745	523	300	330	783	400
26	579	360	300	2,389	2,634	2,251	740	506	289	330	783	380
27	560	360	300	1,654	2,605	2,623	710	491	300	330	760	360
28	540	360	300	2,307	2,605	3,232	1,422	474	289	345	731	360
29	540		289	2,600	2,565	1,870	585	458	276	360	695	360
30	540		289	2,580	2,446	2,050	1,181	435	276	380	676	360
31	523		289		2,559		455	400		400		360
1907.												
1	345	263	200	222	540	5,000						
2	345	263	210	235	506	5,200						
3	330	263	210	235	491	5,250						
4	330	263	210	250	458	5,200						
5	330	250	210	263	435	5,100						

Daily discharge, in second-feet, of Kawishiwi River near Winton—Continued.

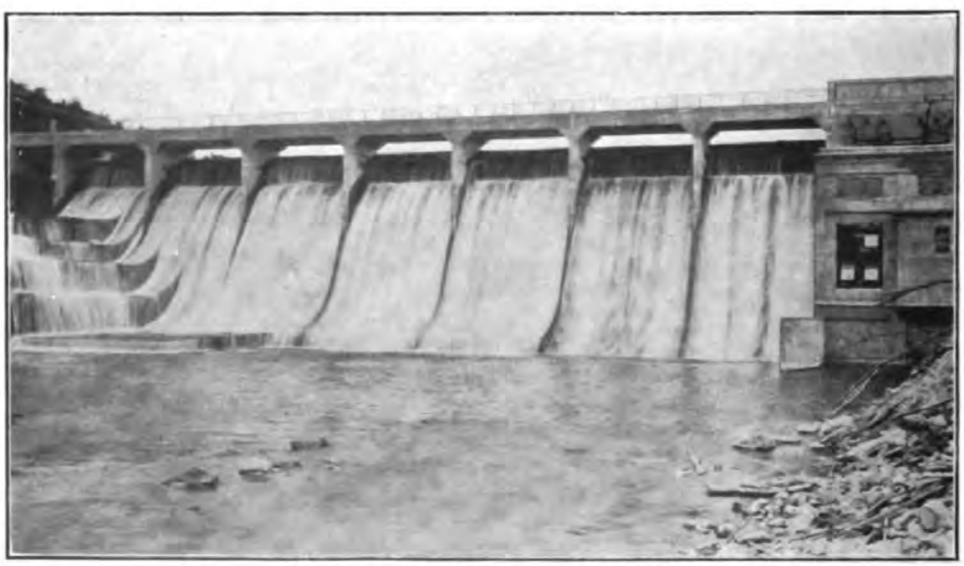
Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
6	330	250	210	276	416	4,900	......	......	......	......	......	......
7	330	250	210	276	305	4,710	......	......	......	......	......	......
8	330	250	210	276	50	4,550	......	......	......	......	......	......
9	315	250	200	289	59	4,350	......	......	......	......	......	......
10	315	250	200	300	66	4,130	......	......	......	......	......	......
11	315	235	200	315	552	4,000	......	......	......	......	......	......
12	315	235	200	330	836	3,375	......	......	......	......	......	......
13	300	235	200	330	1,265	3,700	......	......	......	......	......	......
14	300	235	200	345	1,341	3,440	......	......	......	......	......	......
15	300	222	200	345	1,366	2,947	......	......	......	......	......	......
16	300	222	200	380	983	2,983	......	......	......	......	......	......
17	300	222	200	380	80	3,245	......	......	......	......	......	......
18	300	222	200	380	81	2,900	......	......	......	......	......	......
19	300	222	190	380	1,329	2,695	......	......	......	......	......	......
20	289	210	190	400	2,214	1,327	......	......	......	......	......	......
21	289	210	190	400	2,270	1,601	......	......	......	......	......	......
22	289	210	190	415	2,400	2,600	......	......	......	......	......	......
23	289	210	190	0	1,100	3,810	......	......	......	......	......	......
24	289	210	200	0	2,390	3,[illegible]00	......	......	......	......	......	......
25	289	200	200	951	1,67[illegible]	3,475	......	......	......	......	......	......
26	276	200	210	0	3,716	3,320	......	......	......	......	......	......
27	276	200	210	880	3,810	1,669	......	......	......	......	......	......
28	276	200	222	83[illegible]	4,120	986	......	......	......	......	......	......
29	276	......	222	731	4,415	9[illegible]3	......	......	......	......	......	......
30	263	......	210	621	4,710	539	......	......	......	......	......	......
31	263	......	222	......	4,760	......	......	......	......	......	......	......

Monthly discharge of Kawishiwi River near Winton.

[Drainage area, 1,200 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Per square mile.	
1905.					
June (21-30)	2,921	1,082	2,052	1.71	......
July	4,131	422	2,470	2.06	2.38
August	3,018	0	1,422	1.18	1.36
September	3,790	0	2,086	1.74	1.94
October	3,426	734	1,493	1.24	1.43
November	1,288	629	1,016	.847	.945
December	1,185	880	1,065	.888	1.02
The period	4,131	0	1,658	1.38	9.08
1906.					
January	856	523	672	.560	.646
February	506	360	444	.370	.385
March	360	289	326	.272	.314
April	2,600	276	901	.753	.840
May	3,212	1,682	2,446	2.04	2.35
June	3,327	1,344	2,690	2.24	2.50
July	2,276	455	1,012	.843	.972
August	1,275	0	588	.490	.565
September	435	263	348	.290	.324
October	400	250	310	.258	.297
November	998	400	654	.545	.608
December	660	360	477	.398	.459
The year	3,327	0	906	.755	10.26
1907.					
January	345	263	303	.252	.290
February	263	200	230	.192	.200
March	222	190	204	.170	.196
April	951	0	368	.307	.342
May	4,760	50	1,572	1.31	1.51
June	5,250	539	3,389	2.82	3.15
The period	5,250	0	1,011	.822	5.69

A. LOGGING DAM ON KAWISHIWI RIVER AT OUTLET OF GARDEN LAKE.



B. POWER PLANT OF CONSUMERS POWER CO. ON BLUE EARTH RIVER NEAR RAPIDAN.

STORAGE AND POWER.

To determine the storage and power possibilities of Kawishiwi River a survey was made in 1911 extending from Fall Lake through Garden, Farm, White Iron and Birch lakes, and 4 miles up Birch River (or the South Kawishiwi) from Birch Lake. The results of this survey are given on plate 31 of the atlas. In this portion of the river there are two storage reservoirs, both of which are utilized at the present time for log driving.

BIRCH LAKE RESERVOIR.

At the outlet of Birch Lake in sec. 31, T. 62 N., R. 11 W., there is a logging dam which raises the water level about 6 feet when the lake is filled. If this dam were raised approximately 10 feet or to elevation 1435, it would back the water more than 5 miles up Birch River. The banks of the lake and river are sufficiently high to stand this increased elevation without being overflowed to any considerable extent. The following table shows the capacity of the reservoir formed by the additional height on the dam:

Capacity of Birch Lake reservoir.

Contour.	Area Acres.	Capacity of Section. Acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
1,421.5	6,330	....	....	....
1,426.5	7,220	33,875	33,875	1,476,000,000
1,435	8,880	68,425	102,300	2,981,000,000

GARDEN LAKE RESERVOIR.

The existing logging dam at the outlet of Garden Lake raises the water level to an elevation of about 1,391 feet. If the dam were increased to elevation 1400, a comparatively small amount of land would be overflowed which is swampy in character. High-water elevation of 1400 would hold the water in Garden, Farm and White Iron lakes at the same level, and would hold the water in the North Kawishiwi for a distance of some 4 miles above Farm Lake.

The following table shows the capacity of the reservoir thus formed:

Capacity of Garden Lake reservoir.

Contour.	Area Acres.	Capacity of Section Acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
1,379	5,180	....	....	....
1,392	6,050	73,060	73,060	3,182,000,000
1,400	8,380	57,760	130,820	5,698,000,000

REGULATION OF FLOW.

The combined capacity of the Birch Lake and Garden Lake reservoirs is approximately 8.7 billion cubic feet. From the records of flow a mass curve was constructed to determine the regulation of flow possible with the storage capacity of 8.7 billion cubic feet. From this mass curve it is seen that had the reservoirs been empty at the beginning of July, 1905, it would have been possible to have regulated the discharge at Garden Lake outlet to obtain 1,050 second-feet from July 1, 1905, to April 1, 1906, and 750 second-feet from April 15, 1906, to April 1, 1907. The remainder of the time the flow would have been in excess of these quantities.

It is probable that the flow during 1905 and the first part of 1906 was in excess of that for a normal year, as rainfall records for northern Minnesota show the last half of 1905 to have had an excess of precipitation, the rainfall at Mount Iron, the nearest point of record being 42.83 inches for the entire year against 32 inches as the normal. The rainfall for 1906 was 29.17 inches at the same point, and that for the first half of 1907 about normal.

Water Power.—A study of plate 31 shows that there are two points on Kawishiwi River where the fall would be sufficient for important power developments. These are as follows:

At the Inlet to White Iron.—Above the 1400 contour which would be the highwater elevation of the lower or Garden Lake Reservoir there is a rise of 20 feet to the bottom of the dam at the outlet of Birch Lake. The topography at the entrance to White Iron Lake is favorable to the construction of a dam of that height. Owing to the uncertainty regarding the proportion of the total flow that comes from Birch Lake, no estimate of horsepower at the inlet to White Iron Lake has been made.

Between Garden and Fall Lakes.—From the bottom of the dam at the outlet of Garden Lake to the water level of Fall Lake, a distance of 0.6 of a mile, there is a fall of 61 feet. From the discussion of regulated flow, it is seen that by the operation of Garden Lake and Birch Lake reservoirs it would be possible to secure a regulated flow of 750 second-feet during a year, which would make available a development of 4,160 horsepower at 80% efficiency.

MINNESOTA CANAL AND POWER COMPANY PROJECT.[a]

[a]Compiled chiefly from records filed in the General Land Office at Washington.

This project contemplates the diversion of water from the Kawishiwi River drainage basin which is tributary to Rainy River (an international stream) for use in generating power in the vicinity of Duluth.

VIEWS OF BIRCH LAKE OUTSIDE THE FOREST RESERVE SHOWING CHARACTER OF LAND TO BE OVERFLOWED.

It is proposed to put a dam across the western end of Birch Lake in sec. SE ¼ of SE ¼ of 27, T. 61 N., R. 13 W., which will raise the water 20 feet. The flowage line at this elevation will include Birch Lake as far as the line between townships 61 and 62 in range 11, where a dam will be built to prevent the water flowing down the South Kawishiwi into White Iron Lake. The 20-foot contour line will extend up the South Kawishiwi to the SW ¼ of sec. 24, T. 62 N., R. 11 W., where a second dam is to be built in connection with a second reservoir. It will not extend up Stony River more than a few hundred feet. Three auxiliary dams are needed across low places. This reservoir will have a capacity of 12,172,000,000 cubic feet or 279,400 acre feet. The present area of Birch Lake is given as 5,950 acres and the flowage rights of surrounding land needed 6,307 acres.

A second reservoir is proposed by putting a 10-foot dam in the NE ¼ of NW ¼ of sec. 24, T. 62 N., R. 11 W. (mentioned above). The 10-foot contour will extend to sec. 4, T. 62 N., R. 10 W. (including the small lake in sec. 32, T. 63 N., R. 10 W.) From this point it coincides with the lake and river surface as far upstream as the line between the east half and the west half of SE ¼, sec. 24, T. 63 N., R. 10 W. It will extend westward on the North Kawishiwi as far as the line between the east half and west half of NW ¼ sec. 27, T. 63 N., R. 10 W., where a dam is to be built to prevent the overflow down the North Kawishiwi.

A third reservoir is proposed by building a main 12-foot dam in the SW ¼ SW ¼ sec. 9, T. 62 N., R. 10 W., at the outlet of Gabbro Lake. The 12-foot contour will cover Gabbro and Bald Eagle lakes and will extend up the South Branch of Isabella River 1.5 miles above Bald Eagle Lake.

The entire capacity of this reservoir is 3,100,700,000 cubic feet or 71,181 acre feet, and that of the upper 12 feet 1,528,000,000 cubic feet or 35,083 acre feet. It will be necessary to build five secondary dams across low places, chiefly at the lower end of Gabbro Lake.

From the western end of Birch Lake in sec. 27, T. 61 N., R. 13 W., a canal with a capacity of 694 second-feet will extend in a southwesterly direction until the channel of Embarrass River is reached in sec. 18, T. 60 N., R. 13 W. The river will be canalized to the above capacity as far as upper Embarrass Lake.

The diverted water will be allowed to flow through Embarrass and St. Louis rivers to a point a few miles above Cloquet. A diversion canal heading in sec. 16, T. 50 N., R. 17, will follow the river as far as Cloquet and then take an easterly direction to sec. 23, T. 49 N., R. 15 W., where it is proposed to generate the power.

The theoretical head at this point would be about 590 feet, showing a development of about 32,000 horsepower for the maximum 600 second-feet discharge.

As the canal from Birch Lake to Embarrass River will cross land on the public domain, permission has been obtained from the Federal Government for the right of way. In doing this, the company has not only complied with all existing requirements, but has agreed to meet any that may be imposed in the future. Although the legal difficulties were overcome in 1910 no work has actually been done up to the present time.

SANITARY STATISTICS.

Kawishiwi River drains one of the most sparsely settled sections of the State. Ely, with a population of 4,045, is the only town in the basin having a sewage system and municipal water supply. The source of the supply, which is passed through a mechanical sand filter, is Long Lake, a tributary of the Kawishiwi. The sewage is partially purified by an Imhoff settling tank and discharged into Long Lake.

Aside from the small saw mill town of Winton and a number of mines in that vicinity, there is practically no permanent rural population in the basin. During the winter months there are logging crews on the head waters of the South Kawishiwi (Birch River), but the size of this transient population is unknown. Owing to the many lakes it is probable that the greater number of sewage bacteria entering the waterways are elminated by sedimentation.

VERMILION RIVER.

SOURCE, COURSE AND TRIBUTARIES.

The portion of Rainy River Basin drained by Vermilion River lies south of Namekan River in St. Louis County. Vermilion River which rises in Vermilion Lake has its ultimate source in Pike River which rises in the southern part of T. 58 N., R. 17 W. From Vermilion Lake the general course of Vermilion River is northwest and then northeast, emptying into Crane Lake which in turn empties into Sand Point Lake and then into Namekan Lake which comprises one of the boundary waters. From Vermilion Lake to Crane Lake the length of the river is 42.5 miles. Throughout its course the river falls 245 feet. At the outlet of the lake, Vermilion River falls more than 50 feet in a series of falls in 3 miles. Below this point the river widens out into a chain of lakes which are 7 miles long and have an average width of a quarter of a mile. Their elevation is the same, as they were formed by the rock barrier at their outlet. Here the river descends 81 feet in 1 mile in a series of rapids. Below this fall the river consists of a series of level stretches separated by short rapids until the rice beds are reached. Here the river is level for 14 miles and meanders through the beds of wild rice. Its width in this stretch varies from a few hundred feet to a half mile. At the lower end of the rice beds there is a fall of 87 feet in 4 miles mostly in three series of rapids. The only important tributary is Pelican River, which enters Vermilion River about midway of its length. Other tributaries are the outlets of Elephant and Echo lakes.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

Vermilion Lake is extremely irregular in shape, covering an area of 71 square miles, with a shore line of approximately 147 miles. Tributary to Vermilion Lake and at a somewhat higher elevation is Trout Lake, which has an area of 11 square miles.

North of Vermilion Lake the drainage area embraces the region of light drift or bare rock (comprising granite rocks of the Archean system) and the topography is rugged, while the portion south of the lake is covered with glacial drift in which gravels predominate, and little or no rock is exposed. The topography of this southern portion is much smoother with a gradual rise to the Mesabi Range of hills which rise to 1,800 feet above sea level and form the southern boundary of the basin. The range of elevation within the basin is from 1,100 to 1,450, except the southern boundary, which rises to 1,800 feet or more.

North of the south line of T. 65 N. there is very little swamp land as drainage is good, but south of that, much of the basin lies in the drift covered area, where drainage is poor and one-third the land area swampy. None of this has been drained. The entire area is forested, there being dense tracts of conifers interspersed with tracts where the timber is more scanty. Many thousand acres have been burned over within the last few years and in many places the fire has done serious injury to the soil. There is very little cleared land, as settlers are few and scattered widely.

RAINFALL.

No long time rainfall records are available within the basin except at Tower, which cover the complete years from 1896 to 1903, inclusive. From these records and from the general trend of the lines of equal rainfall in Northern Minnesota, it is believed that the mean annual precipitation varies from 29 inches in the upper portion of the area to 27 inches at the mouth. Of this amount about 5½ inches occur as snow. The highest record at Tower was 35.8 inches in 1899, and the lowest 22.6 inches in 1900. It is very probable that the rainfall for 1910 was considerably lower as it was the driest year in many years throughout the state. At Duluth. the nearest point, the rainfall for 1910 was 18.1 inches.

REGULATION OF FLOW.

The flow of Vermilion River is naturally regulated to a great extent by Vermilion Lake, which drains more than one-half the entire basin. The flow is not controlled artificially, as the only dam is a loose rock structure at the outlet of the lake, which raises the water about 2 feet in Vermilion Lake in the interest of navigation. The effect of this regulation is seen in the comparatively uniform runoff which has a range of 1.7 feet at the outlet of the lake, and a variation in flow from 89 to 622 second-feet.

NAVIGATION.

Owing to the heavy fall of the river there is no navigation on Vermilion River, but a number of small steamers navigate Vermilion Lake, and rafts of logs are towed across it between various points. Vermilion Lake has many summer cottages on its shores and much of the navigation is due to the summer residents.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Vermilion River basin.

River.	Drainage area above.	Square miles.
Vermilion	Vermilion Lake outlet	507
Do	Lower end of Chain Lakes	610
Do	Mouth Pelican River	640
Do	Entrance to Crane Lake	927
Pike	Mouth	185
Pelican	Pelican Lake outlet	71
Do	Mouth	204

GAGING STATION RECORDS.

VERMILION RIVER BELOW LAKE VERMILION.

Location.—Just below the dam at the outlet of Lake Vermilion in Sec. 2, T. 63 N., R. 17 W., in St. Louis County, 4 miles above the mouth of Twomile Creek which enters from the west.

Records available.—May 17, 1911, to December 31, 1912.

Drainage area.—507 square miles.

Gage.—Vertical staff.

Channel.—Permanent.

Discharge measurements.—Made by means of car and cable just above the gage section.

Winter flow.—Owing to the heavy fall at the gage station, amounting to 20 feet in 200 yards, there is little or no backwater from ice during the winter months.

Accuracy.—Conditions are favorable for fairly accurate results, the only uncertainty being some inaccuracy in the discharge measurements owing to the very rocky section, but the results should be well within 10 per cent of the true value.

Daily discharge, in second-feet, of Vermilion River below Lake Vermilion.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1	......	......	......	......	......	490	490	272	167	158	132	130
2	......	......	......	......	......	490	466	272	167	158	127	130
3	......	......	......	......	......	515	442	266	167	156	124	130
4	......	......	......	......	......	490	420	266	167	156	120	130
5	......	......	......	......	......	490	411	263	167	158	117	130
6	......	......	......	......	......	490	407	263	187	158	114	130
7	......	......	......	......	......	490	402	266	321	158	114	130
8	......	......	......	......	......	515	358	263	321	156	114	130
9	......	......	......	......	......	515	358	263	321	156	114	130
10	......	......	......	......	......	568	321	260	257	156	114	130
11	......	......	......	......	......	556	304	260	231	156	114	130
12	......	......	......	......	......	546	287	257	208	158	114	130
13	......	......	......	......	......	540	272	257	208	156	114	130
14	......	......	......	......	......	540	266	244	208	156	114	130
15	......	......	......	......	......	540	257	244	208	156	114	130
16	......	......	......	......	......	515	272	231	208	156	114	130
17	......	......	......	......	515	500	272	231	187	158	117	130
18	......	......	......	......	540	495	257	231	187	159	119	130
19	......	......	......	......	595	490	257	244	183	159	122	130
20	......	......	......	......	540	622	231	244	179	158	127	130
21	......	......	......	......	515	595	208	244	175	156	130	130
22	......	......	......	......	540	568	257	236	167	154	130	130
23	......	......	......	......	568	568	257	231	167	152	130	130
24	......	......	......	......	540	540	257	208	167	148	130	130
25	......	......	......	......	515	540	257	208	167	144	130	130
26	......	......	......	......	490	515	272	187	167	141	130	130
27	......	......	......	......	490	515	272	187	167	137	130	130
28	......	......	......	......	490	490	272	187	163	134	130	130
29	......	......	......	......	490	490	263	187	159	132	130	130
30	......	......	......	......	490	490	263	167	158	130	130	130
31	......	......	......	......	515	......	263	167	......	130	......	130
1912.												
1	130	122	106	93	208	540	340	122	107	114	100	......
2	130	122	103	93	231	540	321	122	107	114	100	......
3	130	122	103	93	257	540	321	122	107	114	100	......
4	130	122	103	93	287	515	304	114	107	114	100	......
5	130	122	103	93	321	515	287	114	114	114	100	......
6	130	122	103	93	358	515	287	114	114	114	100	......
7	130	122	103	93	398	490	287	114	114	114	100	......
8	130	122	100	97	420	490	272	114	114	114	100	......
9	130	122	100	100	442	490	272	107	114	114	100	......
10	130	122	100	100	490	490	257	107	114	114	100	......
11	130	120	100	100	490	515	244	107	114	114	100	......
12	130	119	100	103	540	515	244	107	114	114	100	......
13	130	119	100	100	540	490	244	107	114	114	100	......
14	130	117	94	107	568	466	257	100	114	114	100	......
15	130	117	92	107	568	466	244	100	114	114	100	......
16	130	116	89	107	568	442	244	100	114	114	100	......
17	130	116	89	110	568	442	244	100	114	114	100	......
18	127	114	89	114	568	442	148	100	114	114	100	......
19	127	114	89	119	595	442	148	100	114	114	100	......
20	127	114	89	122	595	420	130	100	114	107	100	......
21	127	114	89	127	595	420	130	100	114	107	100	......
22	122	114	89	130	595	420	130	100	114	107	100	......
23	122	114	89	130	568	420	130	100	114	107	100	......
24	122	114	89	130	568	398	130	100	114	107	100	......
25	122	114	89	139	568	398	122	100	114	107	100	......
26	122	114	90	148	568	378	122	107	114	107	100	......
27	122	111	92	158	568	378	122	107	114	107	100	......
28	122	108	93	158	540	358	122	107	114	107	100	......
29	122	106	93	167	540	340	122	107	114	107	100	......
30	122	......	93	177	540	340	122	107	114	107	100	......
31	122	......	93	......	540	......	122	107	......	107	......	......

NOTE.—Daily discharge computed from a rating curve well defined.

Monthly discharge of Vermilion River below Lake Vermilion.
[Drainage area, 507 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
May (17-31)	595	490	522	1.03	0.57	A
June	622	490	524	1.04	1.16	A
July	490	208	309	.609	.70	A
August	272	167	236	.466	.54	A
September	321	158	197	.389	.43	A
October	159	130	152	.300	.35	A
November	132	114	122	.241	.27	B
December	130	130	130	.256	.30	B
1912.						
January	130	122	127	.250	.29	A
February	122	106	117	.231	.25	A
March	106	89	95.3	.188	.22	A
April	177	93	117	.231	.26	A
May	595	208	490	.966	1.11	A
June	540	340	454	.895	1.00	A
July	340	122	209	.412	.48	B
August	122	100	107	.211	.24	B
September	114	107	113	.223	.25	B
October	114	107	111	.219	.25	B
November	100	100	100	.197	.22	B

UNDEVELOPED WATER POWER.

FEASIBLE, SITES.

To determine the water power possibilities of Vermilion River which lies in a region that is little known, a survey of the river from the outlet of Vermilion Lake to its entrance into Crane Lake was made in 1911. The results of this survey are given on plates 84 to 86, inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Vermilion River from Vermilion Lake to Crane Lake

Stations.	Distance in miles.		Elevation in feet above sea level	Descent in feet between points.	
	Below Vermilion Lake	Point to Point		Total	Per mile
Vermilion dam, crest	0.0		1,360.2		
foot	0.0	0.0	1,357	3.2	
Foot of Rapids	0.2	.2	1,338	19	95.0
Head of Second Rapids	1.3	1.1	1,338	0	0.0
Foot of Second Rapids	1.5	.2	1,318.5	19.5	97.5
Head of Third Rapids	2.5	1.0	1,317	1.5	1.5
Foot of Third Rapids	3.2	.7	1,307.5	9.5	13.6
Two Mile Creek	4.4	1.2	1,307.5	0	0.0
Head of Rapids at lower end of Chain Lakes	10.5	6.1	1,307.5	0	0.0
Foot of Rapids	11.3	.8	1,223	84.5	105.6
Section line 23-26	13.1	1.8	1,219.5	3.5	1.9
Bridge at Halfway House	15.9	2.8	1,212.5	7	2.5
Township line 65-66	19.0	3.1	1,211.5	1	0.3
Pelican River	21.2	2.2	1,210.5	1	0.5
Head of Rapids	22.6	1.4	1,210.5	0	0.0
Foot of Rapids	22.8	.2	1,204	6.5	32.5
Head of Rapids at lower end of Rice Beds	37.6	14.8	1,201.5	2.5	0.2
Foot of Rapids	38.4	.8	1,161	40.5	50.6
Head of Rapids	41.0	2.6	1,160	1	0.4
Foot of Rapids	41.9	.9	1,115.5	44.5	49.4
Crane Lake	42.4	.5	1,115.4	.1	0.2

A. DAM AT OUTLET OF VERMILION LAKE.

B. FALLS ON VERMILION RIVER AT ENTRANCE TO CRANE LAKE.

A study of the foregoing table and the topography as shown on the accompanying sheets shows the following possible developments:

At the outlet of Vermilion Lake.—The river falls 40 feet in a distance of about 7,000 feet, chiefly in two series of rapids, the first having a fall of 22 feet in a few hundred feet, and the second, 18 feet in a like distance. A low diversion dam 200 feet long at the outlet of the lake to replace the existing loose rock structure, with a canal about 7,000 feet long, and a short pipe line at the lower end would give an available head of about 37 feet at the low water elevation of Vermilion Lake.

As the lake is used extensively as a summer resort, it would probably not be feasible to raise the water level to any considerable extent to provide for storage.

At the lower end of Chain Lakes.—Between the lower end of the second rapids mentioned above and the outlet of Chain Lakes the river has practically no fall, but at the latter point it falls 84 feet in a distance of 4,400 feet. By raising the water surface 13 feet on Chain Lakes a head of 100 feet would be available. The land overflowed would amount to 2,900 acres, most of which is swampy in character. None of it is under cultivation, nor does it contain habitations, as it is regarded as of little value.

The capacity of the proposed reservoir is as follows:

Capacity of Chain Lakes reservoir.

Contour.	Area Acres.	Capacity of Section. Acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
[a]1,307	1,072	....	....	....
1,310	2,538	5,415	5,415	236,000,000
1,315	3,314	14,630	20,045	873,000,000
1,320	3,969	18,210	38,255	1,666,000,000

[a] Present water surface.

As no runoff data prior to May, 1911 are available, it is impossible to state what the effect of the above reservoir on the low water flow would be in general. Fortunately, 1911 was a low year, and the effect for that year can be determined. In order to secure a uniform flow for 12 months beginning with the highwater in May, 1911, it would have been necessary to have available storage of about 1,300,000,000 cubic feet. From the above table it is seen that if the lower limit of draft were 1,310 feet, the upper 10 feet of the reservoir would give this amount. Thus with a minimum head of 90 feet there would have been a uniform continuous flow of 210 second-feet for the year. It is fair to assume that as 1911 was a low year, that a storage capacity of 1,400,000,000 cubic feet would insure a flow of 210 second-feet for an average low year.

Below the rice beds.—From the foot of Chain Lakes rapids to the lower end of the rice beds, a distance of 26.3 miles, the river has a fall of 22 feet, which is chiefly concentrated in two rapids near the upper end.

A 50-foot dam in sec. 30, T. 67 N., R. 17 W., at the foot of the first rapids below the rice beds, would store water to a depth of 17 feet on the rice beds and overflow an area of 2,160 acres of swamp and wild rice. The capacity of the reservoir thus formed is as follows:

Capacity of Rice Beds reservoir.

Contour.	Area Acres.	Capacity of Section. Acre-feet.	Total Capacity.	
			Acre-feet.	Cubic feet.
1,203	[a]1,200	....	....	....
1,210	2,397	12,586	12,586	548,000,000
1,220	3,828	31,320	43,706	1,904,000,000

[a] Estimated.

To assure a uniform, continuous flow for the 12 months beginning with May, 1911, it would be necessary to have a storage capacity of 1.9 billion cubic feet if the flow at Chain Lakes were not regulated artificially. The capacity of the Rice Beds reservoir is 1.904 billion cubic feet, which would necessitate the entire draft of 17 feet being utilized. With a total head of 50 feet this would leave a minimum head of 33 feet available for power development.

If the flow from Chain Lakes were regulated, giving a uniform flow of 210 second-feet, the storage needed at the Rice Beds reservoir would be about 600,000,000 cubic feet. As the upper 5 feet of the reservoir has a capacity of approximately 650,000,000 this would be sufficient to regulate the flow, leaving a minimum power head of 45 feet.

At the entrance to Crane Lake.—A 55-foot dam in sec. 22, T. 67 N., R. 17 W., at the foot of the rapids leading into Crane Lake, would back the water nearly to the rapids below the rice beds. This dam would overflow 100 acres of land, none of which is under cultivation nor inhabited.

AVAILABLE HORSEPOWER.

In determining the available horsepower at the various sites, the only data available are the records of flow at the outlet of Lake Vermilion since May, 1911. As the flow at the outlet is so regulated by the lake, the runoff per square mile cannot be used as a basis in determining the flow at points further down the river. The following method has been used instead: The runoff from the additional areas has been determined by means of the runoff per square mile of the Little Fork at Little Fork (the most comparable records). As in the case of Chain Lakes and the rice beds, a deduction from the computed flow has been made for evaporation from the water surfaces.

With the discharge as determined above, the following estimates of horsepower have been made:

Undeveloped horsepower on Vermilion River.

Site	Head in feet	Minimum Run-off			Horsepower (80% Efficiency)		
		Lowest month	6 Highest months	Regulated	Lowest month	6 Highest months	Regulated
Vermilion Lake	37	95	152	....	320	511	....
Chain Lakes	90	93	164	210	761	1,342	1,718
Rice Beds	33	101	227	265	303	681	795
Rice Beds	[a]45	....	....	265	....	....	1,084
Crane Lake	55	101	227	265	505	1,135	1,325

[a] Available head if both Chain Lakes and Rice Beds reservoirs were operated.

SANITARY STATISTICS.

There are no towns having municipal water supplies or sewage systems in the Vermilion River basin. The only town is Tower with a population of 1,111. Above Vermilion Lake the population is 3.8 per square mile. Owing to the size of Vermilion Lake it is probable that sedimentation removes the greater number of any sewage bacteria which may enter the lake. The portion of the basin below Vermilion Lake has a permanent population of 2.1 per square mile. During the winter months this is increased somewhat by logging crews.

LITTLE FORK RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Little Fork River, the largest tributary of Rainy River from the Minnesota side, rises in the central part of St. Louis county, a few miles south of Vermilion Lake, at an elevation of about 1,440 feet above sea level, and flows westward and then northwestward to its junction with Rainy River, about 12 miles below International Falls. Fifteen miles below its source it receives Rice River from the southeast, and about 15 miles farther down stream it is joined by Sturgeon River, its principal tributary. Other tributaries are Valley, Cross and Net Lake rivers, and Beaver and Willow creeks. The total length of the river is about 160 miles.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The river meanders through a narrow valley between wooded banks and throughout its length there are very few clearings. The region is flat and is deeply covered with blue till—a mixture of clay, sand and gravel, which is underlain by crystalline rocks. Rock outcrops in a few places along the river. Altitudes in the basin range from 1,100 to 1,450 feet. The greater part of the area is too wet for cultivation without being drained and little drainage work has been done up to the present time. The State has constructed one system which empties into Little Fork River a short distance below Little Fork and benefits 29,000 acres.

The area supports a dense growth of heavy timber of white and Norway pine, spruce, cedar, balsam and tamarack. There is very little cleared land within the basin.

RAINFALL.

There are no rainfall records at points within the basin, the nearest points being International Falls, Tower and Lake Winnibigoshish. Those at International Falls are too fragmentary to be utilized in determining the mean rainfall. From the remaining records and from the general trend of the lines of equal rainfall for the northern part of the State, it is evident that the mean annual rainfall ranges from about 30 inches in the upper end of the basin to 25 inches near the mouth of the river. Of this amount 5½ inches fall as snow. The longest record is at Lake Winnibigoshish which shows that the wettest year since 1888 was 1905 when 36.6 inches fell. The driest year was 1910 when the rainfall was 18 inches.

FLOODS AND REGULATION OF FLOW.

Little Fork River, especially in its lower course, is subject to rises of as much as 15 or 20 feet in the spring of the year due to melting snow and heavy rains. Except in the extreme upper portion of the basin there are practically no lakes except Net Lake on one of the tributaries, and an absence of the natural regulation of lakes is seen in the highwater which is more marked on this river than on the Big Fork where conditions are similar except that in the latter case there is a considerably larger percentage of lake area. Although there are extensive areas of swamp in the basin, their effect is not sufficient to modify the flow to any great extent, unaided by lakes.

Although Little Fork River is used extensively for log driving there are no logging dams on the main river. The flow of one or two upper tributaries is controlled somewhat by logging dams. The Minnesota Forest Service has made the following estimates of log driving on Little Fork River: 1908, 20,000,000 feet; 1909, 30,000,000 feet; 1910, 60,000,000 feet; 1911, none; 1912, 50,000,000. A lack of water in 1911 caused the drives to become jammed on the rapids in most instances, forcing their abandonment for the season.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Little Fork River basin.

River.	Drainage area above.	Square Miles.
Little Fork	Mouth of Sturgeon River	358
Do	Little Fork Gaging Station	1,720
Do	Mouth	1,900
Sturgeon	Mouth Bear River	317
Do	Mouth	527
Bear	Mouth	196
Willow	Mouth	74
Net Lake River	Mouth	211
Beaver Brook	Mouth	119

GAGING STATION RECORDS.

LITTLE FORK RIVER AT LITTLE FORK.

Location.—At the lower of the two highway bridges in Little Fork in Sec. 9, T. 68 N., R. 25 W., 1½ miles above the mouth of Beaver Brook.

Records available.—June 23, 1909, to December 31, 1912.

Drainage area.—1,720 square miles.

Gage.—Vertical staff; datum unchanged since establishment.

Channel.—Permanent, except for temporary backwater from log jams at the railroad bridge below the station.

Discharge measurements.—Made from the bridge.

Winter flow.—The river is completely frozen over at the station from November to April.

Utilization.—Log driving, although there are no logging dams on the river for the purpose of controlling the natural flow.

Accuracy.—Conditions at the station are favorable and therefore the records of flow should be reliable.

Daily discharge, in second-feet, of Little Fork River at Little Fork.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							240	247	1,030	708	1,360	
2							237	224	900	634	1,240	
3							224	208	757	614	1,170	
4							208	215	667	518	1,090	
5							199	237	940	463	980	
6							193	291	512	393	932	
7							184	304	440	371	864	
8							184	502	405	344	802	
9							178	852	371	347	621	
10							166	896	330	377	680	
11							148	1,650	291	422	750	
12							137	3,760	286	472	694	
13							141	4,120	266	487	598	
14							166	4,380	266	487		
15							160	4,240	254	518		
16							160	3,980	247	598		
17							156	3,650	242	630		
18							164	3,120	228	687		
19							189	2,070	237	698		
20							193	1,860	247	778		
21							193	1,260	268	1,230		
22							197	1,080	288	2,010		
23						377	193	932	360	2,340		
24						360	184	908	382	2,700		
25						333	252	908	640	2,700		
26						307	294	868	920	2,560		
27						296	307	852	988	2,410		
28						281	347	868	988	2,180		
29						268	358	1,050	920	1,860		
30						261	328	1,080	802	1,600		
31							286	1,140		1,490		
1910.												
1					1,390	565	201	271	91	119	176	
2					1,290	512	186	215	92	176	158	
3					1,190	457	146	180	96	197	172	
4					1,080	457	105	172	79	208	176	
5					1,000	472	123	172	40	197	197	
6					900	457	110	156	72	197		
7					816	472	86	128	79	176		
8					768	518	83	119	92	176		
9					732	502	75	119	86	166		
10					650	442	79	110	94	152		
11				2,200	578	411	112	94	94	137		
12				1,940	581	358	119	110	96	137		
13				1,750	546	344	119	110	102	152		
14				1,600	512	330	99	102	99	146		
15				1,490	487	278	123	116	86	137		
16				1,720	457	247	123	110	73	128		
17				2,310	442	237	146	105	72	119		
18				4,580	457	228	156	110	86	119		
19				5,000	454	210	102	116	83	193		
20				4,770	451	193	102	116	80	156		
21				4,610	524	172	99	112	102	160		
22				4,200	575	158	137	110	112	156		
23				3,430	647	148	146	107	100	154		
24				2,870	680	137	123	110	86	156		
25				2,510	698	126	123	110	86	176		
26				2,280	647	119	133	110	86	176		
27				2,040	647	112	133	110	86	176		
28				1,860	647	112	304	96	86	176		
29				1,690	680	242	371	94	96	176		
30				1,490	667	266	358	91	119	176		
31					588		304	91		176		
1911.												
1				900	1,540	1,190	363	665	458	395	289	
2				1,000	1,480	1,540	365	793	429	398	289	
3				1,150	1,410	1,770	312	738	354	412	289	
4				1,400	1,300	1,950	269	705	325	438	289	
5				1,400	1,150	2,260	252	690	368	482	289	

Daily discharge, in second-feet, of Little Fork River at Little Fork—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6				1,450	989	2,320	245	630	438	479	289	
7				1,500	890	2,610	235	630	529	452	289	
8				1,570	793	2,260	216	701	756	438	289	
9				1,400	774	2,460	198	665	811	409	289	
10				1,320	719	2,540	186	605	909	390		
11				1,310	793	2,540	182	562	917	354		
12				1,790	850	2,530	173	438	909	328		
13				1,800	862	2,530	163	485	870	328		
14				1,850	890	2,520	154	510	831	320		
15				1,950	901	2,510	150	513	756	315		
16				3,600	905	2,500	150	458	701	320		
17				3,400	862	2,500	150	429	578	341		
18				3,730	1,010	1,920	150	423	482	341		
19				3,580	1,230	1,780	148	373	482	368		
20				3,370	1,170	1,480	148	331	452	368		
21				3,160	1,110	1,190	150	289	429	368		
22				3,160	1,230	993	150	328	368	354		
23				2,980	1,320	811	142	289	328	341		
24				2,760	1,250	679	150	276	315	328		
25				2,530	909	647	158	274	328	289		
26				2,240	909	581	160	331	302	289		
27				2,050	1,010	476	191	382	289	284		
28				1,900	1,590	443	250	458	315	269		
29				1,720	1,540	406	259	426	438	264		
30				1,630	1,190	390	240	423	409	279		
31					1,030		513	423		289		
1912.												
1					2,000	910	395	160	289	1,030	341	
2					2,040	970	756	140	302	989	341	
3					2,080	1,030	719	150	289	870	341	
4					2,180	793	513	130	276	793	341	
5					2,660	793	423	112	1,360	719	341	
6					2,710	793	341	130	1,110	683	341	
7					3,060	831	341	130	1,320	683	341	
8					3,210	756	368	130	1,280	578	341	
9					3,110	793	341	130	1,320	513	341	
10					3,160	719	341	130	1,280	578	341	
11					3,110	395	289	130	1,190	578	341	
12					3,160	482	289	130	870	545	328	
13				2,130	3,310	545	289	130	949	578	328	
14				1,900	3,260	578	368	112	831	513	315	
15				1,820	2,910	545	341	112	719	545	315	
16				1,590	3,160	513	264	97	647	545	315	
17				1,410	2,910	482	240	112	578	513		
18				1,460	2,660	482	240	121	513	482		
19				1,360	2,360	513	216	130	395	452		
20				1,320	2,360	545	193	130	315	452		
21	64			1,230	2,130	612	204	130	315	395		
22				1,190	1,860	578	193	130	341	423		
23				1,070	1,720	513	193	130	423	423		
24				793	1,500	482	193	130	513	395		
25				719	1,190	423	193	130	612	368		
26		73		909	1,410	395	193	130	719	368		
27				1,540	1,230	341	204	130	756	328		
28				1,860	1,190	289	193	150	909	289		
29				1,900	1,070	264	193	216	989	368		
30			67	1,950	793	264	193	264	647	368		
31					850		193	264		341		

Daily discharges based on a well defined rating curve. Discharge estimated April 1 to 7, 1911, owing to ice, and April 12 to 20 and June 10 to 17, 1911, and April 29 to May 2, May 15 to 25, owing to backwater from log jams. From July 13 to August 31, 1912, the discharge has been reduced on account of backwater from floating logs.

Monthly discharge of Little Fork River at Little Fork.

[Drainage area, 1,720 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (23-30)	377	261	310	0.180	0.05	A
July	358	137	212	.123	.14	A
August	4,380	208	1,540	.895	1.03	C
September	1,030	228	516	.300	.33	B
October	2,700	344	1,080	.628	.72	B
November (1-13)	1,360	598	680	.395	.19	B
1910.						
April (11-30)		1,490	2,720	1.58	1.17	B
May	1,390	442	703	.409	.47	A
June	565	112	309	.180	.20	A
July	371	75	149	.087	.10	A
August	271	91	125	.073	.08	A
September	119	72	88.4	.051	.06	A
October	208	119	163	.095	.11	A
November			[a]160	.093	.10	B
1911.						
April	3,730	900	2,100	1.22	1.36	B
May	1,590	719	1,080	.628	.72	A
June	2,610	390	1,680	.977	1.09	B
July	513	142	212	.123	.14	A
August	793	274	492	.286	.33	A
September	917	289	529	.308	.34	A
October	482	264	356	.207	.24	A
November	289		209	.122	.14	C
December			145	.084	.10	C
1912.						
January			85	.049	.06	C
February			75	.044	.05	C
March			70	.041	.05	B
April			1,130	.657	.73	C
May	3,310	793	2,270	1.32	1.52	B
June	1,030	264	588	.342	.38	B
July	756	193	304	.177	.20	C
August	264	97	140	.081	.09	C
September	1,360	276	735	.427	.48	C
October	1,030	289	539	.313	.36	B
November			318	.185	.21	C

[a] Estimated.

NOTE.—From November 10, 1911, to April 12, and November 17 to 30, 1912, the discharge was estimated from discharge measurements, observer's reports, and climatological records.

UNDEVELOPED WATER POWER.

To determine the power possibilities of Little Fork River a survey was made from Sec. 16, T. 62 N., R. 21 W., to the mouth of the river. The results of the survey are published on plates 32 to 36 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Little Fork River.

Point.	Distance in miles		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Rainy River	0	.....	1,073	.....	.....
Range line 25-26 W	5.0	5.0	1,074.5	1.5	0.3
Section line 18-19, T. 69 N., R. 25 W	9.3	4.3	1,075.5	1	.2
Section line 31-32, T. 69 N., R. 25 W	14.0	4.7	1,076.5	1	.2
Lower bridge at Little Fork	20.6	6.6	1,080.5	4	.6
Crest of Rapids	21.0	.4	1,089	8.5	21.2
Section line 14-15, T. 68 N., R. 25 W	24.2	3.2	1,092.5	3.5	1.1
Crest of Flatrock Rapids	29.1	4.9	1,097	4.5	.9
Township line 67-68 N	36.3	7.2	1,101	4	.6
Section line 7-8, T. 67 N., R. 24 W	41.5	5.2	1,106	5	1.0
Section line 16-17, T. 67 N., R. 24 W	44.0	2.5	1,112	6	2.4
Range line 24-25 W	49.8	5.8	1,115.5	3.5	6
Net Lake River	53.8	4.0	1,120.5	5	1.2
Section line 13-14, T. 66 N., R. 25 W	58.3	4.5	1,125	4.5	1.0
Section line 30-31, T. 66 N., R. 24 W	63.0	4.7	1,128	3	.6
Foot of Rapids	65.8	2.8	1,136	8	2.9
Crest of Rapids	66.2	.4	1,143.5	7.5	18.8
Foot of Rapids	72.8	6.6	1,145.5	2	.3
Crest of Rapids	73.5	.7	1,153	7.5	10.7
T. 65 N., R. 25 W., T. 64 N., R. 24 W.	79.4	5.9	1,156.5	3.5	.6
.....	85.0	5.6	1,160.5	4	.7
.....	89.2	4.2	1,163.5	3	.7
Crest of Rapids	92.7	3.5	1,184	20.5	5.9
Willow Creek	100.2	7.5	1,190	6	.8
Crest of Rapids	101.9	1.7	1,195	5	2.9
Koochiching-St. Louis County line	103.6	1.7	1,198.5	3.5	2.1
Crest of Falls	103.8	0.2	1,205	6.5	32.5
Foot of Rapids	109.6	5.8	1,210	5	.9
Crest of Rapids	110.9	1.3	1,217	7	5.4
Section line 3-4, T. 62 N., R. 21 W	112.7	1.8	1,219	2	1.1
Crest of Rapids	113.3	.6	1,227	8	13.3
Foot of Falls	116.5	3.2	1,232	5	1.6
Crest of Falls	116.6	.1	1,241.5	9.5	.....
Foot of Big Falls	121.5	4.9	1,245.5	4	.8
Crest of Big Falls	121.9	.4	1,268.5	23	57.5

The survey was not carried beyond the big falls as above that point the runoff is too small to permit power development of importance. A study of the survey sheets shows that at the following points the topography is favorable for power development.

In sec. 4, T. 62 N., R. 21 W.—At mile 110.9, a mile below the mouth of Sturgeon River a dam 55 feet high varying from 150 to 400 feet in length would back the water 5 feet deep on the crest of the big falls at mile 122. The water would be backed up Sturgeon River more than 8 miles. With this height dam the amount of timber and brush land overflowed would be comparatively small. The topography at the dam site would permit a dam 65 feet to be built but this would overflow a considerably larger area than the lower dam.

In sec. 23, T. 64 N., R. 23 W.—A 38-foot dam at mile 89.8 varying in length from 120 to 400 feet would back the water 14 miles upstream to the crest of the rapids just west of the Koochiching-St. Louis County Line. A small amount of timber and brush land would be overflowed.

In sec. 30, T. 66 N., R. 24 W.—If a 37-foot dam varying in width from 200 feet at the water surface to 500 feet at the crest, were built at mile 61.9, it would back the water 18 miles upstream nearly to the site in section 23. Very little land would be overflowed.

In sec. 25, T. 68 N., R. 25 W.—A 28-foot dam varying in length from 150 to 500 feet, built at mile 31.1 would back the water 27 miles upstream nearly to the site in Section 30. A considerable area of timbered and brush land would be overflowed.

In sec. 19, T. 69 N., R. 25 W.—A 20-foot dam 200 to 400 feet long at mile 11 would back the water 17.5 miles upstream to Flatrock Rapids above Little Fork. Owing to the height of the banks very little land would be overflowed.

The lower 11 miles of the river have such a slight fall that power development in that stretch is not feasible, especially as water from Rainy River may cause backwater.

AVAILABLE HORSEPOWER.

Records of flow of Little Fork River have been compiled since 1909 but during only one winter period, that of 1911 and 1912 were the records maintained. The flow for that period was extremely low as shown by comparative records at other points and therefore, it is probable that power estimates based on those records will represent very nearly the absolute minimum to be expected.

Owing to lack of data it is impossible to estimate the available power during the lowest month of an ordinary low year but it is doubtless considerably in excess of that for the lowest month recorded.

The following table shows the available power at each site described above, based on the available records of flow:

Undeveloped power on Little Fork River

Site.	Head in feet.	Minimum Runoff.		Horsepower (80% Efficiency).	
		Lowest month.	6 Highest months average low year.	Lowest month.	6 Highest months average low year.
Sec. 4, T. 62 N., R. 21 W.	55	36	171	180	855
Sec. 23, T. 64 N., R. 23 W.	38	47	212	162	732
Sec. 30, T. 66 N., R. 24 W.	37	54	243	182	817
Sec. 25, T. 68 N., R. 25 W.	28	68	289	173	736
Sec. 19, T. 69 N., R. 25 W.	20	74	313	135	569

SANITARY STATISTICS.

There are no settlements in the basin of Little Fork River of sufficient size to have municipal water supplies or sewage systems, and therefore no urban sewage enters the river. The permanent rural population is 2.5 per square miles. This is increased during the winter months by the logging crews which operate on the headwaters. The size of this transient population is unknown.

BIG FORK RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Big Fork River, the second largest tributary of Rainy River from the Minnesota side, rises in Jessie Lake in T. 147 N., R. 25 W., in Itasca County, at an elevation of about 1320 feet above sea level. It flows into Bowstring Lake, thence north into Wabatawangang Lake and thence east and north into Rainy River near Laurel. Its chief tributaries are Caldwell Brook, Sturgeon River, Deer Lake outlet, and Rice River. The entire length of the river is about 175 miles.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The entire basin is covered with a sheet of blue till. In a large part of the area the till is covered with deposits of lacustrine clay from the glacial Lake Agassiz. So thick is the drift that rock outcrops are not found except in a few places along the river

Underlying the glacial deposits are crystalline schists, gneisses, and greenstones. Some outcrops of cretaceous rocks are also found. The big falls where the river descends 36 feet in a few hundred yards are caused by an outcrop of Archean schist.

The region is very flat and so poorly drained that, except in a comparatively narrow strip along Big Fork River, the area is swampy. There is very little cleared land in the basin, as settlers are few and the entire area is heavily forested, with a dense growth of white and Norway pine, spruce, cedar, balsam, and tamarack. Altitudes range from 1080 to 1325 feet above sea level. There are practically no lakes in the basin below the outlet of Lake Wabatawangang, but above that point about 15 per cent of the area is water surface.

RAINFALL.

There are no rainfall records at points within the basin, the nearest points being International Falls, and Lake Winnibigoshish. The records at International Falls are too fragmentary to be utilized in determining the mean rainfall. From the records at Lake Winnibigoshish and from the general trend of the lines of equal rainfall for the northern part of the State, it is evident that the mean annual precipitation varies from 27 inches in the upper portion to 25 inches at the mouth. Of this amount about 4½ inches occur as snow. From the Lake Winnibogoshish records, it is seen that since 1888, the wettest year was 1905 when 36.6 inches fell. The driest year was 1910 when the rainfall was 17.2 inches.

FLOODS AND REGULATION OF FLOW.

The extensive lake and swamp areas, the former in the upper portion of the basin, exert such a natural regulating effect upon the flow, that the river is not subject to severe floods.

Although Big Fork River is used extensively for lóg driving, there are no logging dams to control the flow. The Minnesota Forest Service has made the following estimates of log driving on Big Fork River: 1908, 45,000,000 feet; 1909, 40,000,000 feet; 1910, 80,000,000 feet; 1911, none; 1912, 100,000,000 feet. A lack of water in 1911 caused the drives to become jammed on the rapids and impeded the progress seriously. It is believed however, the Forest Service estimate is in error for 1911, and that a considerable number of drives reached the mills at Baudette and Spooner.

DRAINAGE WORK.

Although a large portion of the basin is swampy, practically the only drainage done is the construction of two systems by the State which benefit 52,000 acres in the central portion.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in Big Fork River basin.

River.	Drainage area above.	Square miles.
Big Fork	Lake Wabatawangang	259
Do	Caldwell Brook	921
Do	Big Falls gaging station	1,320
Do	Mouth	1,840
Caldwell Brook	Mouth	163
Sturgeon River	Mouth	286
Bear River	Mouth	90

GAGING STATION RECORDS.

BIG FORK RIVER AT BIG FALLS.

Location.—At Big Falls, about 500 feet below the lower end of the rapids.

Records available.—August 27, 1909 to December 31, 1912.

Drainage area.—1,320 square miles.

Gage.—Vertical staff. The gage was originally located at the Minnesota and International bridge above the falls, but jams at that point caused so much trouble that on June 10, 1911, the station was moved to its present location, the new gage being set to read approximately 1 foot lower than the old gage. Gage heights for 1911 have been referred to the present gage by means of readings taken at both gages.

Channel.—Unstable by reason of log jams forming below the gage.

Discharge measurements.—From a car and cable one-fourth mile below the gage.

Accuracy.—Although the new location is better than the old, it is not free from backwater caused by log jams. During the greater part of 1911 and 1912 a log jam on the opposite side of the river and a short distance below extended about half way across the river and undoubtedly created some backwater at the gage. For this reason no estimates of daily discharge have been made and only the base data are available.

Daily discharge, in second-feet, of Big Fork River at Big Falls.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1									812	536	1,140	
2									731	492	1,070	
3									628	470	1,000	
4									574	465	955	
5									530	460	918	
6									481	460	854	
7									465	445	805	
8									415	445	770	
9									400	470	770	
10									375	552	738	
11									366	679	712	
12									348	784	628	
13									360	840	580	
14									360	840	552	
15									375	840	525	
16									385	875		
17									395	910		
18									375	910		
19									430	948		
20									470	1,100		
21									514	1,340		
22									616	1,820		
23									738	2,140		
24									784	2,140		
25									777	2,100		
26									718	1,960		
27								978	653	1,780		
28								1,040	604	1,600		
29								1,110	580	1,430		
30								1,060	552	1,310		
31								948		1,210		
1910.												
1				2,960	2,390	1,030	281	108	48	196	293	
2				3,200	2,320	1,000	249	95	40	206	277	
3				3,300	2,070	948	231	86	72	227	242	
4				3,260	2,420	854	224	98	77	214	217	
5				2,860	2,180	970	203	86	100	189	206	
6				2,880	2,140	1,080	238	72	110	175	182	
7				3,000	2,200	1,050	214	61	98	163	163	
8				2,940	2,110	970	196	50	86	172	151	
9				2,920	2,020	903	175	48	84	179	130	
10				2,660	1,960	854	163	40	105	192	100	
11				2,490	1,730	777	253	42	108	203	94	
12				2,330	1,490	764	228	72	98	227	74	
13				2,260	1,280	882	203	86	93	253		
14				2,170	1,110	847	182	77	115	285		
15				2,200	1,000	777	148	70	108	334		
16				2,380	1,240	738	120	63	100	329		
17				3,500	1,540	705	105	59	98	321		
18				4,310	1,690	779	86	50	115	305		
19				4,790	1,750	646	72	42	105	347		
20				4,730	1,620	586	61	38	98	410		
21				4,690	1,510	503	61	86	93	425		
22				4,280	1,450	610	59	74	110	415		
23				3,660	1,570	525	82	59	120	395		
24				3,380	1,500	465	105	46	115	380		
25				3,060	1,440	425	108	70	105	366		
26				2,640	1,380	400	95	52	110	366		
27				2,470	1,340	375	84	34	122	400		
28				2,360	1,260	343	110	72	148	395		
29				2,230	1,170	325	110	72	172	375		
30				2,360	1,120	301	98	63	192	366		
31					1,070		120	52		329		

NOTE.—Daily discharge computed from a rating curve not well defined.

Discharge measurements of Big Fork River at Big Falls.

Date	Hydrographer	No.	Width	Area of section	Mean velocity	Gage height	Discharge
1911.			Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec. ft.
June 10	S. B. Soule	4	274	2090	0.84	[a] 7.07	1760
12	do	5	128	307	.62	[b] 3.89	193
Dec. 13 [c]	do	6	127	176	.37	2.65	65.5
1912.							
Jan. 23 [d]	S. B. Soule	7	117	108	0.25	2.33	26.9
Feb. 27 [e]	do	8	119	114	0.33	2.39	37.2
April 1 [f]	do	9	14	14.2	1.90	2.24	27.0
1 [g]	do	10	30	22.3	1.28	2.24	28.6
May 21	do	11	143	590	1.61	5.06	951
Aug. 8 [h]	do	12	122	159	0.61	3.13	97

[a] Lower gage reading 6.07; measurement made from M. & I. railway bridge.

[b] Lower gage reading 2.99; measurement made at cable section.

[c] Complete ice cover; measured at cable section. Average thickness of ice, 0.7 foot.

[d] Complete ice cover. Average thickness of ice, 1.24 feet. Average distance water surface to top of ice, 0.29 foot.

[e] Complete ice cover. Average thickness of ice, 1.27 feet. Average distance water surface to top of ice, .32 foot.

[f] Section about 40 feet below down stream edge of highway bridge; measurement in open water. Complete ice cover at gage.

[g] Section about 25 feet below down stream edge of highway bridge; measurement in open water. Complete ice cover at gage.

[h] A great many logs in channel causing considerable backwater.

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

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1					4.94	4.89	3.73	3.20	3.70	4.05	4.10	3.0
2					4.89	4.98	3.58	4.00	3.70	4.15	3.90	
3					4.79	5.18	3.56	4.45	3.68	4.15	3.75	
4					4.65	5.47	3.47	4.50	3.88	4.18	3.60	
5					4.70	5.47	3.44	4.45	3.95	4.20	3.80	
6					4.55	5.52	3.34	4.35	4.05	4.22	4.00	
7					4.31	5.32	3.29	4.40	4.15	4.28	4.20	3.0
8					4.21	5.52	3.20	4.35	4.20	4.25	4.22	
9					4.21	5.76	3.10	4.25	4.15	4.20	4.22	
10					4.12	6.14	3.00	4.15	4.25	4.18	4.28	
11					4.16	6.30	2.91	4.05	4.35	4.15	4.12	3.0
12					4.31	6.30	3.00	3.85	4.25	4.20	4.05	
13					4.36	6.30	2.95	3.75	4.20	4.15	4.00	2.65
14					4.31	5.90	2.85	3.70	4.15	4.10	3.65	2.65
15					4.31	5.50	2.75	3.65	4.05	4.12	3.40	
16					4.40	5.20	2.80	3.60	4.00	4.20	3.4	
17					4.36	5.10	2.75	3.55	3.95	4.15		
18					4.45	5.10	2.72	3.45	3.85	4.20		2.6
19				5.57	4.50	5.00	2.75	3.35	3.80	4.30		
20				5.47	4.40	4.30	2.85	3.25	3.85	4.35		
21				5.52	4.70	4.25	2.80	3.60	3.80	4.38	2.8	2.6
22				5.57	4.70	4.10	2.72	3.50	3.80	4.40		
23				5.66	4.89	4.05	2.75	3.50	3.85	4.40	3.0	
24				5.57	4.70	4.60	2.80	3.45	3.80	4.38		
25				5.47	4.65	4.36	2.85	3.40	3.80	4.35		2.8
26				5.37	4.50	4.36	2.85	3.45	3.85	4.28		
27				5.32	4.40	4.02	2.90	3.65	3.90	4.25	2.9	
28				5.32	4.65	3.92	2.88	3.90	3.95	4.22		2.8
29				5.13	5.18	3.87	2.85	4.05	4.00	4.20		
30				5.03	5.18	3.82	2.80	4.00	4.05	4.22	3.0	
31					5.08		2.82	3.85		4.20		

Daily gage height, in feet, of Big Fork River at Big Falls—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
1	2.75	2.2		2.25	5.2	4.8	4.7	3.4	4.6			
2					5.2	4.7	4.6	3.3	4.4			
3					5.0	4.6	4.6	3.3	4.2			
4	2.7		2.5		5.2	4.4	4.5	3.1	3.4			
5		2.2		2.25	5.4	4.4	4.4	3.2	3.1			
6					5.4	4.4	4.0	3.3	3.1			
7			2.35		5.4	4.6	3.8	3.3	3.2			
8	2.65	2.3		4.4	5.4	4.4	4.2	3.2	3.1			
9				4.6	5.6	4.4	4.4	3.2	3.1			
10				4.7	5.8	4.5	4.1	3.1	3.0			
11	2.65		2.4	5.1	6.2	4.4	4.0	3.2	2.9			
12		2.25		5.0	6.0	4.4	4.0	3.3	2.9			
13				5.0	5.8	4.6	3.8	3.3	2.9			
14			2.3	4.8	5.7	4.8	4.4	3.2	2.9			
15	2.55	2.3		4.6	6.0	4.9	4.2	3.2	2.85			
16				4.4	6.2	5.0	4.0	3.2	2.9			
17				4.2	6.0	5.0	4.0	3.2	2.9			
18			2.3	4.2	6.1	4.8	3.9	3.3	2.9			
19		2.25		4.0	5.9	4.8	4.0	3.3	2.9			
20				3.9	5.2	4.7	4.0	3.4	2.8			
21			2.3	4.0	5.0	4.6	4.2	3.5	2.75			
22	2.3	2.3		3.9	4.9	4.5	3.9	3.8	2.8			
23	2.3			3.8	4.9	4.6	3.7	4.2	3.0			
24				3.8	4.8	4.6	3.7	4.8	3.2			
25	2.3		2.3	4.0	4.8	4.4	3.6	4.6	3.3			
26		2.35		4.3	4.8	4.6	3.5	4.2	3.6			
27		2.4		4.5	4.8	4.8	3.5	4.3	4.2			
28			2.2	4.6	4.8	5.1	3.6	4.7	4.6			
29	2.25	2.4		4.8	4.7	4.8	3.4	4.1	4.7			
30				5.2	4.7	5.2	3.4	4.2	4.8			
31					4.7		3.4	4.6				

NOTE.—These gage heights are all referred to a gage established June 10, 1911, those prior to that date having been reduced by simultaneous readings of the two gages.

Monthly discharge of Big Fork River at Big Falls.

[Drainage area, 1,320 square miles.]

Month	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
August (27-31)	1,110	948	1,030	0.780	0.15	B
September	812	348	527	.399	.45	B
October	2,140	445	1,040	.788	.91	B
November	1,140		[a]660	.500	.56	C
1910.						
April	4,790	2,170	3,080	2.33	2.60	D
May	2,420	1,000	1,650	1.25	1.44	D
June	1,080	301	714	.541	.60	C
July	281	59	150	.114	.13	C
August	108	34	65.3	.049	.06	C
September	192	40	105	.080	.09	C
October	425	163	295	.223	.26	B
November (1-12)	293	74	177	.134	.06	C

[a] Partly estimated.

UNDEVELOPED WATER POWER.

A survey of Big Fork River from sec. 32, T. 150 N., R. 25 W., 17.5 miles above Big Fork post office to the mouth of the river, was made in 1912 to determine chiefly the power possibilities of the river. The results of this survey are given on plates 4 to 9 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled.

Elevations and distances along Big Fork River from mouth to Sec. 32, T. 150 N., R. 25 W.

Station	Distance		Elevation above sea level	Ascent between points	
	From Mouth	Point to Point		Total Feet	Feet per Mile
Rainy River	0	....	1,073.5	....	....
Sec. 7-8, T. 69 N., R. 26 W	4.7	4.7	1,074.5	1.0	0.2
Sec. 17-18, T. 69 N., R. 26 W	8.0	3.3	1,077	2.5	.8
Range line, R. 26-27	11.2	3.2	1,079.5	2.5	.8
Sec. 26-35, T. 69 N., R. 27 W	15.0	3.8	1,086.5	7	1.8
Sec. 13-14, T. 157 N., R. 27 W	19.8	4.8	1,097	10.5	2.2
Sec. 1-2, T. 156 N., R. 25 W	26.6	6.8	1,107	10	1.5
Sec. 15-22, T. 156 N., R. 25 W	31.2	4.6	1,111	4	.9
Township line, T. 155-156	36.8	5.6	1,120.5	9.5	1.7
Sec. 7-8, T. 155 N., R. 25 W	41.8	5.0	1,130	9.5	1.9
Sturgeon River	46.7	4.9	1,138	8	1.6
Foot of Big Falls	51.6	4.9	1,151.5	13.5	2.8
Crest of logging Dam	51.9	.3	1,187.7	36.2	....
Sec. 5-6, T. 65 N., R. 26 W	58.1	6.2	1,188	.3	.05
Sec. 9-16, T. 65 N., R. 26 W	61.9	3.8	1,195	7	1.8
Township line, T. 64-65	68.6	6.7	1,203	8	1.2
Riley Brook	71.2	2.6	1,205	2	.8
Sec. 23-26, T. 64 N., R. 26 W	77.3	6.1	1,210.5	5.5	.9
Caldwell Brook	82.0	4.7	1,214	3.5	.7
Sec. 24-25, T. 152 N., R. 25 W	87.8	5.8	1,222	8	1.4
Range line, R. 26-27	92.8	5.0	1,227.5	5.5	1.1
Sec. 16-17, T. 63 N., R. 26 W	97.9	5.1	1,235.5	8	1.6
Sec. 23-26, T. 63 N., R. 26 W	102.7	4.8	1,242.5	7	1.5
Crest of Rapids	104.1	1.4	1,251.5	9	6.4
Koochiching-Itasca County line	107.3	3.2	1,252.5	1	.3
Range line, R. 25-26	112.3	5.0	1,260	7.5	1.5
Crest of Muldson's Rapids	113.1	.8	1,266.5	6.5	8.1
Deer River	121.6	8.5	1,283.5	17	2.0
Crest of Rapids	122.3	.7	1,290	6.5	9.3
Township line, T. 61-62	126.0	3.7	1,290.5	.5	.14
Highway bridge	130.9	4.9	1,292	1.5	.3
Crest of Rapids	132.6	1.7	1,302.5	10.5	6.2
Big Fork	135.8	3.2	1,303.5	1	.3
Range line, R. 26-27	140.2	4.4	1,307.5	4	.9
T. 61 N., R. 27 W., T. 149 N., R. 25 W	144.6	4.4	1,309	1.5	3.4
Township line T. 149-150	149.1	4.5	1,311	2	.4
Crest of Rapids	150.3	1.2	1,316.5	5.5	4.6
Township line 149-150	152.5	2.2	1,317	.5	.2

The portion of the river above the upper limits of the survey has so little fall that the gentle slope accompanied by the small runoff is unfavorable to power development. The following possible developments have been determined from the river survey:

In sec. 12, T. 61 N., R. 26 W.—At mile 131.3, which is 4.5 miles below Big Fork, a 22-foot dam would back the water about 19 miles upstream, overflowing land covered with timber and brush.

In sec. 7, T. 62 N., R. 25 W.—If a 23-foot dam were built at mile 113.6, at the head of Muldson's rapids, it would have a crest length of 350 feet and would back the water 18 miles upstream to the dam site at 131.3, which is the controlling feature. As the banks for some distance above the dam site (mile 113.6) are low, the area overflowed, which consists of timber and brush land, would be considerable. Within a half mile below the dam site the river falls 7 feet, but this additional head is not available in the present development without a pipe line or ditch development, as the banks at the lower end of the rapids are too low to afford an adequate dam site.

In sec. 26, T. 63 N., R. 26 W.—At the foot of little falls at mile 103.8 a 22-foot dam would back the water 10 miles upstream, to the crest of Muldson's rapids, and to the dam site at that point. As the banks are low, a considerable area of timber and brush land would be overflowed. Between this power development, and the possible one at Big Falls, the river has very little slope, and as the banks are low, no feasible development exists.

At Big Falls.—A dam 23 feet higher than the present logging dam at the crest of the big falls would back the water 24.5 miles upstream, but as the banks are high, very little land would be overflowed. By means of a pipe line 2200 feet long, extending to the foot of the falls, a total head of 58 feet would be available.

In sec. 23, T. 156 N., R. 25 W.—A 40-foot dam at mile 32.2 would back the water 19.5 miles upstream to the foot of the big falls. As the banks are high for the most part, there would be comparatively little land overflowed.

In sec. 36, T. 69 N., R. 27 W.—To avoid serious backwater from Rainy River, no dam site has been considered where the fall between it and the mouth of the river is less than 10 feet. This condition limits the development below mile 32.2 to one, at mile 14.2. Here the river is 12 feet above the Rainy, and a 25-foot dam would back the water nearly to the dam site at mile 32.2, the limiting feature of the development.

The stream gaging records of Big Fork River are too fragmentary at this time to be used in estimating the available power on the river.

SANITARY STATISTICS.

There are no settlements in the basin of the Big Fork of sufficient size to have municipal water supplies or sewage systems, and therefore no urban sewage enters the river. The permanent rural population is 1.2 per square mile. This is increased during the winter months by the loggings crews which operate on the headwaters. The size of this transient population is unknown.

MINOR TRIBUTARIES OF RAINY RIVER.

There are available from various sources approximate elevations of various points on Rat Root and Black rivers. From these approximate data the following tables have been compiled:

Elevations and distances along Rat Root River from mouth to Sec. 18, T. 68 N., R. 22 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above Mouth.	Point to Point.		Total.	Per mile.
Rat Root Lake	0	....	1,117	....	....
Sec. 3, T. 69 N., R. 23 W	8	8	1,120	3	0.4
Sec. 10, T. 69 N., R. 24 W	16	8	1,125	5	.6
Range line 23-24	27	11	1,128	3	.3
Sec. 18, T. 68 N., R. 22 W	38	11	1,144	16	1.4

Elevations and distances along Black River from mouth to Sec. 28, T. 157 N., R. 27 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above Mouth.	Point to Point.		Total.	Per mile.
Rainy River	0	....	1,078	....	....
Road Crossing	9	9	1,086	8	0.9
....	12	3	1,095	9	3.0
Section line 34-35	14	2	1,106	11	5.5
Sec. 27, T. 158 N., R. 27 W	23	9	1,122	16	1.8
Brook	26	3	1,126	4	1.3
Sec. 16, T. 157 N., R. 27 W	32	6	1,155	29	4.8
Sec. 28, T. 157 N., R. 27 W	34	2	1,163	8	4.0

STREAM GAGING RECORDS.

Miscellaneous measurements in Hudson Bay drainage basin.

Date	Stream	Tributary to	Locality	Gage Height	Dis-charge
				Feet	Sec.-feet
1910.					
July 2	Red Lake River	Red River	Just below Clear-water River	....	716
August 10	do	do	do	6.50	393
October 16	do	do	do	6.10	328
August 20	do	do	At Mouth	3.37	214
1911.					
March 4	do	do	do	....	134
May 13	do	do	do	7.20	360
July 18	do	do	do	3.83	173
February 2	Little Fork	Rainy River	Hughes post office	....	36
June 18	Vermilion	do	Crane Lake Portage	3.0	652
June 28	Roseau	Nelson River	Roseau City	2.50	29
September 14	do	do	do	1.89	3.2
June 27	E. Br. Roseau	Roseau River	Malung	1.52	18
September 13	do	do	do	.92	2.3

LAKE SUPERIOR DRAINAGE.

ST. LOUIS RIVER.

SOURCE, COURSE AND TRIBUTARIES.

St. Louis River drains an area located in the northeastern part of Minnesota, chiefly in southern St. Louis County. The river rises in a small lake on the extreme western edge of Lake County, Minn.

A. LOG LANDING ON ST. LOUIS RIVER.

B. FALLS ON SPLIT ROCK RIVER.

in T. 59 N., R. 11 W. Its general course is at first southwestward, but after passing through Seven Beaver Lake, which has an area of several square miles, it flows southward until it reaches a point about 6 miles above the St. Louis-Carlton County line, where it turns to the east, southeast, and finally northeast emptying into the extreme west end of Lake Superior. Its principal tributaries are Partridge, Embarrass, and Floodwood rivers from the west and Whiteface and Cloquet rivers from the east.

From the crossing of the D. & I. R. road near Skibo for a distance of 30 miles downstream the St. Louis River flows between banks that are in general 10 feet high. Below that point the banks become higher, averaging 30 feet nearly to the mouth of Whiteface River. Above this point the valley is very narrow being but little wider than the river itself. For 10 miles below the Whiteface, the banks are from 15 to 20 feet high, but below that section the valley gradually widens out and becomes deeper, until Thomson is reached. Here the whole character of the river changes. It enters a deep narrow gorge which continues nearly to Lake Superior, a distance of several miles. In this distance the river falls nearly 500 feet. In the upper portion of the river as far south as Two Rivers the St. Louis has a heavy fall but from there to Cloquet, a distance of 86 miles, the slope is very slight. At Cloquet the river falls 70 feet in one mile which head is wholly developed, and continues with a moderate fall to Thomson. In general, the river pursues a straight course with few bends.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The drainage basin is covered with a thin drift sheet of red-till, a mixture of sand, clay and gravel. Covering this till in a large section of the area are deposits of sand and gravel from which the clay has been removed. The underlying rocks which outcrop frequently in the upper portion of the basin are crystalline rocks of the Cambrian system which are igneous or highly metamorphic and contain little or no water.

In the lower valley of the St. Louis are seen the oldest rocks in the region. These are the slates and other rocks of the Archean system. These outcrops are not numerous as the river has not cut through the drift sheet to any extent.

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

The greater portion of the drainage basin above the mouth of Cloquet River is a vast swampy region containing much muskeag, through which the flow of the rivers is slow and obstructed. The northern and southern borders of this swampy tract are formed by the gradual elevation of the till covered surface. The eastern portion of the drainage basin is rougher than the western portion, although it contains areas of muskeag.

The entire basin is in the forested area of the State. Interspersed in the densely timbered areas are other areas where the cover is thin. The trees found are white, Norway, and jack pine, spruce, balsam, tamarack, and cedar, chiefly. Although the area has been burned and cut over extensively, much of the area is densely forested. Conditions are favorable in most places for the reproduction of the forest cover.

RAINFALL AND RUNOFF.

The mean annual rainfall varies from about 31 inches in the eastern portion of the basin to 28 inches in the western. Of these amounts 5 inches or more occur as snow. The longest rainfall record in this part of the state is that at Duluth which is continuous since 1871. During that period the wettest year was 1879 with a rainfall of 45.3 inches. The driest year was 1910 with a rainfall of 18.1 inches. Runoff records of St. Louis River have been maintained since 1909. These show the runoff to have varied from 4.52 to 8.26 inches or from 22.8 to 32.3 per cent of the rainfall.

REGULATION OF FLOW.

The large swamp areas tend to regulate the flow by preventing floods and increasing the low water flow. The effect of this regulation is largely lost by the many logging dams on the river and its tributaries. These dams are located as follows:

On St. Louis River in sec. 4, T. 57 N., R. 14 W., on Embarrass River in sec. 6, T. 58 N., R. 15 W., on Partridge River in sec. 6, T. 58 N., R. 14 W., on Paleface River in sec. 36, T. 56 N., R. 16 W.

The operation of these dams is a hindrance rather than an aid to the uniform regulation of the streams in the basin as during the winter period in which the flow is a minimum the dams are closed and a large portion of the flow held back until the spring and early summer. Then it is released to increase the flow (that is already greater than the average) in order to drive the logs downstream as far as Cloquet. When the log driving is completed, the dams are usually left open until the late fall and winter. This use of the streams is of course detrimental to other uses especially for power purposes. That it is possible to reconcile these conflicting interests is seen in the number of cases in Maine where the lumber and power interests have cooperated to the extent of increasing the storage facilities and in improving the channel which lessens the necessary waste incidental to log driving.

The Minnesota Forest Service has made the following estimate of the logs driven down the St. Louis and its tributaries, exclusive of Whiteface and Cloquet rivers: 1909, 23,360,890; 1910, 52,554,420; 1911, 32,917,670 feet B. M.

DRAINAGE WORK.

This portion of the state is one of the least developed, logging being the chief industry with very little land cleared and cultivated. The presence of swamps make much of the country impassible during the summer months, but on account of the sparseness of the population very little drainage work has been done. About 117,000 acres have been benefited by drainage.

DRAINAGE AREAS.

The following drainage areas have been measured in the basin:

Drainage areas in St. Louis River basin.

River.	Drainage area above.	Square miles.
St. Louis	Seven Beaver Lake	46
Do	Sec. 4, T. 57 N., R. 14 W	84
Do	Sec. 22, T. 58 N., R. 15 W	109
Do	Sec. 29, T. 58 N., R. 15 W	299
Do	Embarrass River	332
Do	Sec. 2, T. 56 N., R. 17 W	500
Do	Sec. 29, T. 56 N., R. 18 W	881
Do	Whiteface River	1,280
Do	Cloquet River	2,440
Do	Sec. 22, T. 50 N., R. 17 W	3,170
Do	Mouth	3,440
Partridge	Mouth	178
Embarrass	Embarrass Lake	104
Do	Mouth	165
Mud Hen	Mouth	108
Water Hen	Mouth	32
East Two Rivers	Mouth	66
West Two Rivers	Mouth	88
Stone	Mouth	40
Swan	West Branch	118
Do	Mouth	250
West Branch Swan	Mouth	114
Floodwood	Mouth	224
East Savanna	Mouth	98
Yellow Pine	Mouth	62
Nemadji	State Line	141

GAGING STATION RECORDS.

ST. LOUIS RIVER NEAR THOMSON.

Location.—Just below the tailrace of the Great Northern power house, 3 miles east of Thomson, in Sec. 11, T. 48 N., R. 16 W.

Records available.—October 5, 1909 to December 31, 1912. The gage heights are furnished through the courtesy of the Great Northern Power Co.

Drainage area.—3,420 square miles.

Gage.—Chain gage; unchanged since established.

Channel.—Permanent prior to 1912 when a shift occurred.

Discharge measurements.—Made from a car and cable located 1,500 feet below the gage.

Regulation.—St. Louis River falls nearly 500 feet within a distance of a few miles. The records do not show the natural flow of the river at all times owing to reservoirs above which regulate the flow to a certain extent. The dam at Thomson is designed to hold 24 hours' supply of water for the power plant and logging dams control the discharge from a large part of the entire area above the gaging station. As the gage is located just below the tailwater of the power house there is considerable fluctuation during low water due to the opening and shutting of the turbine gates. In order to approximate the mean gage height, four gage readings are taken each day—at 8 and 11 A. M. and 2 and 5 P. M. and the average of these readings taken as the mean for the day. As the plant is operated 24 hours per day, though with varying load, the fluctuations at the gage are not as great as though the turbines were closed a part of the time.

Winter flow.—Previous to November, 1910, gage heights at this station were not affected by ice, but the stage at that time was extremely low and water froze, making the gage heights useless as indications of discharge. During the winter the computation of daily discharge was based on the amount of water passing the turbines as determined by the power company. There was no flow over the spillway during the period.

Accuracy.—Except for possible error in the mean gage height for the day, conditions of flow at this station are excellent and the records of flow should be good.

Daily discharge, in second-feet, of St. Louis River near Thomson.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1											3,970	3,200
2											3,780	3,780
3											3,590	4,250
4											3,710	4,270
5										2,540	4,600	4,270
6										2,070	3,920	4,200
7										1,640	3,240	3,560
8										1,920	2,740	3,530
9										2,340	2,440	2,760
10										2,300	2,220	3,120
11										1,980	2,120	3,420
12										1,470	1,620	3,150
13										1,400	1,440	2,880
14										1,510	1,880	2,760
15										2,680	2,170	2,860
16										2,620	2,960	2,790
17										2,800	2,330	2,320
18										3,530	2,100	1,980
19										2,880	2,370	2,000
20										3,460	3,030	2,110
21										2,900	2,880	2,100
22										3,430	2,420	1,650
23										3,850	2,120	1,560
24										3,800	1,630	1,810
25										4,220	2,200	1,740
26										4,640	2,320	1,650
27										4,640	3,210	1,720
28										4,510	3,300	1,790
29										4,740	2,870	1,520
30										4,320	3,240	1,700
31										4,040		1,430

Daily discharge, in second-feet, of St. Louis River near Thomson—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1910.												
1	1,210	645	645	3,030	2,790	2,580	360	1,960	1,230	1,990	1,310	275
2	1,130	617	680	3,100	1,760	2,110	380	1,940	1,150	2,310	521	248
3	1,120	597	659	3,530	2,070	1,960	410	2,230	885	2,340	1,250	293
4	1,290	710	617	3,370	1,590	1,790	420	2,050	912	1,860	1,330	294
5	1,290	695	666	3,380	2,770	1,760	430	2,730	798	1,920	1,350	318
6	1,110	702	755	3,500	2,160	1,720	425	2,460	912	1,770	617	273
7	1,030	695	823	2,800	1,750	1,580	441	1,740	903	1,800	497	238
8	948	718	912	2,880	1,920	1,620	452	452	1,150	1,630	491	269
9	948	624	885	2,220	2,000	1,270	446	1,150	1,360	1,170	545	289
10	930	645	840	3,180	2,010	1,660	441	604	1,640	939	474	259
11	921	680	772	1,190	1,880	930	410	521	1,750	903	319	294
12	867	631	823	1,740	1,610	714	436	485	1,500	558	407	303
13	780	533	858	1,830	1,520	497	441	463	1,190	515	336	300
14	624	695	1,010	1,630	1,210	798	430	441	1,090	515	375	284
15	695	715	1,080	2,020	1,180	1,170	441	436	995	527	316	309
16	702	735	1,210	2,220	1,120	806	458	463	898	480	280	293
17	740	755	1,270	1,930	1,220	624	441	468	800	823	346	274
18	740	718	1,510	1,700	1,070	645	452	436	703	1,630	321	268
19	772	638	1,520	2,560	966	503	430	458	608	1,750	332	310
20	858	631	1,800	3,660	1,120	410	509	485	509	1,350	327	291
21	832	710	1,950	4,140	1,450	571	497	463	463	1,560	360	283
22	772	680	2,210	4,790	2,180	474	458	463	480	1,510	319	301
23	755	666	2,480	4,040	2,050	463	474	798	485	1,560	355	289
24	764	718	2,580	3,920	2,100	458	515	876	458	1,470	322	237
25	921	755	2,680	3,340	2,830	480	885	1,280	480	1,390	348	298
26	772	755	3,240	3,880	3,160	485	975	1,380	458	948	316	268
27	725	718	3,260	3,180	2,730	308	666	1,330	474	1,310	324	290
28	631	755	2,840	3,060	2,480	312	789	1,340	485	1,370	332	273
29	604	......	2,660	2,990	2,380	316	832	1,260	939	1,390	296	282
30	545	......	2,660	2,790	2,000	335	930	1,330	1,990	1,500	256	246
31	695	......	2,690	......	2,370	......	1,330	1,300	......	1,390	......	278
1911.												
1	259	316	340	2,490	2,870	2,730	2,020	4,200	2,200	2,350	1,160	583
2	278	301	344	2,350	3,540	4,610	1,660	3,990	2,720	2,300	902	578
3	261	302	322	2,220	2,770	3,580	1,300	3,970	2,420	2,270	842	541
4	240	278	318	2,070	2,560	3,130	1,140	3,710	2,120	2,280	783	521
5	213	274	351	1,650	2,300	2,880	984	3,500	1,820	2,270	772	587
6	218	285	349	1,490	3,380	3,730	984	3,480	3,760	2,100	1,060	560
7	228	275	320	1,250	2,690	3,560	1,280	3,370	4,820	2,180	1,020	580
8	192	285	320	1,440	2,000	2,770	2,610	3,580	9,420	2,260	1,020	584
9	205	282	370	1,420	1,870	2,300	2,320	4,940	9,420	1,830	1,090	593
10	247	283	410	1,400	2,240	2,410	1,760	4,990	8,400	1,800	1,070	635
11	236	285	452	1,590	2,770	2,300	1,190	4,960	7,530	1,730	1,100	565
12	231	307	477	2,140	2,000	2,460	702	6,480	7,260	1,940	791	601
13	235	316	503	4,420	1,880	2,610	590	6,460	7,600	1,590	542	496
14	230	308	564	6,680	1,870	3,460	533	6,450	6,700	1,790	685	572
15	223	302	509	6,390	1,860	4,150	527	4,860	5,790	1,760	715	562
16	234	301	718	5,900	3,740	5,120	518	4,110	5,790	2,050	883	586
17	285	306	772	5,420	8,040	3,660	509	4,040	5,760	2,420	893	543
18	292	304	748	5,450	11,200	3,400	468	3,030	5,730	1,700	785	536
19	291	316	840	5,230	9,530	3,150	385	2,580	5,390	1,670	796	601
20	309	318	823	5,670	10,400	2,270	316	2,540	4,360	1,980	709	559
21	290	342	849	5,250	9,250	1,870	298	2,500	3,060	2,180	754	557
22	291	332	912	5,360	8,110	1,870	285	2,120	2,580	2,200	711	674
23	304	362	948	6,140	7,770	1,440	375	2,560	2,490	2,210	692	708
24	284	379	975	6,140	6,120	1,100	590	2,580	2,640	1,510	633	810
25	296	367	1,230	6,270	6,080	1,780	921	2,600	2,060	1,280	706	597
26	287	338	1,340	5,670	4,820	2,400	1,160	2,560	1,840	1,710	946	518
27	322	362	1,440	4,840	6,020	1,790	1,150	2,520	1,720	1,720	768	488
28	318	337	1,840	4,400	3,060	2,000	1,560	2,480	1,990	1,650	763	444
29	303	......	2,170	3,530	2,580	2,280	1,840	1,950	2,240	1,560	777	515
30	317	......	2,410	3,200	1,630	2,380	1,440	1,770	2,410	1,460	800	447
31	308	......	2,580	......	2,410	......	1,820	1,860	......	1,470	......	459
1912.												
1	372	379	387	1,040	5,910	8,630	1,830	1,610	693	1,180	1,000	......
2	379	361	398	1,140	5,050	6,370	1,500	1,610	716	1,390	955	......
3	422	336	403	1,340	7,590	6,600	1,280	600	740	1,390	890	......
4	397	340	407	1,610	8,630	6,840	1,500	635	670	1,390	820	......
5	438	344	407	2,070	10,700	6,140	2,070	670	820	1,390	780	......

Daily discharge, in second-feet, of St. Louis River near Thomson—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
6	633	341	382	2,910	12,300	5,260	1,340	635	910	1,360	820	......
7	667	339	393	2,480	13,200	5,050	1,090	635	910	1,340	820	......
8	677	331	382	2,480	11,000	4,250	600	600	910	1,280	780	......
9	848	330	388	2,620	11,300	3,580	1,280	565	1,180	1,140	820	......
10	1,040	330	375	2,340	9,930	2,910	865	635	1,720	1,280	820	......
11	1,330	261	336	2,480	10,400	2,480	820	780	1,830	1,090	820	......
12	936	196	327	2,480	9,670	3,380	1,180	865	1,950	1,090	780	......
13	625	338	343	2,300	9,410	3,060	1,950	804	1,950	1,120	865	......
14	392	326	342	2,120	8,110	3,540	1,500	705	1,830	1,140	780	......
15	340	328	364	1,950	9,410	2,620	1,040	635	1,830	1,040	720	......
16	355	329	384	1,950	8,630	3,220	2,480	565	1,830	1,390	670	......
17	310	320	417	1,950	9,670	5,260	2,480	530	1,610	1,090	670	......
18	309	240	411	1,830	8,370	5,260	2,620	565	1,500	1,040	670	......
19	314	171	399	1,610	6,600	4,840	2,200	600	1,500	1,090	586	......
20	283	346	425	1,830	7,330	4,250	2,070	330	1,440	1,400	392	......
21	343	333	418	1,890	6,600	4,250	1,490	330	1,340	1,720	437	......
22	327	349	439	1,950	5,470	4,840	910	955	1,120	2,480	437	......
23	382	368	447	2,620	5,470	4,110	1,830	530	910	2,340	374	......
24	425	401	471	1,830	5,470	3,380	2,200	530	865	1,610	330	......
25	423	402	442	1,720	5,470	3,540	1,500	450	1,090	1,090	426	......
26	401	394	452	2,910	5,050	2,910	910	370	1,000	865	429	......
27	384	386	465	4,440	6,140	2,200	780	955	910	880	432	......
28	386	378	553	5,470	8,370	1,950	338	600	1,040	910	330	......
29	387	385	656	8,110	8,630	1,610	469	670	1,090	1,090	330	......
30	388	......	675	5,690	7,850	1,610	600	670	1,140	1,000	330	......
31	384	......	724	......	7,850	......	600	670	......	1,000	......	......

Daily discharges computed from a rating curve well defined above 500 second-feet. No flow over the dam Nov. 11, 1910, to March 8, 1911, and during that period the discharges have been taken directly from the records of flow through the wheels of the power plant, as determined by the Great Northern Power Co. From November 1, 1911, to March 30, 1912, the discharges have been taken from the records of the Great Northern Power Co.

Monthly discharge of St. Louis River near Thomson.

[Drainage area, 3,420 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area.)	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
October (5-31)	4,740	1,400	3,050	0.892	0.90	B
November	4,600	1,440	2,750	.804	.90	B
December	4,270	1,430	2,640	.772	.89	B
1910.						
January	1,290	545	862	.252	.29	B
February	755	533	683	.200	.21	C
March	3,260	617	1,570	.459	.53	B
April	4,790	1,190	2,920	.854	.95	B
May	3,160	966	1,920	.561	.65	B
June	2,580	368	978	.286	.32	B
July	1,330	360	549	.161	.19	C
August	2,730	436	1,090	.319	.37	B
September	1,750	458	923	.270	.30	B
October	2,340	480	1,360	.398	.46	B
November	1,350	256	499	.146	.16	B
December	318	237	282	.082	.09	B
The year	4,790	237	1,140	.332	4.52	

Monthly discharge of St. Louis River near Thomson—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
January	322	192	265	0.077	0.09	A
February	379	274	313	.092	.10	A
March	2,580	318	856	.250	.29	B
April	6,680	1,250	3,920	1.15	1.28	A
May	11,200	1,630	4,430	1.30	1.50	A
June	5,120	1,100	2,770	.810	.90	A
July	2,610	285	1,070	.313	.36	B
August	6,480	1,770	3,570	1.04	1.20	A
September	9,420	1,720	4,400	1.29	1.44	A
October	2,420	1,460	1,910	.558	.64	A
November	1,160	542	839	.245	.27	A
December	810	444	568	.166	.19	A
The year	11,200	192	2,080	.608	8.26	
1912.						
January	1,330	283	493	.144	.17	....
February	402	171	334	.098	.11	....
March	724	327	433	.127	.15	....
April	8,110	1,040	2,570	.751	.84	C
May	13,200	5,050	8,240	2.41	2.78	B
June	8,630	1,610	4,130	1.21	.135	B
July	2,620	338	1,400	.409	.47	B
August	1,610	330	687	.201	.23	B
September	1,950	670	1,230	.360	.40	B
October	2,480	865	1,280	.374	.43	B
November	1,000	330	644	.188	.21	C

DEVELOPED WATER POWER.

The lower portion of St. Louis River is especially suited for power development. Two of the largest developments in the State (one of them the largest *single* development) are located on this river. These developments are as follows:

Cloquet.—The Northwest Paper Co. has 2 plants. At the upper one an island separates the river into 2 channels. A lumber company has built a timber dam across the right channel for the purpose of floating logs to the mill. No power is developed. Across the other channel the Northwest Paper Co. has built a timber dam which creates a head of about 18 feet. This is utilized by a pulp mill located on the left bank. In this mill are located three 66-inch American wheels of 412 horsepower capacity each, and one 33-inch American wheel of 150 horsepower capacity. The 66-inch wheels are set vertically and each bevel geared to a short horizontal shaft that is belt connected to the wood grinders. The 33-inch wheel is belt connected to a small dynamo used in lighting the mill and running other machinery.

At the lower plant there is a timber crib dam, which gives a head of about 36 feet by means of flashboards about 9 feet long. The pondage here is slight as the area is small and the draft so great that the head is quickly drawn down. At the right end of the dam is located the portion of the Northwest Paper Co.'s plant in which are located the grinders and hydraulic power house. Here are installed five double 36-inch new American turbines of 1040 horsepower capacity per pair, two 36-inch single new American turbines of 520 horsepower each and one 16-inch New American wheel of 96 horsepower capacity. The double wheels are direct connected to the grinding machinery, the 36-inch wheels are belt connected to shafting which operates the paper mill. The 16-inch wheel is belt connected to an Edison alternating current generator of 110 volts used in lighting the mill.

Altho the water supply is very insufficient at times, there is no auxiliary steam power as the grinders are shut down. The paper machinery is run by steam at all times and the mill receives power from the Cloquet Electric Co. when necessary to run the mill.

Below Thomson in T. 48 N., R. 16 W.—The Great Northern Power Co. has a plant a few miles below Thomson which utilizes a head of 378 feet. At Thomson a concrete dam about 40 feet high creates a service reservoir having an area of ¾ square mile, and designed to have sufficient capacity to operate the ultimate installment of 80,000 horsepower continuously for 24 hours without additional supply from the river. Besides this, there is a storage reservoir on Wild Rice Lake in T. 51 N., R. 15 W., having an area of 5 square miles and available draft of 5 feet. There is also a storage reservoir on Beaver River of which the Wild Rice is a tributary, having a capacity of about 60 square mile feet. From the service reservoir at Thomson, there is a canal 2 miles long which terminates in 3 pipe lines leading to the powerhouse. Each line is 7 feet in diameter composed of California redwood staves, 3⅓ inches thick, for a distance of 4000 feet. The lower 1,000 feet of each line is constructed of riveted steel plates. The maximum capacity of the canal is 2900 second-feet, and that of each pipe line is 335 second-feet.

On the brow of the hill overlooking the power plant is a stand pipe and tank 250 feet high connected with the pipe lines and designed to take up the excess pressure due to the closing of the turbine gates. Each pipe line leads to a 13,000 horsepower Allis-Chalmers turbine of the Frances type, vertically connected to a 7,500 KW 3 phase, 25-cycle alternating current generator of 6,600 volts. The turbines are controlled by automatic governors of the Escher-Wyss oil type, built by the Allis-Chalmers Co. There are two small turbines which drive two 250 KW exciter generators of 125 volts. There is space for a fourth turbine, not yet installed. It is expected that the power house will be enlarged to double its present size with a final installation of 8 units similar to those now in use. The power is stepped up to 30,000 volts and is transmitted to Duluth by means of a line 14 miles long, having steel towers from 40 to 60 feet high, spaced from 300 to 1000 feet apart. There are two circuits either of which can take the full load in case of accident. If necessary the transmission tension can be increased to 60,000 volts. In Duluth there is a second power house where the current is transformed to a voltage suitable for light and power purposes. The plant is operated continuously, there being excess power contracts which tend to make the load more or less uniform. There is no auxiliary steam plant at the Thomson power plant.

A separate transmission line has recently been constructed from the power station to the city of Superior on the Wisconsin side.

The line is about 15 miles long and will consist of one circuit at present. The towers have been arranged for an additional circuit when needed. This line is carried on galvanized structural steel towers ranging in height from 71 to 86 feet, spaced approximately 800 feet apart. The insulators are of the suspension type instead of the pin type as used on the Duluth line. The line terminates at a transformed station in Superior where the current is stepped down to a distributing voltage of 13,200 volts.

AVAILABLE HORSEPOWER.

From the records of flow of the St. Louis the following table has been compiled to show the available continuous horsepower at the developed sites:

Available horsepower at developed power sites.

Developed site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Cloquet, upper dam.........	18	246	416	990	403	681	1,620
Cloquet, lower dam..........	36	246	416	990	806	1,360	3,240
Below Thomson.............	378	265	430	1,050	9,100	14,800	36,100

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of St. Louis River from Scanlon to the Duluth and Iron Range crossing near Skibo was made during 1910 to determine, chiefly, the power possibilities of the river. The results of this survey are given on plates 76 to 82 inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along St. Louis River from Scanlon to Skibo.

Stations.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	From Scanlon.	Point to Point.		Total.	Per mile.
M. & N. W. R. R. bridge at Scanlon.	0.0	....	1,100	....	....
Lower dam at Cloquet, foot........	1.8	1.8	1,105	5	2.8
Lower dam at Cloquet, crest........	1.8	0.0	1,155	50	....
Upper dam at Cloquet, foot........	2.8	1.0	1,156	1	1.0
Upper dam at Cloquet, crest........	2.8	0.0	1,172	16	....
Upper end of pond upper dam........	7.5	4.7	1,172	0	0.0
....	9.6	2.1	1,177	5	2.4
....	13.0	3.4	1,202	25	7.4
....	16.0	3.0	1,202	0	0.0
Cloquet River........	18.5	2.5	1,205.5	3.5	1.4
G. N. Ry. bridge........	21.8	3.3	1,207.5	2	0.6
Congo........	26.9	5.1	1,208	0.5	0.1
....	30.4	3.5	1,208	0	0.0
....	36.2	5.8	1,224	16	2.8
Floodwood River........	38.6	2.4	1,225	1	0.4
Whiteface River........	45.4	6.8	1,225.5	0.5	0.1
D. M. & N. Ry. bridge........	55.2	9.8	1,232.5	7	0.7
Sand Creek........	59.7	4.5	1,235	2.5	5.5
Swan River........	63.8	4.1	1,241	6	1.5
....	65.0	1.2	1,245	4	3.3
....	70.0	5.C	1,247.5	2.5	0.5
Bridge west of Zim........	78.4	8.4	1,261	13.5	1.6
....	85.0	6.6	1,271	10	1.5
....	89.0	4.0	1,293	22	5.5
Bridge near Forbes........	91.1	2.1	1,294	1	0.5
....	95.5	4.4	1,305.5	11.5	2.6
Mudhen Creek........	99.3	3.8	1,308.5	3	0.8
Otter Creek........	104.4	5.1	1,316	7.5	1.5
Embarrass River........	105.7	1.3	1,317.5	1.5	1.2
....	106.3	0.6	1,321.5	4	6.7
....	110.5	4.2	1,324	2.5	0.6
Vermilion Lake Road bridge........	115.1	4.6	1,330.5	6.5	1.4
....	120.0	4.9	1,338.5	8	1.6
....	126.3	6.3	1,356	17.5	2.8
....	128.5	2.2	1,385	29	13 2
....	129.4	0.9	1,385.5	0.5	0.6
Abandoned logging dam........	130.3	0.9	1,409.5	24	26.7
....	132.3	2.0	1,413.5	4	2.0
....	133.3	1.0	1,443	29.5	29.5
....	134.4	1.1	1,450	7	6.4
Logging dam, foot........	135.2	0.8	1,475	25	31.2
Logging dam, crest........	135.2	0.0	1,477	2	....
....	138.0	2.8	1,478	1	0.4
....	140.9	2.9	1,486	8	2.8
....	145.2	4.3	1,502	16	3.7
....	147.1	1.9	1,540	38	20.0
D. & I. R. Ry. bridge near Skibo....	149.4	2.3	1,562	22	9.6

Although the river has a heavy fall above the upper limits of the survey, the discharge is too small to make possible power development of any size. Below Scanlon, the fall is nearly all utilized by the Great Northern Power Company as far down the river as the tailrace of the power plant. Below that point there is approximately 90 feet fall to Lake Superior. Within the limits of the survey are the following power sites:

In sec. 30, T. 58 N., R. 13 W.—If a 42-foot dam were built at mile 145.9, 3.5 miles below the Duluth & Iron Range Ry. bridge, it would back the water 2.5 miles upstream and overflow 125 acres of brush land. The crest length of the dam would be 700 feet.

In sec. 4, T. 57 N., R. 14 W.—A 5-foot dam at the site of the present logging dam at mile 135.2 would back the water 3 miles upstream overflowing 100 acres of brush land. By means of a pipe line 9500 feet long a total head of 60 feet can be obtained.

In sec. 22, T. 58 N., R. 15 W.—At mile 129.8, 2.5 miles above Partridge River a 30-foot dam would back the water upstream 2.5 miles, and overflow 300 acres of brush and timber land. The length of the dam would vary from 100 feet at the water surface to 800 feet at the top.

In sec. 29, T. 58 N., R. 15 W.—A 30-foot dam, 3.5 miles below Partridge River, at mile 123.9 would back the water 4 miles upstream, and overflow 100 acres of brush land. The crest length of the dam would be 500 feet.

In sec. 2, T. 56 N., R. 17 W.—Two and one-half miles above the crossing of Miller Trunk Road at mile 100, a 30-foot dam would back the water 21 miles upstream, overflowing about 800 acres of timbered land. The length of the dam would vary from 50 feet at the water surface to 400 feet at the crest.

In sec. 29, T. 56 N., R. 18 W.—Just above the highway bridge west of Zim at mile 78.5, a 38-foot dam would back the water upstream overflowing about 500 acres. The length of the dam would be 150 feet at the water surface, and 400 feet at the crest.

In sec. 20, T. 53 N., R. 19 W.—If a 28-foot dam were built 3 miles below the Duluth, Mesabi and Northern Ry. crossing near Elmer, at mile 52.4 it would back the water 26 miles upstream nearly to the dam site west of Zim. As the banks are high in this portion of the river there would be little land overflowed. The crest length of the dam would be 300 feet.

Below this dam site, the slope of the river is slight and the topography is unsuited to power development nearly to White Pine Creek.

In sec. 22, T. 50 N., R. 17 W.—A 21-foot dam, three-quarters of a mile above White Pine Creek at mile 9.8 would back the water 3 miles upstream and would overflow about 70 acres of land.

From this last dam site to the tailrace of the Great Northern Power Co.'s plant, a distance of about 17 miles, the fall is nearly all utilized. Below that point there is a fall of about 90 feet to Lake Superior a distance of 4 miles, which is not utilized. The valley in this stretch of the river is very narrow with steep slopes. A spur track of the Northern Pacific Ry. extends from Fond du Lac to the Great Northern power plant.

AVAILABLE HORSEPOWER.

Records of flow of St. Louis River are available since the latter part of 1909. In 1910 the basin suffered a severe drought which so depleted the ground water that the flow during the winter months of 1911 and 1912 was still affected. Thus, the estimates of flow probably do not represent that to be expected during ordinary years or even ordinary low years. In the absence of further data the estimated flow for ordinary low years has been based on the mean of the lowest monthly flow in 1910, 1911, and 1912.

The following table shows the estimated power at the dam sites described previously:

Undeveloped horsepower on St. Louis River.

Site.	Head in feet.	Minimum Run-off.			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Sec. 30, T. 58 N., R. 13 W.	42	6	10	34	23	38	130
Sec. 4, T. 57 N., R. 14 W.	60	6	10	34	33	55	185
Sec. 22, T. 58 N., R. 15 W.	30	7	11	44	19	30	120
Sec. 29, T. 58 N., R. 15 W.	30	20	30	120	55	82	327
Sec. 2, T. 56 N., R. 17 W.	30	34	50	200	93	136	545
Sec. 29, T. 56 N., R. 18 W.	38	60	88	352	207	304	1,216
Sec. 20, T. 53 N., R. 19 W.	28	87	128	512	221	326	1,303
Sec. 22, T. 50 N., R. 17 W.	21	244	412	983	466	786	1,877
Below Great Northern Power Plant	90	265	430	1,050	2,168	3,517	8,591

EMBARRASS RIVER.

There have been compiled from various sources approximate elevations at different points along Embarrass River, which is tributary to the St. Louis. From these approximate data the following table of elevations and distances has been compiled:

Elevations and distances along Embarrass River from mouth to Sec. 5, T. 59 N., R. 15 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points	
	Above mouth.	Point to Point.		Total.	Per mile.
St. Louis River	0	....	1,317	....	....
Esquagama Lake, outlet	4	4	1,353	36	9
Esquagama Lake, inlet	6	2	1,353	0	0
Lower Embarrass Lake, outlet	6.5	0.5	1,360	7	14
Lower Embarrass Lake, inlet	12	5.5	1,360	0	0
Upper Embarrass Lake, outlet	12.5	0.5	1,366	6	12
Upper Embarrass Lake, inlet	17	4.5	1,366	0	0
Sec. 5, T. 59 N., R. 15 W.	21	4	1,400	34	8

From the preceding table it is seen that the best opportunity for power development on the Embarrass is between the outlet of Esquagama Lake and the mouth, where the river has a fall of 36 feet in four miles. As no records of flow of the river are available, no estimate of available horsepower has been made.

SANITARY STATISTICS.

To show the sanitary quality of the water in St. Louis River, and the extent to which it is used for municipal purposes, data showing the source of municipal supply and disposal of sewage have been compiled for all towns of 500 inhabitants, or more, located on the river or its tributaries. These data are given in the following table in order of location, beginning near the source:

Municipal water supply and sewage disposal of towns on St. Louis River and tributaries.

Town.	Distance above mouth	Population 1910.	Water Works System.			Sewerage System.		Rural population per square mile above.
			Source of Supply.	Filtered.	Amount gallons 24 hours.	Outlet.	Treated.	
			St. Louis River.					
Mouth Partridge River	149	....	....	....	....	....	....	1.7
Mouth Embarrass River	128	....	....	....	....	....	....	....
Mouth E. Two Rivers	109	....	....	....	....	....	....	....
Mouth W. Two Rivers	108	....	....	....	....	....	....	....
Mouth E. Swan River	86	....	....	....	....	....	....	15.8
Floodwood	61	481	none	....	....	none	....	....
Cloquet	24	7,031	springs	no	600,000	river	no	11.0
Scanlon	22	572	none	....	....	none	....	....
Carlton	17	597	none	....	....	none	....	10.8
			Partridge River.					14.3
Aurora	5	1,919	well	no	70,000	river	no	....
			Embarrass River.					12.2
Biwabik	17	1,690	mine shaft	natural sand filter	125,000	tributary	no	....
			East Two Rivers.					34.1
Virginia	25	10,473	deep wells	no	600,000	Three Mile Lake	no	....
Eveleth	12	7,036	St. Mary's L.	no	350,000	tributary	no	....
			W. Two Rivers.					12.2
Buhl	20	1,005	deep well	no	60,000	W. Two Rivers	no	
			E. Swan River.					40.3
Chisholm	40	7,684	mine water	yes	300,000	Long Year L.	yes	....
Hibbing	40	8,832	deep well	no	1,000,000	tributaries	no	....

From the preceding table it appears that no urban sewage enters St. Louis River above the mouth of Partridge River. The rural population is very small being 1.7 per square mile. During the winter months this population is increased by the presence of logging crews, which operate extensively in this basin.

At the mouth of Partridge River is received the drainage from 178 square miles, which contains untreated sewage from Aurora located 5 miles above the mouth of the river. As Partridge River drains a portion of the iron range, it has a rural population of 14.3 per square mile.

From Partridge River to Floodwood, a distance of 88 miles, no urban sewage enters St. Louis River direct, but the water is polluted by the drainage of the various tributaries. Twenty-one miles below the Partridge, Embarrass River brings into the St. Louis. the drainage from 165 square miles, containing untreated sewage from Biwabik, a town of 1690 inhabitants located 17 miles above the mouth. However, as much of the channel of Embarrass River below Biwabik is through a chain of lakes where sedimentation is an active factor, it is probable that much of the sewage pollution is removed before reaching the St. Louis. The rural population of this basin is 12.2 per square mile.

Nineteen miles below the Embarrass, East Two Rivers brings in the drainage of 66 square miles, containing untreated sewage from Virginia and Eveleth, representing an urban population of 17,500. This basin has a rural population of 34.1 per square mile as it is nearly all included in the iron range district.

One mile below East Two Rivers, West Two Rivers enters with the drainage from 88 square miles. This contains the untreated sewage from Buhl, a town of 1005 inhabitants, located 20 miles below the mouth. Only the upper portion of this basin is within the range district, and therefore the rural population is only 12.2 per square mile.

East Swan River enters 22 miles below West Two Rivers and brings into the St. Louis the drainage from 250 square miles. This river contains raw sewage from Hibbing, representing a population of 8832, and treated sewage from Chisholm with a population of 7684. As nearly all the drainage area is within the range district, the rural population is high, being 40.3 per square mile.

From the mouth of Partridge River to Floodwood, a distance of 88 miles the St. Louis has an average fall of 1.6 feet per mile which insures the presence of sewage pollution from the various tributaries reaching Floodwood.

Although there are no towns located on the St. Louis above Floodwood, the presence of the iron range increases the rural population of the St. Louis basin from 1.7 per square mile above Partridge, to 15.8 per square mile, above East Swan River. From the mouth of East Swan River to Cloquet, a distance of 62 miles, the river receives no additional urban sewage. The rural population of this portion of the basin is less than that above, being 11.0 per square mile for the entire area above Cloquet. The average fall in the river in this section is 1.1 feet per mile. The lower 4.7 miles of the distance is within the mill pond created by the upper dam at Cloquet. The average width of this pond is about 700 feet.

At Cloquet, the river receives untreated sewage from a population of 7031. This is the last source of urban pollution, as below Cloquet, there are no towns on the river or on tributaries entering below. As the river below Cloquet has a heavy fall it is probable that the sewage pollution from that source is found at the mouth of the river.

No water from the St. Louis or its tributaries is used for municipal purposes.

WHITEFACE RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Whiteface River rises in Jack Pine Lake in sec. 4, T. 57 N., R. 12 W., on the eastern edge of St. Louis County and flows in a generally, though winding, southwesterly course, entering St. Louis River in sec. 24, T. 52 N., R. 20 W. Its chief tributaries are North Branch, Paleface River and Bug Creek.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The upper portion of the basin is rugged but this ruggedness gradually becomes gently undulating toward the mouth of the river. Elevations range from 1200 to 1800 feet. The entire area is covered with a thin layer of red till, a mixture of sand, clay, and gravel. In the upper portion of the basin it is underlain by gabbros of the Cambrian system. The lower half of the basin is flat and contains large areas of muskeag, due to inadequate natural drainage. The drift sheet in this portion of the area is much thicker than in the remaining portion.

The entire area is forested with dense areas of pine, balsam, spruce, cedar and tamarack. There are dense areas alternating with areas where the growth is thin. The basin has been cut over extensively but very little of the land has been cleared.

RAINFALL.

The mean annual rainfall increases from 28 inches at the mouth to 31 inches or more at the upper edge of the basin.

REGULATION OF FLOW.

The few lakes and the large swamp areas in the lower part of the area tend to equalize the flow to a certain extent. This effect is more than offset by the logging dams located as follows: on Whiteface River in sec. 2, T. 54 N., R. 16 W.; on Paleface River in sec. 36, T. 56 N., R. 16 W.; on Bug Creek in sec. 21, T. 54 N., R. 16 W. These dams control the flow from 215 of the 522 square miles drained by Whiteface River. The operation of these dams increases the inequality of the flow by storing water during the winter time which is the period of natural minimum flow, and releasing this stored water in the spring to increase the natural highwater flow.

The Minnesota Forest Service has made the following estimate regarding the log driving on the Whiteface and its tributaries: 1909, 21,314,360; 1910, 9,997,780; 1911, 13,733,150 feet B. M.

DRAINAGE WORK.

Although there are large swamp areas in the basin, very little land has been drained as through a lack of settlers very little of it has been cleared.

DRAINAGE AREAS.

The following drainage areas have been measured:

Drainage areas in Whiteface River basin.

River.	Drainage area above.	Square miles.
Whiteface	Sec. 9, T. 54 N., R. 17 W	370
Whiteface	Gaging station at Meadowlands	442
Whiteface	Mouth	522

GAGING STATION RECORDS.

WHITEFACE RIVER AT MEADOWLANDS.

Location.—At the highway bridge at Meadowlands, in Sec. 14, T 53 N, R 19 W, ½ mile below nearest tributary, a small stream entering from the east.

Records available.—June 7, 1909, December 31, 1912.

Drainage area.—442 square miles.

Gage.—Vertical staff; datum unchanged since establishment.

Channel.—May be shifting at bridge; nearly permanent at control point.

Discharge measurements.—Made from highway bridge except during extremely low water when wading measurements are made.

Regulation.—The flow is controlled to a large extent by logging dams above. The opening and shutting of the gates of these dams causes a fluctuation in gage heights of several feet at the gaging section.

Accuracy.—Logs collect on the control point some 2 miles below the gage causing varying amount of backwater at the gage. Prior to 1912, the flow during such periods of the year has been computed from a number of rating curves, some of which have been applied indirectly. During 1912, the flow during periods of backwater has been computed using gage height at a chain gage established below the rapids applied to a rating curve which has been developed for that point.

Daily discharge, in second-feet, of Whiteface River at Meadowlands.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							40	1,130	510	355	440	
2							35	960	470	315	395	
3							35	870	365	305	260	
4							35	575	390	570	350	
5							35	325	320	250	470	
6							30	375	220	255	385	
7						570	30	210	190	225	385	
8						480	30	220	170	245	295	
9						310	30	430	165	220	465	
10						345	30	750	165	245	250	
11						305	40	3,400	160	225	225	
12						120	50	2,820	150	370	225	
13						165	90	2,400	180	395	240	
14						570	90	2,580	275	480	345	
15						120	95	2,930	360	495	385	
16						120	95	2,580	260	510	350	
17						120	60	2,450	205	505	350	
18						760	220	2,250	190	465	250	
19						80	585	1,990	190	530	290	
20						50	140	1,190	365	420	365	
21						50	635	1,040	475	400	345	
22						45	2,480	950	720	570	365	
23						690	2,520	950	1,130	610	345	
24						280	2,710	635	860	600	405	
25						335	2,520	550	605	675	470	
26						135	2,250	520	670	645	440	
27						95	1,800	515	750	645	450	
28						75	1,200	460	680	690	505	
29						50	1,300	550	610	550	440	
30						45	800	645	480	430	470	
31							1,310	645		405		
1910.												
1				285	390	545	115	485	105	730	115	
2				275	178	415	105	215	115	415	115	
3				255	1,000	390	115	85	115	940	115	
4				245	922	315	115	75	115	765	115	
5				235	295	275	140	75	140	590	115	
6				208	125	315	140	75	178	765	115	
7				185	132	485	115	75	208	590	115	
8				185	125	712	110	75	132	440	115	
9				178	125	315	105	75	140	265	105	
10				545	115	185	100	75	162	170	105	
11				215	125	132	90	75	170	155		
12				178	125	200	80	75	155	155		
13				155	390	1,300	75	110	115	170		
14				608	125	695	75	170	115	140		
15				185	200	120	75	140	115	140		
16				245	125	90	75	200	105	140		
17				178	105	95	65	200	100	140		
18				208	120	80	65	192	85	125		
19				818	132	75	55	170	85	125		
20				712	140	75	65	140	75	115		
21				545	328	75	65	125	75	295		
22				178	378	75	65	125	75	365		
23				922	470	75	85	115	65	315		
24				590	1,350	75	85	115	75	275		
25				852	1,290	100	75	115	85	255		
26				660	980	192	65	110	105	200		
27				560	835	170	65	105	125	185		
28			275	245	852	148	65	105	200	185		
29			295	225	678	140	105	105	235	185		
30			275	980	590	140	85	115	590	170		
31			275		608		818	105		140		
1911.												
1					880	195	315	1,120	608	352	215	
2					320	515	240	485	365	345	215	
3					140	945	590	305	305	315	200	
4					125	650	355	748	340	315	192	
5					440	310	240	545	1,160	315	178	

Daily discharge, in second-feet, of Whiteface River at Meadowlands—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
6					80	650	285	888	1,640	295	170	
7					75	1,000	265	1,420	1,660	295	170	
8					295	890	160	1,600	1,500	295	170	
9					970	530	115	1,000	1,620	279	170	
10					255	640	110	470	1,220	275	170	
11					70	735	65	782	960	275	155	
12				455	100	930	60	1,080	922	365	155	
13				821	100	1,130	60	1,100	730	402		
14				1,010	170	620	60	782	560	390		
15				862	295	295	60	440	660	390		
16				1,140	1,600	875	60	352	625	730		
17				1,240	2,310	1,200	60	765	530	360		
18				1,080	2,330	1,050	60	1,100	625	295		
19				1,030	1,980	485	65	765	695	285		
20				475	2,370	445	65	455	608	275		
21				725	2,070	515	70	340	530	275		
22				760	1,690	475	70	428	575	255		
23				1,010	1,390	680	70	360	608	255		
24				805	795	460	70	618	470	255		
25				645	695	205	120	428	378	275		
26				325	590	245	320	305	315	275		
27				305	530	690	515	275	295	255		
28				365	360	310	215	255	255	255		
29				680	310	590	275	440	340	235		
30				920	250	360	428	922	378	235		
31					200		625	1,000		215		
1912.												
1						660	151	50	90	151	50	
2						870	135	50	90	135	50	
3						800	120	40	90	135	50	
4						695	120	40	90	120	50	
5						590	120	40	90	120	50	
6						560	90	40	90	120	50	
7						530	76	40	90	105	50	
8						530	62	40	90	90	50	
9						470	62	40	90	90	50	
10				247	1,020	440	62	50	90	90		
11				269	1,020	415	90	50	90	90		
12				247	1,020	390	90	50	90	90		
13				227	905	365	76	50	90	90		
14				315		470	90	50	76	83		
15				390		695	90	50	76	76		
16				280		980	90	45	76	62		
17				207		1,180	90	45	76	69		
18				187	870	1,220	90	40	76	69		
19				160		1,060	90	40	76	62		
20				169		940	90	40	76	62		
21				187		730	90	45	76	62		
22				169		590	90	45	76	62		
23				227		500	76	45	76	62		
24				160		440	62	50	76	62		
25				227		415	62	69	76	56		
26				365		365	62	90	90	56		
27				380		269	62	62	90	50		
28				420		227	62	69	135	50		
29				460		187	50	76	187	50		
30				500		151	50	90	169	50		
31							50	90		50		

Daily discharges computed from a fairly well-defined rating curve that was applied indirectly at different periods owing to shifting conditions.

Monthly discharge of Whiteface River at Meadowlands.

[Drainage area, 442 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
June (7-30)	760	45	246	0.557	0.50	C
July	2,710	30	688	1.56	1.80	C
August	3,400	150	1,230	2.78	3.20	C
September	1,130	150	409	.925	1.03	C
October	690	220	439	.993	1.14	C
November	505	225	365	.826	.92	C
1910.						
April	980	155	395	.894	1.00	C
May	1,350	105	431	.975	1.12	C
June	1,300	75	267	.604	.67	C
July	818	55	112	.253	.29	C
August	485	75	130	.294	.34	C
September	590	65	139	.314	.35	C
October	940	115	311	.704	.81	C
November (1-10)			113	.256	.10	C
1911.						
April (12-30)	1,240	305	771	1.74	1.23	C
May	2,370	70	767	1.74	2.01	C
June	1,200	195	621	1.40	1.56	C
July	625	60	197	.446	.51	C
August	1,600	255	696	1.57	1.81	B
September	1,660	255	716	1.62	1.81	B
October	730	215	311	.704	.81	B
November (1-12)	215	155	180	.407	.18	B
1912.						
April (10-30)	[a]500	160	276	.624	.49	B
May			865	1.96	2.26	B
June	1,220	151	591	1.34	1.50	A
July	151	50	83.9	.190	.22	B
August	90	40	52.3	.118	.14	B
September	187	76	91.8	.208	.23	B
October	151	50	81.3	.184	.21	B

[a] Estimated.

UNDEVELOPED WATER POWER.

Although no survey of Whiteface River has been made there are available approximate elevations at different points from which the following table of elevations and distances has been compiled:

Elevations and distances along Whiteface River from mouth to Jack Pine Lake.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above Mouth.	Point to Point.		Total.	Per mile.
St. Louis River	0		1,226		
Sec. 24, T. 52 N., R. 20 W	7	7	1,232	6	0.9
Meadowlands	18	11	1,259	27	2.5
Sec. 29, T. 54 N., R. 18 W	26	8	1,269	10	1.2
Kelsey	30	4	1,281	12	3.0
Sec. 9, T. 54 N., R. 17 W	36	6	1,306	25	4.2
Bassett	80	44	1,610	304	6.9
Jack Pine Lake	86	6	1,660	50	8.3

From this table it is seen that below Kelsey the general slope of the river is too slight to afford important power development. Above Kelsey the river has considerable fall. The greatest fall is between Bassett and Jack Pine Lake, but as the drainage area above the former point is only 25 square miles, the discharge is too small to admit of development.

Between Kelsey and sec. 9, T. 54 N., R. 17 W., the river has a fall of 25 feet in 6 miles with a mean drainage area for the section of 385 square miles.

Between sec. 9, T. 54 N., R. 17 W., and Bassett, a distance of 44 miles, the total fall of the river is 304 feet. The drainage area at the upper end of this section is 25 square miles and at the lower end 370 square miles.

As no map of the river is available it is not known whether suitable dam sites exist, so no estimate of power can be made other than the total power in each stretch of river.

In determining the discharge, use has been made of the winter records of the Cloquet and St. Louis, as the low water occurs during that period, when the Whiteface records are discontinued.

Undeveloped horsepower on Whiteface River.

Section of river.	Total fall in feet.	Minimum Runoff.[a]			Horsepower (80% Efficiency.)		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
From Kelsey to Sec. 9, T. 54 N., R. 17 W.	25	28	62	300	64	141	682
From Sec. 9, T. 54 N., R. 17 W. to Bassett	304	14	32	154	387	884	4,256

[a] Based on the mean drainage area for the section.

SANITARY STATISTICS.

The basin of Whiteface River is almost entirely covered with brush and timber land with very little cleared land. The population is very sparse, being only 2.7 per square mile, located chiefly in the lower portion of the basin. There are no settlements of sufficient size to have municipal water supplies and sewage systems, and therefore the water in Whiteface River contains no urban sewage. During the winter months the population of the headwater portion of the area is increased by the presence of logging crews, and although nothing is known regarding the size of these crews, it is probable that they are not large, as logging has been carried on for a considerable period.

CLOQUET RIVER.

SOURCE, COURSE AND TRIBUTARIES.

Cloquet River, the principal tributary of the St. Louis rises in township 57 north, range 9 west, in Lake County, and flows in a general southwesterly course through Alden Lake, Island Lake, and Wood Lake, emptying into the St. Louis in sec. 36, T. 51 N., R. 18 W. Its chief tributaries are Pequaywan Lake, and Boulder Lake, outlets, Beaver, West Branch, and Ushkabwakka rivers.

From the Duluth and Iron Range railroad crossing nearly to Little Cloquet River, the Cloquet flows through a narrow valley from 20 to 30 feet below the general level and pursues a fairly straight course. In this stretch the river, has in general, a gentle slope. From Little Cloquet River to the outlet of Wood Lake the shores are low and swampy with little fall except between Alden and Island lakes where the river falls 55 feet. Below Wood Lake the banks become higher again, averaging about 20 feet for the remainder of the distance to the mouth. The fall in the lower stretch becomes heavier.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The drainage area is covered by a thin layer of red till underlain by gabbros and red rock of the Cambrian series. The topography is rugged, and the streams in general have cut shallow valleys into the overlying drift. Elevations range from 1200 to 1800 feet. There are numerous lakes, but little swamp land.

The entire basin is in the forested area of the State. Interspersed among the densely timbered areas are other areas where the cover is thin. The trees found are chiefly, white, Norway and jack pine, spruce, balsam, tamarack, and cedar. There is very little cleared land.

RAINFALL AND RUNOFF.

The mean annual rainfall decreases from about 31 inches in the upper part of the basin to 28 inches at the mouth. Of these amounts, 5 inches or more occur as snow. The longest rainfall record in this portion of the State is that at Duluth which is continuous since 1871. During that period the wettest year was 1879 with a rainfall of 45.3 inches, and the driest, 1910 with a rainfall of 18.1 inches.

Runoff records of Cloquet River have been maintained since 1909. These show the runoff to vary from 8.61 to 9.79 inches or from 38.2 to 43.4 per cent of the rainfall.

REGULATION OF FLOW.

There are three lakes in the channel of Cloquet River, namely, Alden, Island, and Wood, lakes which tend naturally to regulate the flow. There is a storage reservoir on Wild Rice Lake in T. 51 N., R. 15 W., which is used for the purpose of increasing the low water flow of St. Louis River at the power plant near Thomson. This reservoir has an area of 5 square miles and a draft of 5 feet giving an available storage capacity of 697,000,000 cubic feet. Another storage reservoir has recently been constructed on Beaver River which drains Wild Rice Lake. This reservoir has a capacity of 60 square mile-feet or 1,670,000,000 cubic feet. By far the greatest regulator of the flow of Cloquet River is the logging dams which are located as follows: On Cloquet River in sec. 19, T. 53 N., R. 13 W., and sec. 15, T. 52 N., R. 15 W.; on West Branch of Cloquet River in sec. 15, T. 55 N., R. 13 W.; on branch of Cloquet River in sec. 12, T. 55 N., R. 13 W.; on Little Cloquet River, in sec. 18, T. 54 N., R. 12 W., sec. 25, T. 54 N., R. 13 W., and sec. 36, T. 54 N., R. 13 W.; on a branch of the Cloquet in sec. 17, T. 53 N., R. 13 W.; on Ushkabwakka River in sec. 14, T. 52 N., R. 16 W. These logging dams control the runoff from 570 of the 742 square miles comprising the area drained by the Cloquet River at its mouth.

The effect of these dams is to vitiate the natural regulation of the lakes, and the artificial regulation of the storage reservoirs, tends to increase the inequality of flow by storing the water during the period of minimum flow during the winter months, and thereby increasing the spring and early summer flow for the purpose of driving logs down to the St. Louis River. The Minnesota Forest Service has made the following estimate of log driving on Cloquet River and its tributaries: 1909, 13,583,470; 1910, 20,203,340; 1911, 67,976,540 feet B. M.

DRAINAGE AREAS.

The following drainage areas have been measured:

Drainage areas in Cloquet River Basin.

River.	Drainage area above.	Square miles.
Cloquet	Sec. 20, T. 54 N., R. 13 W	313
Do	Alden Lake outlet	395
Do	Sec. 34, T. 53 N., R. 14 W	438
Do	Sec. 15, T. 52 N., R. 15 W	523
Do	Gaging station at Independence	698
Do	Mouth	742
Beaver	Mouth	74
Ushkabwakka	Mouth	47

GAGING STATION RECORDS.

CLOQUET RIVER AT INDEPENDENCE.

Location.—At the highway bridge at Independence postoffice in Sec. 26, T 52 N, R 17 W, just below a small tributary entering from the north.

Records available.—June 28, 1909, to December 31, 1912.

Drainage area.—698 square miles.

Gage.—Vertical staff; datum unchanged since establishment.

Channel.—Permanent except when affected by log jams.

Discharge measurements.—Made from bridge.

Regulation.—Cloquet River is used extensively for log driving, and the runoff from by far the greater part of the drainage area above Independence is controlled by logging dams. This control causes violent fluctuations in the gage height during the day, amounting at times to several feet, and consequently the mean daily gage height,—which is the mean of three readings taken morning, noon and night, can only be considered approximate. The chief purpose of the records is to show the approximate mean monthly discharge and total discharge.

Winter flow.—Prior to the latter part of 1911 observations have been discontinued during the winter on account of ice and the mean monthly flow based on records of flow at the Island Lake logging dam and from the discharge from Wild Rice Lake on Beaver River. During the winter season of 1911 and 1912, the station was maintained and records based on actual discharge measurements supplemented by storage records as furnished by the Great Northern Power Co.

Accuracy.—During the open season of 1911 a wing dam of logs placed at the rapids just below the bridge, caused backwater at the gage. The amount of this backwater lessened at low stages as the wing dam rested on rocks between which a large part of the water flowed. A rating table was constructed based on measurements made when the wing dam was in place. The dam was removed June 5, 1912. Measurements made after June 5, 1912, indicate that conditions have changed slightly from what they were before the wing dam was constructed.

Daily discharge, in second-feet, of Cloquet River at Independence.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
1							103	1,370	1,000	920	1,850	
2							90	1,270	331	1,040	1,040	
3							90	2,530	199	1,150	1,850	
4							90	2,390	392	1,270	3,270	
5							90	3,120	244	622	2,670	
6							85	810	185	392	1,720	
7							85	260	160	540	1,320	
8							80	2,110	138	1,000	1,000	
9							80	416	128	650	810	
10							80	260	128	490	810	
11							80	1,480	119	350	392	
12							85	1,850	128	331	277	
13							90	2,670	149	920	244	
14							103	3,750	172	882	260	
15							103	3,430	172	2,250	294	
16							128	3,270	185	1,720	350	
17							119	3,120	172	2,250	775	
18							128	2,820	160	2,820	622	
19							1,480	3,430	185	2,530	650	
20							1,720	2,390	185	1,370	416	

Daily discharge, in second-feet, of Cloquet River at Independence—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.												
21							2,530	2,390	331	1,220	371	
22							4,390	2,670	650	1,480	416	
23							4,710	1,850	1,220	1,180	465	
24							3,910	1,130	2,530	1,720	490	
25							4,230	294	3,910	1,600	650	
26							5,190	1,370	3,120	2,250	845	
27							5,190	1,000	2,970	2,530	810	
28						1,600	3,590	1,850	2,250	3,270	490	
29						1,080	1,000	1,850	1,980	3,120	490	
30						595	1,480	1,720	1,080	3,270	595	
31							1,480	1,320		2,530		
1910.												
1				2,030	723	406	219	156	612	216	302	
2				3,160	1,190	316	228	584	435	165	302	
3				3,150	525	1,030	267	860	402	123	264	
4				3,060	1,930	674	274	2,120	247	133	153	
5				2,820	992	1,160	238	1,920	1,450	103	106	
6				1,750	831	1,240	244	331	2,560	99	117	
7				1,710	617	1,250	244	465	1,770	96	84	
8				639	789	680	267	435	354	84	82	
9				2,660	1,200	520	251	213	1,760	89	84	
10				622	723	379	257	123	1,380	86	88	
11				490	500	379	260	130	875	85	79	
12				379	288	367	350	119	617	84	78	
13				379	244	358	346	142	520	82	73	
14				354	254	277	358	175	402	84	76	
15				367	639	228	291	156	312	85	76	
16				421	490	238	207	138	267	85	70	
17				460	375	288	213	130	251	280	70	
18				460	264	288	244	142	216	3,270	70	
19				500	247	219	191	219	185	2,240	70	
20				1,670	530	232	170	342	172	775	70	
21				2,780	686	298	160	298	165	525	70	
22				2,220	556	264	160	852	162	435	70	
23				2,710	656	238	185	600	165	323	70	
24				1,500	1,180	210	1,700	824	165	270	70	
25			2,110	1,520	952	270	375	898	156	308	70	
26			2,460	976	952	363	251	736	185	505	70	
27			762	860	968	270	320	323	280	323	70	
28			890	698	445	205	342	736	445	308	70	
29			920	1,260	354	188	202	606	320	308	70	
30			1,220	860	460	207	178	460	277	294	70	
31			1,580		490		158	762		294		
1911.												
1					1,560	6,010	88	2,070	1,300	608	235	
2					612	1,890	78	1,350	311	764	204	
3					277	480	70	826	217	594	171	
4					191	402	70	650	138	944	286	
5					156	1,260	69	581	581	690	490	
6					138	1,520	617	568	396	826	568	
7					130	327	2,160	599	1,240	604	536	
8					134	173	1,770	599	1,430	645	469	
9					662	131	944	442	800	558	469	
10					992	124	192	214	1,170	944	506	
11					302	214	103	180	2,070	524	524	
12					207	169	82	167	1,910	494	269	
13					196	986	68	154	1,500	770		
14					199	576	66	152	1,700	400		
15					1,760	2,430	62	314	1,430	453		
16					1,260	1,660	61	404	1,810	891		
17					2,280	1,400	59	192	2,180	718		
18					1,580	1,740	56	144	2,040	506		
19					1,770	324	55	124	2,080	826		
20				686	4,630	154	54	115	718	891		
21				440	3,570	109	54	144	225	917		
22				968	4,280	85	54	173	171	707		
23				2,040	2,710	73	73	180	140	204		
24				2,680	3,150	396	94	187	134	340		
25				2,380	3,030	1,600	103	162	131	269		

Daily discharge, in second-feet, of Cloquet River at Independence—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
26				2,170	4,420	404	94	140	131	180		
27				2,120	3,090	178	77	453	404	199		
28				644	674	156	89	494	898	418		
29				294	327	120	89	212	734	718		
30				232	789	97	88	144	746	660		
31					421		2,580	453		746		
1912.												
1					317	1,530	274	60	193	85	257	
2					1,450	1,930	179	152	165	179	208	
3					1,000	2,250	845	370	152	257	224	
4					524	2,170	1,080	415	165	330	224	
5					1,450	1,690	274	370	152	350	224	
6					2,170	2,390	208	330	140	392	224	
7					1,450	2,250	700	440	165	415	257	
8					2,010	1,180	350	392	193	330	257	
9					1,850	440	240	465	208	311	240	
10					1,690	193	465	274	224	292	179	
11					1,370	1,600	1,370	240	311	274	129	
12					1,610	1,370	1,000	224	311	257	152	
13					800	1,850	240	208	330	240	118	
14	88			90	1,370	440	808	224	292	224	100	
15				90	1,610	208	2,820	152	240	224	92	
16				90	1,930	193	3,120	208	208	193	64	
17				78	2,250	208	2,970	274	274	224	85	
18				90	930	193	1,720	257	257	208	73	
19				158	1,220	165	1,480	179	208	193	92	
20				158	1,370	370	240	193	257	1,040	85	
21				685	302	700	118	140	240	1,600	79	
22				590	461	1,000	2,250	118	224	1,480		
23				217	545	635	1,080	118	224	1,270		
24		180		192	461	920	700	92	224	920		
25				635	1,070	700	415	85	257	920		
26				685	1,690	415	193	79	257	845		
27				590	740	224	129	73	292	575		
28				1,070	1,450	257	79	73	292	548		
29			267	685	1,300	440	62	152	129	370		
30				1,220	2,250	257	58	152	79	292		
31					2,250		55	179		257		

Daily discharges for 1909 and 1910 computed from a well defined rating table. Daily discharges for 1911 computed from two well defined rating tables, one used prior to June 5. Daily discharges for 1912 computed from two well defined rating curves, made necessary by the removal of the wing dam on June 5, 1912.

Monthly discharge of Cloquet River at Independence.

[Drainage area, 698 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1909.						
January			[a]160	0.229	0.26	C
February			[a]195	.279	.29	C
March			[a]275	.394	.45	C
July	5,190	80	1,370	1.96	2.26	B
August	3,750	260	1,940	2.78	3.20	B
September	3,910	119	819	1.17	1.30	B
October	3,270	331	1,540	2.21	2.55	B
November	3,270	260	875	1.25	1.40	B
December			[a]840	1.20	1.61	C

[a] Estimated from records of flow from Island Lake dam and from Wild Rice reservoir, as maintained by the Great Northern Power Co. A small allowance has been made for flow of intervening streams.

Monthly discharge of Cloquet River at Independence—Continued.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1910.						
January			[a]220	.315	.36	C
February			[a]300	.430	.45	C
March	2,460		[a]370	.530	.57	C
April	3,160	354	1,420	2.03	2.26	B
May	1,930	244	679	.973	1.12	B
June	1,250	188	435	.623	.70	B
July	1,700	158	295	.423	.49	B
August	2,120	119	516	.739	.85	B
September	2,560	156	570	.817	.91	B
October	3,270	82	392	.562	.65	B
November			100	.143	.16	B
December			[a] 80	.115	.13	C
The year	3,270		444	.636	8.61	
1911.						
January			[a] 90	.129	.15	C
February			[a]100	.143	.15	C
March			[a]130	.186	.21	C
April	2,680	232	[b]800	1.15	1.28	B
May	4,630	130	1,470	2.11	2.43	B
June	6,010	73	840	1.20	1.34	B
July	2,580	54	326	.467	.54	B
August	2,070	115	406	.582	.67	B
September	2,180	131	958	1.37	1.53	B
October	944	180	613	.878	1.01	B
November			[c]250	.358	.40	D
December			[c] 50	.072	.08	D
The year			504	.722	9.79	
1912.						
January			[d]150	.215	.25	D
February			[d]140	.201	.22	D
March			[d]190	.272	.31	C
April			[d]318	.456	.51	C
May	2,250	302	1,320	1.89	2.18	A
June	2,390	165	939	1.35	1.51	B
July	3,120	55	823	1.18	1.36	B
August	465	60	216	.309	.36	A
September	330	79	222	.318	.35	A
October	1,600	85	487	.698	.80	B
November	257	64	140	.201	.22	C

[a] Estimated from records of flow from Island Lake dam and from Wild Rice reservoir, as maintained by the Great Northern Power Co. A small allowance has been made for flow of intervening streams.

[b] Mean discharge April 1-19 estimated at 492 second-feet, from climatologic records and by comparison with records of flow of St. Louis River.

[c] Estimated from climatologic records, one measurement in December and by comparison with records of flow of St. Louis River.

[d] Discharge from January 1 to April 13, 1912, estimated from discharge measurements and records of the Great Northern Power Co.

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

A survey of Cloquet River from the crossing of the D. & I. R. railroad near Brimson to the mouth of the river was made in 1910. The results of this survey are given on plates 15 to 18, inclusive of the atlas. From these sheets the following table of elevations and distances has been compiled:

Elevations and distances along Cloquet River from Brimson to the mouth.

Stations.	Distance in miles.		Elevation in feet above sea level.	Descent in feet between points.	
	From Brimson.	Point to Point.		Total.	Per mile.
Duluth & Iron Range R. R. crossing near Brimson	0.0	.....	1,468	.....	.....
.....	2.5	2.5	1,463.5	4.5	1.8
West Branch Cloquet River	4.7	2.2	1,459.5	4.0	1.8
Foot of Rapids	4.9	0.2	1,454	5.5	27.5
.....	8.0	3.1	1,450.5	3.5	1.1
.....	12.0	4.0	1,440	10.5	2.6
.....	14.0	2.0	1,421	19	9.5
Section line 29-32	19.7	5.7	1,407	14	2.5
Little Cloquet River	22.8	3.1	1,395	12	3.9
Crest of Rapids	24.5	1.7	1,395	0	0.0
Foot of Rapids	24.8	0.3	1,384.5	10.5	35.0
Logging dam at Alden Lake, crest	26.8	2.0	1,383.5	1.0	0.5
Logging dam at Alden Lake, foot	26.8	0	1,377.5	6.0	.....
Rapids above Big Falls, crest	31.6	4.8	1,363	14.5	3.0
Rapids above Big Falls, foot	31.8	0.2	1,353.5	9.5	47.5
Big Falls, crest	32.3	0.5	1,353	0.5	1.0
Big Falls, foot	32.4	0.1	1,335	18	.....
Upper end of Island Lake	33.3	0.9	1,330	5	5.5
Dam at outlet of Wood Lake, crest	42.2	8.9	1,330	0	0.0
Dam at outlet of Wood Lake, foot	42.2	0	1,319	11	.....
Lily Lake, outlet	47.2	5.0	1,316	3	0.6
Beaver River	49.6	2.4	1,314	2	0.8
Duluth & Northeastern R. R. crossing	52.8	3.2	1,312	2	0.6
Foot of Rapids	54.5	1.7	1,295	17	10.0
.....	57.4	2.9	1,290	5	1.7
.....	58.6	1.2	1,289	1	0.8
Swan Lake Road (Independence P.O.)	60.7	2.1	1,270	19	9.0
Head of Rapids	62.2	1.5	1,262	8	5.3
Foot of Rapids	63.6	1.4	1,248	14	10.0
D. M. & N. R. R. crossing near Burnett	66.2	2.6	1,240	8	3.1
Mouth of River	70.2	4.0	1,206	34	8.5

Although there is considerable fall above Brimson, the runoff is too small to afford important power developments above that point. Between Brimson and the mouth of the river are the following feasible developments:

In sec. 20, T. 54 N., R. 13 W.—A 30-foot dam at mile 17.3, 5 miles above Little Cloquet River, would back the water 5.2 miles upstream and overflow 400 acres. The length of the dam would vary from 300 feet at the water surface to 800 feet at the crest.

Alden Lake.—At the outlet of Alden Lake at mile 26.9 there is a logging dam 7 feet high which holds the water in the lake, and for a short distance above the lake. It would be possible to raise this dam to an elevation of 1,400 feet, giving a head of 23 feet.

In sec. 34, T. 53 N., R. 14 W.—There is a dam site at the foot of the big falls, at mile 32.4, where a dam 35 feet high could be built. This would back the water to the logging dam at the outlet of Alden Lake, submerging the lower 3 feet of the dam. The pond formed by this dam would have a capacity of 168,000,000 cubic feet. To utilize this storage to a greater extent than to meet daily demands for peak load would reduce the head so materially that this method of operation is not considered in determining the available power.

In sec. 15, T. 52 N., R. 15 W.—At the outlet of Wood Lake at mile 42.2 there is a logging dam, 11 feet high, known as the high dam. This dam holds the water in Wood and Island lakes, backing it to the rapids below the big falls. It is possible to raise this dam 10 feet to elevation 1340 without overflowing any great amount of land. This would submerge the lower 5 feet of the big falls. The reservoir thus formed would have a total capacity of 1,570,000,000 cubic feet, of which 224,000,000 cubic feet would be in the upper 10 feet. To utilize this latter amount for storage would reduce the power head to a minimum of 11 feet. Therefore, in considering the available power it is assumed that the storage capacity would not be drawn upon, except to meet the daily demands for peak load.

In sec. 34, T. 52 N., R. 17 W.—One mile below Independence at mile 61.5 it would be possible to erect a dam 45 feet high which would back the water 8.5 miles upstream nearly to the crossing of the Duluth & Northeastern railroad. The length of the dam would vary from 200 feet at the water surface to 800 feet at the crest. The land overflowed, 950 acres, would be almost entirely timbered, except in the immediate vicinity of Independence.

In sec. 36, T. 51 N., R. 18 W.—A half mile above the mouth at mile 69.9 it would be possible to erect a 50-foot dam which would back the water 7.5 miles upstream, overflowing 750 acres of timbered land. The length of the dam would vary from 250 feet at the water surface to 1300 feet at the crest.

AVAILABLE HORSEPOWER.

From the records of flow, which represent the flow of the river as controlled to a certain extent by existing logging dams, the following table has been compiled to show the available horsepower at the power sites.

Undeveloped power on Cloquet River.

Site.	Head in feet.	Minimum Runoff.			Horsepower (80% Efficiency).		
		Lowest month.	Lowest month average low year.	6 Highest months average low year.	Lowest month.	Lowest month average low year.	6 Highest months average low year.
Sec. 20, T. 54 N., R. 13 W.	30	23	50	244	63	136	665
Alden Lake	23	31	68	315	65	142	659
Sec. 34, T. 53 N., R. 14 W.	35	32	70	342	102	223	1088
Sec. 15, T. 52 N., R. 15 W.	21	38	84	408	73	160	779
Sec. 34, T. 52 N., R. 17 W	45	50	112	545	205	457	2,230
Sec. 36, T. 51 N., R. 18 W	50	53	118	577	241	536	2,623

SANITARY STATISTICS.

Cloquet River drains an area that contains little cleared land. There are no settlements of sufficient size to have municipal water supplies and sewage systems. The population is 2.3 per square mile —located chiefly in the lower portion of the basin. During the winter months the population of the upper basin is increased by the presence of logging crews.

MINOR LAKE SUPERIOR DRAINAGE BASINS.

THE STREAMS.

Beside the St. Louis River basin, there is an extensive area in northeastern Minnesota, extending across the southern portion of Lake and Cook counties that is tributary to Lake Superior. The dividing line between this drainage and that of Rainy Lake which embraces the northern portion of the two counties, enters Minnesota in the center of T. 65 N., R. 2 W., between North Lake and South Lake. It takes a southwesterly course crossing the Lake-Cook county line in T. 63 N. Across Lake County its course is in general parallel to the lake shore and lying from 12 to 14 miles from it.

This region is drained by many short streams, the principal ones being Lester, Sucker, Stewarts, Gooseberry, Split Rock, Beaver Bay, Baptism, Manitou, Temperance, Poplar, Cascade, Devil Track, Brule and Pigeon rivers.

TOPOGRAPHY, GEOLOGY AND FORESTATION.

The land rises rapidly from the shores of Lake Superior so that within a few miles of the lake the rivers have a fall of from 600 to 800 feet. At the eastern end of the area the rise is precipitous in many places, while to the westward, there are no cliffs as the rise is more gradual. Further inland, the surface is rough but without any very marked elevations, except in the northern part of the basin in Cook County where are found several parallel ranges of hills extending east and west, formed chiefly of Keweenawan granites. One of these ranges contains points over 2200 feet above sea level which is the highest land in Minnesota. The portion drained by Pigeon River is markedly different from the remainder. It is underlain by Cambrian rocks and has parallel east and west ridges capped by diabase sills. The northern slope of each ridge is steep and frequently precipitous while the southern slope is quite gentle.

Further west in Lake County the northern boundary is a broad undulating plateau rising to an elevation of 1800 feet above sea level, and deeply covered with glacial drift. The remainder of the area has much less drift than the plateau, and outcroppings of rocks of the later diabases, surface basic rocks, and red rock of the Keweenawan series, are frequent.

In the northeastern portion, lakes are numerous and are prevalent throughout the portion in Cook County, but in Lake County, the topography is less rugged and there are very few lakes. The range of elevations is from Lake Superior level (602) to 2200 feet above sea level.

The entire area is forested, chiefly with white and Norway pine, spruce, cedar, balsam, tamarack, birch, and poplar. There are dense patches interspersed with areas where the growth is thinner. Fire has swept over large areas, in many places seriously injuring the soil. Relatively less logging has been done in this section than in any other part of the State, owing to a lack of transportation facilities. There are practically no settlers in the entire section except in the vicinity of Grand Marais and scattered settlements chiefly of fishermen along the lake shore, and consequently little or none of the land has been cleared.

RAINFALL.

The only rainfall records of any length in this section are those at Duluth and Two Harbors. The former is continuous since 1871 and shows a mean annual precipitation of 30 inches. The wettest year was 1879 with a rainfall of 45.3 inches, and the driest 1910 with 18.1 inches. The Two Harbors records are continuous since 1895. During that period the mean annual rainfall was 31.7 inches. The wettest year was 1909 with a rainfall of 43.2 inches. The driest year was 1910 with a rainfall of 14.1 inches. It is possible that the rainfall increases somewhat toward the eastward of the area but the scattering records at Hovland do not indicate this.

WINTER FLOW.

On the streams which are uncontrolled by logging dams it is probable that the minimum flow occurs during the winter months. Owing to the northern latitude there are no winter thaws, and the only sources of supply for the streams are the few lakes and the ground water. Where there are logging dams it is probable that the summer flow when the dams are closed is as low as that during the winter months. On account of the inaccessibility of the stations adequate winter records have not yet been secured.

DRAINAGE AREAS.

The following drainage areas have been measured:

Drainage areas in minor Lake Superior drainage.

River.	Drainage area above.	Square miles.
Lester	Mouth	55
Sucker	do	35
Stewarts	do	32
Gooseberry	do	85
Split Rock	do	48
Beaver Bay	do	120
Baptism	do	135
Manitou	do	71
Cross	do	32
Temperance	do	198
Poplar	do	144
Cascade	do	84
Devil Track	do	75
Brule	North Branch	99
Do	Mouth	282
Pigeon	do	628

GAGING STATIONS.

Owing to the absence of settlers, it has been impossible to establish regular gaging stations on any of the rivers except Beaver Bay River at Beaver Bay, Poplar at Mouth, Brule at the Mouth and Devil Track at the Mouth. The latter two stations have gage heights taken weekly.

The following rivers are measured near the mouth whenever a hydrographer visits the regular stations; Cascade, Temperance, Cross, Manitou, and Baptism.

GOOSEBERRY RIVER.

Gooseberry River rises in T. 56 N., R. 10 W., in Lake County at an elevation of about 1,700 feet and flows south and east into Lake Superior in sec. 22, T. 54 N., R. 9 W. It has numerous tributaries draining nearly all portions of the basin showing that the runoff is uniformly distributed. The lowest tributary which drains an area of about 25 square miles enters Gooseberry River about two miles above its mouth. The entire area drained by Gooseberry River is 85 square miles.

Owing to an absence of lakes in the drainage basin, there are no good reservoir sites for storage. As there are no logging dams on the river, the flow is entirely uncontrolled.

BEAVER BAY RIVER.

Beaver Bay River rises in T. 57 N., R. 9 W., at an elevation of 1,700 feet and flows southeast into Lake Superior. It has tributaries entering throughout its entire length, showing that the runoff from the drainage basin is uniform. The lowest tributary of any size enters Beaver Bay River about two miles above its mouth. This stream drains an area of 45 square miles or more than one-third the drainage area at the mouth of Beaver Bay River which is 120 square miles.

There is but one lake in the drainage basin, and this has too small a tributary area to be of value as a reservoir site.

Beaver Bay River is used somewhat for log driving but no dams are known to exist to control its flow.

BAPTISM RIVER.

Baptism River rises in sec. 35, T. 59 N., R. 8 W., in Lake County at an elevation of about 1850 feet and flows southeast into Lake Superior in sec. 14, T. 56 N., R. 7 W. There are two tributaries of fair size entering Baptism River in sections 20 and 34 respectively in T. 57 N., R. 7 W. From the lower of these streams to the mouth of the river the distance is about 7 miles and in this distance there are no tributaries of any size. Baptism River drains an area of 135 square miles at its mouth.

There is an almost total absence of lakes in the drainage basin and therefore, the flow is not regulated by these natural reservoirs. Although there are a number of old logging dams these are not used at present, and thus the flow of the river is entirely uncontrolled.

MANITOU RIVER.

This river rises in a small lake in sec. 2, T. 59 N., R. 7 W., in Lake County and flows southeast through two small lakes, entering Lake Superior in sec. 10, T. 57 N., R. 6 W. Its chief tributaries are a stream entering Manitou River in sec. 6, T. 58 N., R. 6 W., and a stream entering in sec. 17, T. 58 N., R. 6 W. Between this latter stream and the mouth a distance of 6 miles or more, there are no tributaries, of any size. The entire area drained by Manitou River is 71 square miles.

The flow of the river is not controlled by any dams so far as known, nor is the river used for logging. The few lakes in the drainage basin are too far up on the headwaters to afford suitable reservoir sites for power possibilities.

TEMPERANCE RIVER.

Temperance River derives its name from the fact that it has no bar at its mouth as the water is deep as far back as the first falls. It is the only stream along the north shore that has this formation.

The river has the same source as that of the South Branch of Brule River, namely Brule Lake (elev. 1851) located in T. 63 N., R. 3 W., in Cook County. The former river drains the west end of the lake and the latter the east. The two outlets of the lake are nearly equal in size. From Brule Lake, the Temperance flows southward passing through a chain of small lakes in the upper half of its course and thence into Lake Superior in sec. 32, T. 59 N., R. 4 W.

The area drained by Temperance River is 198 square miles.

The lakes on the upper portion of the drainage basin afford reservoir sites of limited capacity. Logging operations are not carried on to any extent and there are no dams controlling the flow.

CASCADE RIVER.

Cascade River rises in a lake in sec. 30, T. 63 N., R. 1 W. (elev. 1950), in Cook County. Its course is west and then south emptying into Lake Superior in sec. 1, T. 60 N., R. 2 W. Throughout its entire length it has small tributaries, indicating that the runoff from the drainage basin is uniformly distributed. In the upper third of the area there are a number of small lakes, but in the remainder there are none.

When the water in Devil Track Lake is raised to the entire height of the logging dam at its outlet, the lake overflows into a tributary of Cascade River which enters the main stream in sec. 1, T. 61 N., R. 2 W., increasing the natural runoff of the Cascade basin. As the dam was closed during the summer of 1911, it is probable that the results of the measurements given below were increased somewhat from that source. The entire area drained by Cascade River (exclusive of overflow) is 84 square miles.

The flow of Cascade river is not controlled by any dams upon its headwaters. Owing to the absence of lakes, except small ones far up on the headwaters, there are no good reservoir sites within the drainage basin.

POPLAR RIVER.

The source of Poplar River is a lake in sec. 11, T. 62 N., R. 3 W., in Cook County from which it flows in a generally southerly direction through a number of lakes, entering Lake Superior in sec. 34, T. 60 N., R. 3 W., at Lutsen, Postoffice. Its chief tributary rises in a lake in sec. 27, T. 62 N., R. 3 W., and flows through four lakes, entering Poplar River in sec. 3, T. 60 N., R. 3 W. The only other important tributary rises in a lake in the central part of T. 61 N., R. 2 W., having an area of 2 square miles, and flows southwest through two other lakes into Poplar River just below the mouth of the other tributary. The area drained by Poplar River is 144 square miles.

The drainage basin of Poplar River is unlike the other minor streams entering Lake Superior on account of the many lakes scattered over the entire area. These lakes have sufficient tributary drainage areas to afford good reservoir sites.

Poplar River has been used somewhat for log driving, and there are two dams on the river, one located 2.9 miles above the mouth and the other 5.6 miles above.

DEVIL TRACK RIVER.

The source of Devil Track River is Round Lake, which is located in sec. 34, T. 63 N., R. 1 W., at an elevation of about 1,920 feet. From Round Lake the river flows south through Little Pine Lake (elev. 1,837) into Devil Track Lake (elev. 1,636). From this lake, Devil Track River flows southeast into Lake Superior in sec. 13, T. 61 N., R. 1. E., a few miles east of Grand Marais. Between Devil Track Lake and the mouth there are two fairly important tributaries, Elbow Lake outlet, which drains an area of 23 square miles and enters Devil Track River in sec. 34, T. 62 N., R. 1 E., and the South Branch of Devil Track River which drains an area of 9 square miles and empties into the main river in sec. 10, T. 61 N., R. 1 E. The entire area drained by Devil Track River is 75 square miles.

Owing to the very heavy fall and canyon-like walls of the lower river, it is not used as much for log driving as formerly. There is a logging dam at the outlet of Devil Track Lake, having a head of 7 feet, which was closed during the greater portion of 1911, thus holding back much of the natural flow. It is probable that a considerable portion of the runoff from Devil Track basin was diverted into the Cascade, as when the entire 7 feet of storage is held, the lake overflows from the central portion of the south shore, into a tributary of Cascade River. The effect of this storage was shown in the small measurements of flow given below.

The best reservoir site in the basin is Devil Track Lake, which has an area of about 3 square miles. The other lakes in the basin are too far up on the headwaters to have an adequate water supply.

BRULE RIVER.

This river is formed by the union of the North and South branches in sec. 22, T. 63 N., R. 1 E., in Cook County. The South Branch which drains a larger area than the North rises in Brule Lake which has an area of about 8 square miles and is in T. 63 N., R. 3 W., at an elevation of about 1,850 feet. It flows eastward through a number of small lakes till it joins the North Branch. Between the lakes and the forks, it has many small tributaries. The North Branch rises in North Brule Lake in sec. 19, T. 64 N., R. 1 W., and flows in a general southeasterly direction to the forks. From the junction of the two branches, Brule River follows a generally southeasterly course, passing through Elephant Lake and entering Lake Superior in T. 62 N., R. 3 E. The chief tributary of Brule River is the outlet of Greenwood Lake, which enters about 12 miles above the mouth. Between this point and the mouth there are no tributaries of appreciable size. The area drained by Brule River at its mouth is about 282 square miles.

Brule River is used somewhat for logging and there is said to be a dam at the outlet of Brule Lake. This lake forms the largest reservoir site in the basin, but is somewhat deficient in water supply owing to the small drainage area tributary to it. At the present time a portion of the runoff from the lake finds its way into Temperance River which has its source in the west end of the lake.

PIGEON RIVER.

Pigeon River, which throughout its length forms a portion of the boundary between Minnesota and Canada, rises in Mountain Lake in T. 65 N., R. 2 E. and flows in a generally southeasterly direction through Upper Lily, Lower Lily, Moose, North Fowl and South Fowl lakes into Lake Superior. Its chief tributaries are Pine, Stump and Missaieh rivers and Portage Brook from the Minnesota side, and Arrow River from the Canadian. In the northwestern portion of the area are a number of large lakes which have no apparent surface outlet, though they are probably connected with Pigeon River tributaries by underground channels. The entire area drained by Pigeon River is 628 square miles.

Extensive lumbering operations are carried on in the area drained by Pigeon River and the logs are floated down Pigeon River to Lake Superior, and from there towed to Port Arthur, Ontario. At two of the heaviest falls on the river, the high falls and Big Falls log chutes have been constructed. There are a number of dams on the river to control the flow in the interest of logging. One dam giving a head of 12 feet is located at the outlet of South Fowl Lake, another with a head of 16 feet is located 2,100 feet below South Fowl Lake, and a third one with a head of 20 feet is located 1,700 feet further down stream. Beside these, there are said to be other dams further up stream, the most remote being at the outlet of Moose Lake. The only dam known to be on the tributary waters is one on Arrow River at the outlet of Arrow Lake.

STREAM GAGING RECORDS.

The stream gaging records for the Minor Lake Superior drainage are arranged as follows: The data for the regular stations are given first, followed by the miscellaneous measurements made on the other streams:

BEAVER BAY RIVER AT BEAVER BAY.

Location.—Bridge at Beaver Bay a few hundred yards above the mouth of the river.

Records available.—July 26, 1911, to December 31, 1912.

Gage.—Staff gage July 26, 1911 to April 9, 1912, when it was washed away. On April 22, a chain gage was fastened on the steel highway bridge. The chain gage is in the same section and at the same datum as the staff gage.

Channel.—Permanent, bank high and rocky bed and control point solid rock. Temporary changes may result from drift or logs lodging in the rapids below gage.

Winter flow.—Measurements made during winter season 1911 and 1912, show that the control point remains open and open water rating curve is applicable throughout the year.

Regulation.—None.

Accuracy.—Records should be excellent.

Daily discharge, in second-feet, of Beaver Bay River at Beaver Bay.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911												
1								370	51	152	48	32
2								335	29	124	41	32
3								225	25	132	36	31
4								132	51	262	29	31
5								94	940	225	29	30
6								72	920	188	41	30
7								335	760	142	55	29
8								440	560	115	55	29
9								370	370	100	87	40
10								335	290	82	152	50
11								290	290	77	124	59
12								212	238	72	82	58
13								108	164	67	124	57
14								77	132	67	124	55
15								67	175	63	132	51
16								55	132	94	152	48
17								44	100	250	130	45
18								41	82	225	100	43
19								36	87	152	80	40
20								31	87	115	59	38
21								36	87	87	59	36
22								44	94	87	59	35
23								38	87	87	59	34
24								31	77	77	55	33
25								29	67	72	50	32
26							63	25	67	63	45	31
27							38	25	77	63	38	30
28							50	23	100	63	36	29
29							94	21	212	51	34	27
30							72	23	200	48	33	26
31							67	38	......	51	......	25
1912.												
1	25	9	......	50	480	124	23	12	115	77	18	......
2				75	680	100	23	15	87	59	18	......
3				115	840	275	31	14	59	48	21	......
4	25	......	9	370	1,080	238	29	8	67	38	25	......
5	......	7	......	1,000	1,000	250	25	10	77	41	20	......
6				1,400	840	238	24	14	87	38	25	......
7		......	11	1,200	680	175	20	12	87	36	27	......
8	17	7	......	1,100	680	115	16	15	77	31	25	......
9				680	480	100	15	33	67	29	25	......
10				480	760	87	12	29	59	31	23	......

Daily discharge, in second-feet, of Beaver Bay River at Beaver Bay—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
11	13			370	1,009	100	14	33	41	38	21	
12			4	480	840	87	20	29	36	59	21	
13				305	560	100	21	17	27	67	31	
14			4	440	370	100	25	17	25	61	29	
15	11			520	370	305	19	14	25	53	23	
16				480	305	560	18	14	25	50	21	
17				335	250	480	16	24	29	43	21	
18	13		4	305	225	275	14	18	29	37	18	
19				275	200	175	12	18	27	32	15	
20				250	175	132	9	14	33	29	15	
21			4	275	175	100	10	15	36	25	18	
22	9			262	175	77	12	12	44	25	15	
23				250	175	59	15	10	55	24	21	
24				250	152	45	17	20	48	23	18	
25	9		9	275	152	37	11	18	77	21	21	
26				1,240	152	28	13	21	200	21	29	
27				1,240	262	27	10	19	164	25	18	
28			13	920	335	21	9	77	115	44	25	
29	5	13		560	250	23	8	100	132	25	21	
30				305	200	29	3	87	59	25	21	
31					370		9	77		21		

NOTE.—Daily discharge computed from a rating table well defined between discharges 7 and 132 second-feet, fairly well defined between discharges 152 and 305 second-feet, which is an extension above 305 second-feet and is subject to an error of about 10 per cent above discharge 680 second-feet. Daily discharge estimated April 5 to 9, 1912, from observer's notes regarding highwater stages.

Monthly discharge of Beaver Bay River at Beaver Bay.

[Drainage area, 120 square miles.]

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).	Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.		
1911.						
August	440	21	129	1.08	1.24	A
September	940	25	218	1.82	2.03	B
October	262	48	111	.925	1.07	B
November	152	29	71.6	.597	.67	C
December	59	25	37.6	.313	.36	B
1912.						
January			20	.167	.19	B
February			10	.083	.09	B
March			7	.058	.07	C
April	[a]1,400	50	527	4.39	4.90	C
May	1,080	152	458	3.82	4.40	C
June	560	21	149	1.24	1.38	B
July	31	3	16.2	.135	.16	C
August	100	8	26.3	.219	.25	B
September	200	25	67.0	.558	.62	A
October	77	21	37.9	.316	.36	B
November	31	15	21.6	.180	.20	B

[a] Estimated.

POPLAR RIVER AT LUTSEN.

Location.—About 800 feet above mouth of river in sec. 34, T. 60 N., R. 3 W.

Records available.—May 6, 1911 to November 4, 1911[a]; August 22, 1912 to December 31, 1912. Gage heights and discharge measurements only.

[a] Records of gage heights at a staff gage 350 feet below present staff gage.

Drainage area.—144 square miles.

Gage.—From May 16, 1911 to November 4, 1911, a staff gage, about 400 feet above the mouth of the river was used. August 26, 1912, a staff gage fastened to the rock face on the right bank about 800 feet above the mouth.

Channel.—Solid rock.

Discharge measurements.—Made by wading.

Winter flow.—As the control point is the crest of the falls below in solid rock, it is believed that the open water rating will hold throughout the year.

Artificial Control.—The flow of the river is controlled to some extent by two dams above; the nearest being the dam of the National Paper & Pulp Co. 2½ miles above the mouth.

Accuracy.—Relation between gage height at the gage section between May 6 and November 4, 1911, and discharge at time affected by backwater from deposits of gravel which is washed up into the mouth of the river during storms on Lake Superior. The present gage is located between two falls and except for temporary drift lodging on the rapids below, will give excellent records.

Discharge measurements of Poplar River at Lutsen.

Date.	Hydrographer.	Gage height.	Discharge.
1911.		Feet.	Sec.-ft.
May 6	Follansbee & Hawley	12.75	142
July 3	Hawley & Smith	12.37	61.5
Aug. 4	C. L. Smith	12.53	65.4
Oct. 5	S. B. Soule	12.94	82.6
1912.			
Aug. 22	S. B. Soule	1.00[a]	25.6

[a] Old gage read 13.07 feet.

Daily gage height, in feet, of Poplar River at Lutsen.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1911.												
1						12.70	12.00	12.60	12.80	13.38	12.90	
2						12.68	12.60	12.60	12.72	13.38	13.40	
3						12.65	12.35	12.55	12.70	13.28	13.50	
4						12.60	12.20	12.50	12.70	13.15	13.60	
5						12.60	12.20	12.50	12.72	13.02		
6					12.75	12.58	11.95	12.50	13.05	12.92		
7					12.70	12.55	11.70	12.52	13.25	12.82		
8					12.70	12.55	11.88	12.60	13.08	12.92		
9					12.70	12.50	11.98	12.68	12.92	12.95		
10					12.75	13.05	12.05	12.60	12.90	12.90		
11					12.88	13.18	12.10	12.55	12.85	12.88		
12					12.95	13.08	12.02	12.50	12.82	12.85		
13					12.90	12.70	11.05	12.50	12.80	12.80		
14					12.85	12.90	11.05	12.48	12.75	12.75		
15					12.85	12.55	12.00	12.50	12.92	12.70		
16					13.00	12.15	12.05	12.52	13.00	12.82		
17					13.12	12.08	12.05	12.48	13.10	12.92		
18					13.12	12.65	12.10	12.42	13.05	12.98		
19					13.05	13.15	12.15	12.38	13.00	12.98		
20					13.02	12.05	12.18	12.32	13.00	12.90		
21					12.98	12.90	12.20	12.35	12.95	12.82		
22					12.92	12.22	12.30	12.40	12.90	12.78		
23					12.92	12.60	12.95	12.45	12.98	12.80		
24					12.90	12.20	12.70	12.40	13.08	12.80		
25					12.88	12.00	12.60	12.55	13.18	12.80		
26					12.82	12.00	12.60	12.75	13.12	12.80		
27					12.75	12.00	12.52	12.90	13.08	12.78		
28					12.75	12.02	12.48	12.92	13.05	12.75		
29					12.68	12.50	12.40	13.00	13.15	12.70		
30					12.62	12.55	12.40	12.92	13.30	12.70		
31					12.70		12.52	12.88		12.70		
1912.												
1									1.08	1.36	1.00	
2									1.05	1.31	.98	
3									1.06	1.26	.98	
4									1.11	1.22	.98	
5									1.79	1.20	.98	
6									2.45	1.20	.98	
7									2.20	1.08	.98	
8									1.89	1.08	1.01	
9									1.72	1.06	1.02	
10									1.66	1.05	1.02	
11									1.58	1.05	1.02	
12									1.49	1.29	1.02	
13									1.42	1.26	1.00	
14									1.32	1.24	1.00	
15									1.26	1.21	.99	
16									1.21	1.19	.98	
17									1.22	1.16	.98	
18									1.31	1.14	.98	
19									1.26	1.11	.95	
20									1.26	1.06	.95	
21									1.38	1.05	.95	
22								1.00	1.41	1.04	.95	
23								1.00	1.36	1.02	.95	
24								.98	1.34	1.02	.95	
25								.98	1.38	1.02	.95	
26								.98	1.65	1.01	.94	
27								1.00	1.65	1.00	.92	
28								1.01	1.58	1.00	.92	
29								1.04	1.51	1.00	.92	
30								1.06	1.42	1.00	.92	
31								1.08		1.00		

Miscellaneous measurements in Minor Lake Superior drainage basins.

Date.	Stream.	Locality.	Discharge second-feet
1911.			
May 9	Lester	Mouth	16
1911.			
July 29	Gooseberry	Mouth	27
August 6	do	do	15
1911.			
May 8	Baptism	Mouth	135
July 22	do	do	19
August 5	do	do	272
October 7	do	do	139
1912.			
August 23	do	do	29
1911.			
May 7	Manitou	Mouth	119
August 5	do	do	147
October 6	do	do	121
1912.			
August 23	do	do	34
1911.			
July 13	Cross	Mouth	7.6
August 1	do	do	90
October 6	do	do	66
1912.			
August 23	do	do	13
1911.			
July 9	Temperance	Mouth	35
August 4	do	do	106
October 6	do	do	180
1912.			
August 22	do	do	28
1911.			
May 6	Cascade	Mouth	329
June 28	do	do	62
August 4	do	do	46
October 5	do	do	109
1912.			
August 22	do	do	30
1911.			
May 5	Devil Track	Mouth	96
July 3	do	do	11
August 3	do	do	43
October 2	do	do	97
1912.			
August 21	do	do	16
1911.			
May 5	Brule	Mouth	527
June 21	do	do	82
August 2	do	do	105
October 2	do	do	62
1912.			
August 20	do	do	32
1911.			
June 4	Pigeon	Above Arrow River	107
May 29	Arrow	Near mouth	284
1912.			
August 20	Pigeon	Mouth	79

UNDEVELOPED WATER POWER.

FEASIBLE SITES.

To determine the availability of the minor streams draining into Lake Superior for power development surveys were made in 1911 of Gooseberry, Beaver Bay, Baptism, Manitou, Temperance, Cross, Poplar, Cascade, Devil Track, Brule and Pigeon rivers. These surveys extend from the mouth of the river to points which are either above the heavy fall or above the forks in the streams, above which the runoff is too small to make the rivers of importance for power development. The results of these surveys are given on the following plates of the atlas, Gooseberry (30), Beaver Bay (3), Baptism (2), Manitou (37), Temperance (83), Cross (19), Poplar (51), Cascade (14), Devil Track (29), Brule (10), Pigeon (47 to 50 incl.). From these the following tables of elevations and distances have been compiled.

Elevations and distances along Gooseberry River from mouth to Forks in Sec. 21, T. 54 N., R. 9 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0	....	602	....	....
Foot of Rapids	0.75	.75	609	7	9
Head of Rapids	.95	.2	722	113	565
Foot of Rapids	1.8	.85	770	48	56
Head of Rapids	1.85	.05	817	47	....
Forks in Sec. 21	2.7	.85	843	26	31

Elevations and distances along Beaver Bay River from mouth to highway bridge in Sec. 17, T. 55 N., R. 8 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Beaver Bay (Lake Superior)	0	....	602	....	....
Foot of Falls	0.2	0.2	605	3	15
Head of Falls	0.3	.1	716	111	1,110
Head of Rapids	1.0	.7	905	189	270
Highway bridge	2.5	1.5	915	10	7
Foot of Rapids	3.9	1.4	937	22	16
Head of Rapids	4.1	.2	1,002	65	325
....	5.0	.9	1,026	24	27
....	6.0	1.0	1,087	61	61
Highway bridge, Sec. 17	6.6	.6	1,088	1	2

Elevations and distances along Baptism River from mouth to top of plateau.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Foot of Rapids	0.1	0.1	603	1	10
Foot of Falls	.85	.75	670	67	89
Crest of Falls	1.0	.15	727	57	380
Foot of Rapids	1.3	.3	730	3	10
Head of Rapids	1.8	.5	843	113	226
	3.0	1.2	975	132	110
	4.0	1.0	1,044	69	69
Highway bridge	5.8	1.8	1,107	63	35
	6.6	.8	1,177	70	88
	8.0	1.4	1,306	129	92
Highway bridge	8.9	.9	1,335	29	32

Elevations and distances along Manitou River from mouth to top of plateau.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Foot of Falls	0.05	0.05	602	0	0
Crest of Falls	.1	.05	656	54	
	1.0	.9	806	150	167
	2.0	1.0	887	81	81
	3.0	1.0	973	86	86
	4.0	1.0	1,084	111	111
	5.0	1.0	1,305	221	221

Elevations and distances along Temperance River from mouth to forks in Sec. 5, T. 59 N., R. 4 W.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Foot of Rapids	.05	0.05	602	0	0
Head of Rapids	.5	.45	764	162	360
	1.0	.5	805	41	82
	2.0	1.0	886	81	81
	3.0	1.0	947	61	61
	4.0	1.0	1,027	80	80
	5.0	1.0	1,052	25	25
Forks, Sec. 5	6.0	1.0	1,065	13	13

Elevations and distances along Cross River from mouth to top of plateau.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Foot of Rapids	0.3	0.3	619	17	57
Head of Rapids	.35	.05	715	96	
Foot of Rapids	1.2	.85	838	123	145
Head of Rapids	1.5	.3	993	155	517
	2.7	1.2	1,194	201	168
	4.0	1.3	1,280	86	66
	5.0	1.0	1,340	60	60
	6.0	1.0	1,383	43	43
Foot of logging dam	7.2	1.2	1,450	67	56
Crest of logging dam	7.2	0	1,460	10	
Upper end of pond	7.5	.3	1,460	0	0
End of Survey	8.2	.7	1,469	9	13

Elevations and distances along Poplar River from mouth to top of plateau.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Highway bridge	0.3	0.3	673	71	237
	1.0	.7	799	126	180
	2.0	1.0	955	156	156
Foot of Rapids	2.5	.5	1,025	70	140
Foot of logging dam	2.8	.3	1,210	185	617
Crest of logging dam	2.8	0.0	1,221	11	
	4.0	1.2	1,222	1	1
Highway bridge	5.1	1.1	1,236	14	13
Foot of logging dam	5.6	.5	1,250	14	28
Crest of logging dam	5.6	0.0	1,252	2	
End of Survey	6.2	.6	1,254	2	3

Elevations and distances along Cascade River from mouth to top of plateau.

Point.	Distance in miles		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Foot of Falls	0.15	0.15	610	8	53
Crest of Falls	0.35	.2	734	124	620
	1.0	.65	828	94	145
	2.0	1.0	1,000	172	172
	3.0	1.0	1,158	158	158
	4.0	1.0	1,290	132	132
	5.0	1.0	1,337	47	47
	6.0	1.0	1,419	82	82
End of Survey	6.8	.8	1,442	23	29

Elevations and distances along Brule River from mouth to top of plateau.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Lake Superior	0		602		
Highway bridge	0.5	0.5	620	18	36
	1.0	.5	676	56	112
	2.0	1.0	830	154	154
	3.0	1.0	922	92	92
	4.0	1.0	1,017	95	95
	5.0	1.0	1,156	139	139
	6.0	1.0	1,283	127	127
	7.0	1.0	1,365	82	82
End of Survey	7.2	.2	1,370	5	25

Elevations and distances along Pigeon River from mouth to South Fowl Lake.

Point.	Distance in miles.		Elevation in feet above sea level.	Ascent in feet between points.	
	Above mouth.	Point to point.		Total.	Per mile.
Pigeon Bay (Lake Superior)	0		602		
Foot of Rapids	1.5	1.5	605	3	2
Foot of Big Falls	1.7	.2	619	14	70
Crest of Big Falls—(slightly raised by logging dam)	1.7	0.0	713	94	
Upper end of pond	2.0	.3	713	0	0
Head of Rapids	2.4	.4	754	41	102
Foot of Rapids	3.45	1.05	765	11	10
Head of Rapids	3.5	.05	792	27	
	5.0	1.5	800	8	5
Foot of Rapids	6.05	1.05	825	25	24
Head of Rapids	6.1	.05	843	18	
Eastern Boundary Pigeon River Indian Reservation	8.15	2.05	873	30	15
	9.2	1.05	890	17	16
	10.5	1.3	924	34	26
Arrow River	11.5	1.0	933	9	9
	12.65	1.15	942	9	8
Foot of Rapids	14.95	2.3	981	39	17
Foot of Falls	17.45	2.5	1,121	140	56
Crest of Falls—(slightly raised by logging dam)	17.45	0.0	1,254	133	
Upper End of pond	19.1	1.65	1,254	0	0
Foot of Partridge Falls	19.8	.7	1,266	12	17
Crest of Partridge Falls	19.8	0.0	1,316	50	
Western Boundary Pigeon River Indian Reservation	21.95	2.15	1,316	0	0
Missaieh River	24.45	2.5	1,327	11	4
Portage Brook	27.85	3.4	1,348	21	6
Stump River	28.8	.95	1,350	2	2
Foot of logging dam	29.7	.9	1,364	14	16
Crest of logging dam	29.7	0.0	1,384	20	
Foot of logging dam	30.05	.35	1,393	9	26
Crest of logging dam	30.05	0.0	1,410	17	
Foot of Rapids	30.3	.25	1,410	0	0
Foot of logging dam	30.4	.1	1,430	20	200
Crest of logging dam, South Fowl Lake	30.4	0.0	1,436	6	

The study of the foregoing tables and the topography as given on the accompanying plates shows the points on the rivers which are favorable to power development. A brief discussion of the possibilities of each river is given herewith.

A. FALLS ON GOOSEBERRY RIVER.

B. BIG FALLS ON PIGEON RIVER.

Gooseberry River.—Between the forks in the river and the mouth, a distance of nearly 3 miles, there is one power site. If a low diversion dam were erected at mile 1.9 (about sec. 22, T. 54 N., R. 9 W.), a pipe line 4,500 feet long would make available at the foot of the falls 0.8 of a mile above the mouth, a head of 230 feet.

Beaver Bay River.—The heaviest fall on this river is concentrated on the first mile above the mouth. Above that point the fall is not sufficient to be of value for power development on account of the small discharge.

A low diversion dam at the head of the falls in sec. 12, T. 55 N., R. 8 W., a mile above the mouth, with a pipe line 3,500 feet long (or canal and penstock) would make available at the foot of the falls a head of 300 feet.

Baptism River.—The greater portion of the fall on Baptism River occurs in the lower 3 miles of the river, above which the slope is very much less. If a diversion dam were built across the river 3.1 miles above the mouth (about sec. 3, T. 56 N., R. 7 W.) and a pipe line or canal constructed for approximately 11,000 feet, there would be an available head of 375 feet near the mouth.

Manitou River.—Throughout the 5 miles of river that were surveyed there is a heavy fall. This is especially heavy between miles 4 and 5, and in the first mile above the lake. There are two favorable developments on the river.

In sec. 10, T. 57 N., R. 6 W.—A dam 110 feet high one-half mile above the mouth where the river is in a rock gorge, with a pipe line 2,000 feet long would give a head of 255 feet at the mouth of the river.

About sec. 28, T. 58 N., R. 6 W.—At mile 4.4 the river flows between steep banks, so that a dam 60 feet high with a pipe line or canal 4,500 feet long would create a head of 250 feet at a point 3.5 miles above the mouth. If the canal were extended 1.5 miles further, there would be available an additional head of 150 feet, making a total head of 400 feet.

Temperance River.—The heaviest fall on Temperance River occurs within 3 miles of the mouth. Although there is an additional fall of 70 feet in the next mile above, an important tributary enters at mile 3, so that a development should be below the forks to utilize the entire flow. A diversion dam at this point, which is in sec. 19, T. 59 N., R. 4 W., with a canal or pipe line 11,000 feet long, would give a head of 335 feet at the mouth of the river.

Cross River.—Within 2.8 miles of the mouth occurs the heaviest fall on Cross River. Above that section the fall is not sufficient to make possible important developments. A diversion dam at mile 2.7 in sec. 25, T. 59 N., R 5 W., with a canal or pipe line 10,000 feet long, would give a head of 585 feet at the mouth.

Poplar River.—Almost the entire fall on Poplar River occurs within 3 miles of the mouth. At the upper end of this stretch there is a low logging dam. From this dam to the mouth of the river there is a fall of 610 feet which could be utilized for power by means of a canal or pipe line about 12,100 feet long. Above this logging dam the river has a further fall of more than 30 feet before reaching the general swamp level of the plateau. If the dam were raised by this amount, it would create a reservoir of 251 million cubic feet capacity which would be available in regulating the flow of Poplar River without reducing the power head below 610 feet.

Cascade River.—This river has a fall of nearly 660 feet within 3.5 miles of its mouth, with a further fall of 180 feet in the next 3 miles. There are two feasible developments on this river as follows:

About sec. 26, T. 61 N., R. 2 W.—At mile 3.6 a diversion dam with a canal or pipe line 5,000 feet long would give a head of 210 feet.

In sec. 36, T. 61 N., R. 2 W.—1.8 miles above the mouth the river flows through a narrow gorge which is favorable for the construction of a 60-foot dam. With a dam of this height and a canal or pipe line 8,200 feet long, there would be available at the mouth of the river a head of 415 feet.

Devil Track River.—There are two favorable developments on Devil Track River as follows:

In sec. 34, T. 62 N., R. 1 E.—A diversion dam at mile 5.1, just below the outlet of Elbow Lake, with a canal or pipe line of 10,500 feet would give a head of 400 feet.

In sec. 10, T. 61 N., R. 1 E.—Just below the mouth of the South Branch a diversion dam with a pipe line or canal, 15,000 feet long would give a head of 470 feet.

Brule River.—In 6 miles above its mouth Brule River has a fall of 695 feet, which is fairly uniformly distributed. A diversion dam at mile 6.1 with a canal or pipe line approximately 5 miles long would make the entire fall available for development at the mouth of the river.

Pigeon River.—Unlike the other rivers in this drainage, the descent from the general plateau level to Lake Superior does not occur in the last few miles of its course, but extends over a distance of 30 miles with intervening stretches of river with little or no fall. For this reason high head developments comparable to those on the

A. BIG FALLS ON PIGEON RIVER DURING HIGHWATER.

B. LOG SLUICE AROUND BIG FALLS, PIGEON RIVER.

other streams are not found, but instead there are 5 sites of moderate head as follows:

Outlet of South Fowl Lake.—A dam 65 feet high at this point with a canal and pipe line 6,500 feet long would give a total head of 150 feet. Below the tailwater for this development the river has very little fall for more than 3 miles, thus limiting the head available.

Partridge Falls.—If a 23-foot dam were erected at the crest of Partridge Falls in sec. 30, T. 64 N., R. 5 E., it would overflow 1,150 acres of timbered land. The total head available from the crest of the dam to the foot of the falls would be 75 feet.

At the High Falls in sec. 21, T. 64 N., R. 5 E.—A 16-foot dam at the crest of the high falls 17.4 miles above the mouth would overflow 100 acres of timber land and back the water 5 feet on the foot of Partridge Falls, reducing any development at that point by that amount. The 16-foot dam would make available at the falls a head of 150 feet. A canal and pipe line 10,200 feet long would increase the head to 290 feet.

In sec. 20, T. 64 N., R. 6 E.—At a point 9.9 miles above the mouth there is a favorable location for a 65-foot dam which would back the water nearly to the tailwater of the high falls site. About 450 acres of timber and brush land would be overflowed. A pipe line 200 feet long would give an available head of 80 feet.

In sec. 19, T. 64 N., R. 7 E.—Three thousand feet above the crest of the Big Falls the river flows through a narrow gorge. If a 160-foot dam were built at this point it would overflow approximately 850 acres of timber and brush land, and would back the water 7.2 miles up stream to the tailwater of the preceding proposed development. A canal and pipe line 4,200 feet long would give an available head of 295 feet a short distance below the foot of the falls.

Available Water Supply.—Investigation of the runoff in the Minor Superior drainage basins was not started until the spring of 1911, so at this time there are available only fragmentary records for 1911 and 1912, which are insufficient for making power estimates.

LAWS AND REGULATIONS PERTAINING TO MINNESOTA STREAMS.

OBSTRUCTION OF STREAMS.

NAVIGABLE AND NON-NAVIGABLE STREAMS.

The waters in the State may be divided into two classes—navigable and non-navigable. If a stream is capable of being used for the purposes of trade and commerce in any mode, even by a skiff or for floating logs, the stream is considered navigable. This definition of navigability is so broad that in order to reach a working basis in determining whether the Federal Government has rights on the streams. a more or less arbitrary standard is adopted. It is tacitly understood that, in general, a stream is navigable if it is meandered, i. e., if the land lines stop at the water's edge causing fractional sections to be known by lot number. If the land lines on the original land office plats continue across the river uninterruptedly the stream is not meandered, and according to the above arbitrary standard is considered non-navigable. At the end of this chapter will be found a list of the meandered rivers in Minnesota.

It should be borne in mind that this standard of navigability and non-navigability may be modified by the actual facts in any particular case.

FEDERAL JURISDICTION.

On a navigable stream, the Federal Government, having jurisdiction over interstate commerce, has the power to prevent the placing in or across the stream any obstruction to navigation. This power is exercised by the Secretary of War through the Chief of Engineers, U. S. Army.

The following extracts taken from the River and Harbor Act approved March 3, 1899, shows the necessity for obtaining Federal approval to obstruct in any way a navigable stream. Following this, is a copy of the regulations to be observed in making application to obstruct the stream (although these regulations are intended primarily to govern bridge applications, they also govern applications for the erection of dams):

Sec. 9. That it shall not be lawful to construct or commence the construction of any bridge, dam, dike, or causeway over or in any port, roadstead, haven, harbor, canal, navigable river, or other navigable water of the United States until the consent of Congress to the building of such structures shall have been obtained and until the plans for the same shall have been submitted to and approved by the Chief of Engineers and by the Secretary of War: PROVIDED, That such structures may be built under authority of the Legislature of a State across rivers and other waterways the navigable portions of which lie wholly within the limits of a single state, provided the location and plans thereof are submitted to and approved by the Chief of Engineers and by the Secretary of War before construction is commenced: AND PROVIDED FURTHER, That when plans for any bridge, or other structure have been approved by the Chief of Engineers and by the Secretary of War, it shall not be lawful to deviate from such plans either before or after completion of the structure unless the modification of said plans has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War.

Sec. 10. That the creation of any obstruction not affirmatively authorized by Congress to the navigable capacity of any of the waters of the United States is hereby prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boon, weir, breakwater, bulkhead, jetty or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, conditions, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure with the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same.

Sec. 11. That where it is made manifest to the Secretary of War that the establishment of harbor lines is essential to the preservation and protection of harbors he may, and is hereby, authorized to cause such lines to be established, beyond which no piers, wharves, bulkheads, or other works shall be extended or deposits made, except under such regulations, as may be prescribed from time to time by him: PROVIDED, That whenever the Secretary of War grants to any person or persons permission to extend piers, wharves, bulkheads, or other works, or to make deposits in any tidal harbor or river of the United States beyond any harbor lines established under authority of the United States, he shall cause to be ascertained the amount of tide water displaced by any such structure or by any such deposits, and he shall, if he deem it necessary, require the parties to whom the permission is given to make compensation for such displacement either by excavating in some part of the harbor, including tide-water channels between high and low water mark, to such an extent as to create a basin for as much tide water as may be displaced by such structure or by such deposits, or in any other mode that may be satisfactory to him.

Sec. 12. That every person and every corporation that shall violate any of the provisions of sections nine, ten, and eleven of this Act, or any rule of regulation made by the Secretary of War in pursuance of the provisions of the said section, eleven, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding twenty-five hundred dollars nor less than five hundred dollars, or by imprisonment (in the case of a natural person) not exceeding one year, or by both such punishments, in the discretion of the court. And further, the removal of any structures or parts of structures erected in violation of the provisions of the said sections may be enforced by the injunction of any circuit court exercising jurisdiction in any district in which such structures may exist, and proper proceedings to this end may be instituted, under the direction of the Attorney-General of the United States.

RULE TO BE OBSERVED BY PARTIES MAKING APPLICATION, UNDER THE PROVISIONS OF SECTION 9 OF THE ACT OF CONGRESS APPROVED MARCH 3, 1899, FOR APPROVAL BY THE SECRETARY OF WAR OF PLANS FOR A BRIDGE.

When application is made pursuant to the provisions of section 9 of the act of Congress approved March 3, 1899, for the approval by the Secretary of War of plans for a bridge, the applicant will be required to furnish—

1. A copy of, or reference to, the law of the State authorizing the construction of the bridge, certified to by the Secretary of State, under seal.

(a) If the bridge is to be built under authority of a special act of a State Legislature, a copy of such act duly authenticated should be furnished.

(b) If a bridge is to be built under authority of a general law, a simple reference to such law by volume, page, and section will be sufficient.

(c) Where the legal authority to build a bridge is shown conclusively by the charter of articles of incorporation of a company, a copy of such paper, INFRA, will be sufficient.

(d) In cases where state laws vest the power to authorize the construction of bridges in county offices, such as boards of supervisors or county courts, certified extracts from the proceedings of such organization must be furnished.

2. Drawings, in triplicate, showing the plan of the bridge, that is, length and height of spans, width of draw openings, position of piers, abutments, etc., and those features which affect navigation. (Details of construction are not required.)

3. A map, in triplicate, showing the location of the bridge, giving, for the distance of one mile above and one-half mile below the proposed location, such data in regard to low and high water, direction and strength of currents, soundings, existing bridges, etc., as may be necessary to enable the Secretary of War to judge whether the location is a proper one.

If the applicant is a corporation, in addition to the papers enumerated above, there will be required:

1. A copy of the charter or articles of incorporation of the company, certified to by the Secretary of State, or such other officer as may have the custody of the original, under seal.

2. A copy of the minutes of the organization of the company, certified to by the secretary of the Company, under seal.

3. An extract from the company minutes showing the present officers of the company, certified to by the secretary thereof, under seal.

July 1, 1899.

An Act to amend an Act, entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

BE IT ENACTED BY THE SENATE AND HOUSE OF REPRESENTATIVES OF THE UNITED STATES OF AMERICA IN CONGRESS ASSEMBLED, That the act entitled "An act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, be, and the same is hereby, amended to read as follows:

Sec. 1. That when authority has been or may hereafter be granted by Congress, either directly or indirectly or by any official or officials of the United States, to any persons, to construct and maintain a dam for water power or other purposes across or in any of the navigable waters of the United States, such dam shall not be built or commenced until the plans and specifications for such dam and all accessory works, together with such drawings of the proposed construction and such map of the proposed location as may be required for a full understanding of the subject, have been submitted to the Secretary of War and the Chief of Engineers for their approval, nor until they shall have approved such plans and specifications and the location of such dam and accessory works; and when the plans and specifications for any dam to be constructed under the provisions of this act have been approved by the Chief of Engineers and by the Secretary of War it shall not be lawful to deviate from such plans or specifications either before or after completion of the structure unless the modification of such plans or specifications has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: PROVIDED, That in approving the plans, specifications, and location for any dam, such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that the persons constructing or mainaining such dam shall construct, maintain, and operate, without expense to the United States, in connection with any dam and accessory or appurtenant works, a lock or locks, booms, sluices, or any other structure or structures which the Secretary of War and the Chief of Engineers or Congress at any time may deem necessary in the interests of navigation, in accordance with such plans as they may approve, and also that whenever Congress shall authorize construction of a lock or other structures for navigation purposes in connection with such dam, the persons owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States free water power or power generated from water power for building and operating such constructions: PROVIDED FURTHER, That in acting upon said plans as aforesaid the Chief of Engineers and the Secretary of War shall consider the bearing of said structure upon a comprehensive plan for the improvement of the waterway over which it is to be constructed with a view to the promotion of its navigable quality and for the full development of water power; and, as a part of the conditions and stipulations imposed by them, shall provide for improving and developing navigation, and fix such charge or charges for the privilege granted as may be sufficient to restore conditions with respect to navigability as existing at the time such privilege be granted or reimburse the United States for doing the same, and for such additional or further expense as may be incurred by the United States with reference to such project, including the cost of any investigations necessary for approval of plans and of such supervision of construction as may be necessary in the interests of the United States: PROVIDED FURTHER, That the Chief of Engineers and the Secretary of War are hereby authorized and directed to fix and collect just and proper charge or charges for the privilege granted to all dams authorized and constructed under the provisions of this act which shall receive any direct benefit from the construction, operation, and maintenance by the United States of storage reservoirs, at the headwaters of any navigable streams, or from the acquisition, holding, and maintenance of any forested watershed, or lands located by the United States at the headwaters of any navigable stream, wherever such shall be, for the development, improvement, or preservation of navigation in such streams in which such dams may be constructed.

"Sec. 2. That the right is hereby reserved to the United States to construct, maintain, and operate, in connection with any dam built in accordance with the provisions of this act, a suitable lock or locks, booms, sluices, or any other structures for navigation purposes, and at all times to control the said dam and the level of the pool caused by said dam to such an extent as may be necessary to provide proper facilities for navigation.

"Sec. 3. That the persons constructing, maintaining, or operating any dam or appurtenant or accessory works, in accordance with the provisions of this act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise. The persons owning or operating any such dam, or accessory works, subject to the provisions of this act, shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe, and for failure so to do in any respect shall be deemed guilty of a misdemeanor and subject to a fine of not less than five hundred dollars, and each month of such failure shall constitute a separate offense and subject such persons to additional penalties therefor.

"Sec. 4. That all rights acquired under this act shall cease and be determined if the person, company, or corporation acquiring such rights shall, at any time, fail, after receiving reasonable notice thereof, to comply with any of the provisions and requirements of the act, or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War, including the payment into the Treasury of the United States of the charges provided for by section one of this act: PROVIDED, That Congress may revoke any rights conferred in pursuance of this act whenever it is necessary for public use, and, in the event of any such revocation by Congress, the United States shall pay the owners of any dam and appurtenant works, built under authority of this act, as full compensation, the reasonable value thereof, exclusive of the value of the authority or franchise granted, such reasonable value to be determined by mutual agreement between the Secretary of War and the said owners, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of such properties: AND PROVIDED ALSO, That the authority granted under or in pursuance of the provisions of this act shall terminate at the end of a period not to exceed fifty years from the date of the original approval of the project under this act, unless sooner revoked as herein provided or Congress shall otherwise direct: PROVIDED, HOWEVER, That this limitation shall not apply to any corporation or individual heretofore authorized by the United States, or by any State, to construct a dam in or across a navigable waterway, upon which dam expenditures of money have heretofore been made in reliance upon such grant or grants.

"Sec. 5. That any persons who shall fail or refuse to comply with the lawful order of the Secretary of War and the Chief of Engineers, made in accordance with the provisions of this act, shall be deemed guilty of a violation of this act, and any persons who shall be guilty of a violation of this act shall be deemed guilty of a misdemeanor and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, and every month such persons shall remain in default shall be deemed a new offense and subject such persons to additional penalties therefor; and in addition to the penalties above described the Secretary of War and the Chief of Engineers may, upon refusal of the persons owning or controlling any such dam and accessory works to comply with any lawful order issued by the Secretary of War or Chief of Engineers, in regard thereto, cause the removal of such dam and accessory works as an obstruction to navigation at the expense of the persons owning or controlling such dam, and suit for such expense may be brought in the name of the United States against such persons and recovery had for such expense in any court of competent jurisdiction. Said provision as to recovery of expense shall not apply wherever the United States has been previously reimbursed for such removal; and the removal or any structures erected or maintained in violation of the provisions of this act or the order or direction of the Secretary of War or the Chief of Engineers made in pursuance thereof may be enforced by injunction, mandamus, or other summary process, upon application to the circuit court in the district in which such structure may, in whole or in part, exist, and proper proceedings to this end may be instituted under the direction of the Attorney-General of the United States at the request of the Chief of Engineers or the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to navigation created by the construction of any dam under this act the cause or question arising may be tried before the Circuit Court of the United States in any district in which any portion of said obstruction or dam touches.

"Sec. 6. That whenever Congress shall hereafter by law authorize the construction of any dam across any of the navigable waters of the United States, and no time for the commencement and completion of such dam is named in said act, the authority thereby granted shall cease and be null and void unless the actual construction of the dam authorized in such act be commenced within one year and completed within three years from the date of the passage of such act.

"Sec. 7. That the right to alter, amend, or repeal this act is hereby expressly reserved as to any and all dams which may be constructed in accordance with the provisions of this act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions.

"Sec. 8. That the word 'persons' as used in the act shall be construed to import both the singular and the plural, as the case demands, and shall include corporations, companies, and associations. The word 'dam' as used in this act shall be construed to import both the singular and plural, as the case demands."

Approved, June 23, 1910.

All applications for approval of the Secretary of War are referred to the Engineer Office of the district in which the proposed bridge, dam, or other structure is to be built, and, therefore, time will be saved if letters of application are sent direct to the district office of the U. S. Engineer Corps.

STATE JURISDICTION.

Although the waters of a navigable stream are subject to the supervision of the Federal Government in the interest of navigation, the title to the *water* in the stream is not in the Federal Government but in the State, as has been stated in decisions of the United States Supreme Court. Thus the use of the water in the navigable streams lying wholly within the State is a matter of State regulation and State control, so long as this use does not interfere with the Federal Government's interest in navigation.

In Minnesota the Supreme Court has taken the view, in some of its decisions, that a riparian owner has the right, without any license from the State, to construct and maintain a dam, subject of course to the Federal regulations stated previously. Minnesota dams are usually built by corporations whose articles of incorporation empower them to build and maintain the dams.

As no laws have been enacted by the State looking to the control of the water in navigable streams, it is evident that the generally accepted view is that the State has surrendered its rights to the riparian owner (which in some few localities, where State land abuts on a stream, is the State itself). This view is borne out by sec. 2550 of the Revised Statutes of 1905 which reads as follows:

Sec. 2550. Logging streams—Boundary waters.

The owners of land bordering upon that part of any stream or other watercourses for the floating of logs, lumber or timber may dam the same and construct a connection with such dam, all raceways and other appliances necessary to the development of water power for any lawful purpose or for the supplying of water to municipalities. If such stream or water course be a common boundary between this state any any other state or country, the consent, if any, required by law or treaty from owners of the opposite bank, from the states or countries bordering thereon, and from the United States shall first be obtained.

This statute apparently ignores the fact that if logs are driven down a river it is a navigable stream and therefore subject to the consent of the Federal Government, even though it lies wholly within the State. Practically all the logging dams in Minnesota have been built without authority from the Federal Government. As no complaint has ever been made to the War Department, the dams have been left undisturbed.

Non-Navigable Streams.—In non-navigable streams the Federal Government has no interest (except some slight interest in the non-navigable head waters of navigable streams.) Here the right of eminent domain is conferred by state statute on any owner of a water power to be used in milling or manufacturing. Sec. 2543 of the Revised Statutes reads:

Sec. 2543. Dams—Eminent Domain.

Whenever any person in order to create or improve a water power for milling or manufacturing purposes shall desire to erect and maintain upon his own land a dam across any stream or other water courses not navigable, or to raise or extend any such dam already erected, whereby lands owned by other persons shall be overflowed or otherwise damaged, he may acquire the right so to do by causing such damages to be ascertained, and paid as prescribed in chapter 41. But no such dam shall be erected, raised or maintained to the injury of any water power previously improved.

Whenever the right to erect, raise or extend any such dam shall have been acquired hereunder, the improvement shall be commenced within one year and completed and the water applied to the purpose stated in the petition within three years after such acquisition; and if any such dam be destroyed, the rebuilding thereof shall be commenced and completed within the same period after such destruction. Failure to comply with the foregoing requirements shall work a forfeiture of all rights so acquired, and a like forfeiture shall result from a failure to operate such mill or machinery after the same is erected, for one consecutive year.

POLLUTION OF STREAMS.

FEDERAL STATUTES.

Beside the foregoing laws and regulations which pertain to the obstruction of the streams, statutes have been enacted by both the Federal and State governments prohibiting certain kinds of pollution. In the River and Harbor Act, approved March 3, 1899, is the following:

Sec. 13. That it shall not be lawful to throw, discharge, or deposit, or cause, suffer, or procure to be thrown, discharged, or deposited either from or out of any ship, barge, or other floating craft of any kind, or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States, or into any tributary of any navigable water from which the same shall float or be washed into such navigable water; and it shall not be lawful to deposit, or cause, suffer, or procure to be deposited material of any kind in any place on the bank of any navigable water, or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise whereby navigation shall or may be impeded or obstructed. PROVIDED, That nothing herein contained shall extend to, apply to, or prohibit the operation in connection with the improvement of navigable waters or construction of public works, considered necessary and proper by the United States officers supervising such improvement or public work: AND PROVIDED FURTHER, That the Secretary of War, whenever in the judgment of the Chief of Engineers anchorage and navigation will not be injured thereby, may permit the deposit of any material above mentioned in navigable waters, within limits to be defined and under conditions to be prescribed by him, provided application is made to him prior to depositing such material; and whenever any permit is so granted the conditions, thereof shall be strictly complied with, and any violation thereof shall be unlawful.

STATE STATUTES.

To safeguard the sources of municipal water supply and thus preserve the general health, the Revised Statutes of 1905 provide as follows:

Sec. 2147. No sewage or other matter that will impair the healthfulness of water shall be deposited where it will fall or drain into any pond or stream used as a source of water supply for domestic use. The State Board of Health shall have general charge of all springs, wells, ponds, and streams so used, and shall take all necessary and proper steps to preserve the same from such pollution as may endanger the public health.

Sec. 2131. The State Board of Health may adopt, alter, and enforce reasonable regulations of permanent application throughout the whole or any part of the state for the preservation of the public health. Upon the approval of the attorney general, and the due publication thereof, such regulations shall have the force of law, except in so far as they may conflict with a statute or with the charter or ordinances of cities of the first class upon the same subject. In and by the same, the board may control by requiring the taking out of licenses or permits or by any other appropriate means, any of the following matters:

* * * * * *

5. The pollution of streams and other waters, and the distribution of water by private persons for drinking or domestic use.

MEANDERED STREAMS IN MINNESOTA.

As those streams which have been meandered when surveyed by the United States Land Office are in general considered to be navigable and thus under the jurisdiction of the United States, so far as relates to the placing of obstructions in or across them, the following list of such streams has been compiled from the plats of the United States Land Office surveys, as filed in the office of the State Auditor:

Meandered Streams in Minnesota.

Drainage basin.	River.	Meandered from	To
Hudson Bay......	Ash............	Sec. 5, T. 68 N., R. 19 W., 4th Meridian....................	Mouth (Rainy Lake.)
Hudson Bay......	Big Fork.........	Bow String Lake (Called Bow String River), Sec. 7, T. 64 N., R. 26 W., 4th Meridian. (Mouth of Reily Creek)...............	E. Boundary, T. 149 N., R. 25 W., 5th Meridian. (8 miles above big Fork).
Hudson Bay......	Black............	Sec. 33, T. 157 N., R. 27 W., 5th Meridian. (At one time boundary of Red Lake Indian Reservation)......................	Mouth (Rainy.)
Mississippi River..	Blue Earth.......	T. 108 N., R. 27 W., 5th Meridian only........................	....
Hudson Bay......	Bois des Sioux....	Lake Traverse.................	(Mouth) confluence with Red River of North.

Meandered Streams in Minnesota—Continued.

Drainage basin.	River.	Meandered from	To
Mississippi River..	Boy..............	South boundary T. 142 N., R. 27 W., 5th Meridian............	Leech Lake.
Hudson Bay......	Clearwater.......	Sec. 32, T. 152 N., R. 41 W., 5th Meridian. (Reservation boundary).........................	Sec. 15, T. 150 N., R. 37 W., 5th Meridian.
Lake Superior....	Cloquet..........	T. 56 N., R. 12 W., 4th Meridian, (5 miles above Brimson)......	Confluence with St. Louis.
Mississippi River..	Crow Wing.......	Sec. 7, T. 137 N., R. 33 W., 5th Meridian. (about 6 miles above Nimrod)....................	Confluence with Mississippi River.
Hudson Bay......	Kawishiwi (Incl. S. K. or Birch R.)..	Source in T. 62 N., R. 6. W., 4th Meridian......................	Confluence with Rainy River.
Mississippi River..	Kettle...........	Town Line 47-48 N., R. 20 W., 4th Meridian, near Kettle River. Ts. 39 and 40 N., R. 19. (into St. Croix River)	Town Line 42-43, R. 20 W., 4th Meridian, near Banning.
Mississippi River..	Leaf.............	Sec. 28, T. 135 N R. 34 W., 5th Meridian. Near Lukens....	Confluence with Crow Wing.
Hudson Bay......	Little Fork.......	Town line 62-63 R. 21. Mouth of Sturgeon River...............	Mouth (Rainy.)
Mississippi River..	Leech Lake.......	Mud Lake T. 144 N., R. 26 W., 5th Meridian......................	Leech Lake.
Mississippi River..	Long Prairie......	Sec. 33, T. 133 N., R. 32 W.......	Confluence with Crow Wing.
....	Loon (Little Indian Sioux).....	T. 65, 66 N., R. 15 W., 4th Meridian.........................	....
Mississippi River..	Minnesota.......	Big Stone Lake................	Confluence with Mississippi River.
Mississippi River..	Mississippi.......	Range line 35-36, T. 145 N., Sec. 30, R. 35......................	Southern boundary of State.
Mississippi River..	Moose...........	Sec. 29, T. 46 N., R. 19 W., 4th Meridian. Moose Lake.......	Mouth confluence with Kettle River.
Hudson Bay......	Ottertail.........	From northern boundary T. 137 N., R. 40 W., Rush Lake (called Red River of North below Fergus Falls)...................	Pine Lake Fergus Falls.
Lake Superior....	Pigeon...........	(Mountain Lake)...............	Lake Superior........
Mississippi River..	Pine.............	Sec. 6, T. 137 N., R., 29 W.......	Confluence with Mississippi River.
Mississippi River..	Prairie...........	Range Line 23-24, T. 57 N........	Mouth Mississippi River.
Hudson Bay......	Rainy............	Rainy Lake—entire length as boundary.....................	Lake of the Woods.
Hudson Bay......	Rat Root.........	Sec. 5, T. 69 N., R. 23 W........	Outlet into Rainy Lake
Hudson Bay......	Red.............	Fergus Falls—continuation of Ottertail.......................	Canadian boundary.
Hudson Bay......	Red Lake........	Red Lake.....................	Confluence with Red River.
Mississippi River..	Root.............	Sec. 36, T. 104 N., R. 4, 5th Meridian only.....................	
Mississippi River..	Rum.............	Sec. 31, T. 36 N., R. 24, 3 miles above Walbo. Town line 32-33 N., R. 24.....................	Isanti; mouth (Mississippi River.)
Mississippi River..	St. Croix.........	Entire length as State boundary..	....
Lake Superior....	St. Louis.........	Town line 56-57, R. 17 (Perry)...	Mouth(Lake Superior)
Mississippi River..	Sandy...........	Sec. 14, T. 48, R. 24, above Axtell.	Mouth (Mississippi River) near Libby P. O.
Mississippi River..	Snake...........	T. 39 N., R. 19 W. 4th Meridian only.........................	(into St. Croix River.)
Mississippi River..	Swan............	Swan Lake, T. 56 N., R. 23 W....	Mouth (Mississippi River.)
Mississippi River..	Swift............	Swift Lake....................	Boy Lake.
Hudson Bay......	Thief............	Entrance of Mud River T. 156 N., R. 42 W.....................	Mouth.
Hudson Bay......	Vermilion........	Vermilion Lake................	Crane Lake.
Hudson Bay......	Warroad.........	In T. 163, R. 36 only...........	....
Lake Superior....	White Face.......	Townline 55-56, R. 15, near Markham.........................	Mouth(St.Louis River)
Mississippi River..	Willow..........	Ts. 49, 50, R. 25 (To Mississippi River).....................	....

INTERNATIONAL AGREEMENT RELATING TO THE USE OF BOUNDARY WATERS.

The greater part of the northern boundary of Minnesota is formed by Rainy River and the chain of lakes and rapids flowing into it through Rainy Lake, and by Pigeon River which flows into Lake Superior. The use of these waters either on the American or Canadian side is governed by a treaty between the United States and Great Britain signed at Washington, January 11, 1909.

It will be noted that in the Preliminary Article of the treaty it is stated that "the boundary waters are defined as the waters from main shore to main shore of the lakes and rivers and connecting waterways, or the portions thereof, along which the international boundary passes, including all bays, arms, and inlets thereof, but not including tributary waters which in their natural channels would flow into such lakes, rivers and waterways, or the waters of rivers flowing across the boundary."

In article 2, however, there is an exception relating to the tributary waters, which provides: "but it is agreed that any interference with or diversion from their natural channel of such waters on either side of the boundary resulting in any injury on the other side of the boundary, shall give rise to the same rights and entitles the injured parties to the same legal remedies, as if such injury took place in the country where such diversion or interference occurs."

From the foregoing, and from other articles in the treaty, it is evident that all future uses, obstructions, and diversions from the boundary waters shall be made subject to the authority of the Federal Government, and the approval of the International Joint Commission, which is created by the treaty.

Future uses of the streams tributary to the boundary waters are not subject to the treaty except where water is to be diverted into another drainage basin in such quantities as to materially affect the water level or flow of the boundary waters themselves.

The following articles of the treaty which relate to the waters on the Minnesota boundary are taken from the Report of the Commission of Conservation of Canada entitled "Waterpowers of Canada."

PRELIMINARY ARTICLE.

For the purpose of this Treaty boundary waters are defined as the waters from the main shore to main shore of the lakes and rivers and connecting waterways, or the portions thereof, along which the international boundary between the United States and the Dominion of Canada passes, including all bays, arms, and inlets thereof, but not including tributary waters which in their natural channels would flow into such lakes, rivers, and waterways, or waters flowing from such lakes, rivers, and waterways, or the waters of rivers flowing across the boundary.

ARTICLE 1.

The High Contracting Parties agree that the navigation of all navigable boundary waters shall for ever continue free and open for the purposes of commerce to the inhabitants and to the ships, vessels, and boats of both countries equally, subject, however, to any laws and regulations of either country, within its own territory, not inconsistent with such privilege of free navigation, and applying equally and without discrimination to the inhabitants, ships, vessels, and boats of both countries.

It is further agreed that so long as this Treaty shall remain in force, this same right of navigation shall extend to the waters of Lake Michigan and to all canals connecting boundary waters, and now existing or which may hereafter be constructed on either side of the line. Either of the High Contracting Parties may adopt rules and regulations governing the use of such canals within its own territory, and may charge tolls for the use thereof, but all such rules and regulations and all tolls charged shall apply alike to the subject or citizens of the High Contracting Parties and the ships, vessels, and boats of both of the High Contracting Parties, and they shall be placed on terms of equality in the use thereof.

ARTICLE 2.

Each of the High Contracting Parties reserves to itself or to the several State Governments on the one side and the Dominion or Provincial Governments on the other, as the case may be, subject to any treaty provisions now existing with respect thereto, the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side of the line which in their natural channels would flow across the boundary or into boundary waters; but it is agreed that any interference with or diversion from their natural channel of such waters on either side of the boundary, resulting in any injury on the other side of the boundary, shall give rise to the same rights and entitle the injured parties to the same legal remedies as if such injury took place in the country where such diversion or interference occurs; but this provision shall not apply to cases already existing or to cases expressly covered by special agreement between the parties hereto.

It is understood, however, that neither of the High Contracting Parties intends by the foregoing provision to surrender any right which it may have to object to any interference with or diversions of waters on the other side of the boundary the effect of which would be productive of material injury to the navigation interests on its own side of the boundary.

ARTICLE 3.

It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the Parties hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission.

The foregoing provisions are not intended to limit or interfere with the existing rights of the Government of the United States on the one side and the Government of the Dominion of Canada on the other, to undertake and carry on governmental works in boundary waters for the deepening of channels, the construction of breakwaters, the improvement of harbors, and other governmental works for the benefit of commerce and navigation, provided that such works are wholly on its own side of the line and do not materially affect the level or flow of the boundary waters on the other, nor are such provisions intended to interfere with the ordinary use of such waters for domestic and sanitary purposes.

ARTICLE 4.

The High Contracting Parties agree that, except in cases provided for by special agreement between them, they will not permit the construction or maintenance on their respective sides of the boundary of any remedial or protective works or any dams or other obstructions in waters flowing from boundary waters or in waters at a lower level than the boundary in rivers flowing across the boundary, the effect of which is to raise the natural level of waters on the other side of the boundary unless the construction or maintenance thereof is approved by the aforesaid International Joint Commission.

It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.

ARTICLE 7.

The High Contracting Parties agree to establish and maintain an International Joint Commission of the United States and Canada composed of six commissioners, three on the part of the United States appointed by the President thereof, and three on the part of the United Kingdom appointed by His Majesty on the recommendation of the Governor in Council of the Dominion of Canada.

ARTICLE 8.

This International Joint Commission shall have jurisdiction over and shall pass upon all cases involving the use of obstruction or diversion of the waters with respect to which under Articles 3 and 4 of this Treaty the approval of this Commission is required, and in passing upon such cases the Commission shall be governed by the following rules and principles which are adopted by the High Contracting Parties for this purpose:

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

The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

(1) Uses for domestic, and sanitary purposes;

(2) Uses for navigation, including the service of canals for the purposes of navigation;

(3) Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary.

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

The Commission in its discretion may make its approval in any case conditional upon the construction of remedial or protective works to compensate so far as possible for the particular use or diversion proposed, and in such cases may require that suitable and adequate provision, approved by the Commission, be made for the protection and indemnity against injury of any interests on either side of the boundary.

In cases involving the elevation of the natural level of waters on either side of the line as a result of the construction or maintenance on the other side of remedial or protective works or dams or other obstructions in boundary waters or in waters flowing therefrom or in waters below the boundary in rivers flowing across the boundary, the Commission shall require, as a condition of its approval thereof, that suitable and adequate provision, approved by it, be made for the protection and indemnity of all interests on the other side of the line which may be injured thereby.

The majority of the Commissioners shall have power to render a decision. In case the Commission is evenly divided upon any question or matter presented to it for decision, separate reports shall be made by the Commissioners on each side to their own Government. The High Contracting Parties shall thereupon endeavor to agree upon an adjustment of the question or matter of difference, and if an agreement is reached between them, it shall be reduced to writing in the form of a protocol and shall be communicated to the Commissioners, who shall take such further proceedings as may be necessary to carry out such agreement.

ARTICLE 9.

The High Contracting Parties further agree that any other questions or matter of difference arising between them involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along the common frontier between the United States and the Dominion of Canada, shall be referred from time to time to the International Joint Commission for examination and report, whenever either the Government of the United States or the Government of the Dominion of Canada shall request that such questions or matters of difference be so referred.

The International Joint Commission is authorized in each case so referred to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

Such reports of the Commission shall not be regarded as decisions of the questions or matters so submitted either on the facts or the law, and shall in no way have the character of an arbitral award.

The Commission shall make a joint report to both Governments in all cases in which all or a majority of the Commissioners agree, and in case of disagreement the minority may make a joint report to both Governments, or separate reports to their respective Governments.

In case the Commission is evenly divided upon any question or matter referred to it for report, separate reports shall be made by the Commissioners on each side to their own Government.

ARTICLE 10.

Any questions or matters of difference arising between the High Contracting Parties involving the rights, obligations, or interests of the United States or of the Dominion of Canada either in relation to each other or to their respective inhabitants, may be referred for decision to the International Joint Commission by the consent of the two Parties, it being understood that on the part of the United States any such action will be by and with the advice and consent of the Senate, and on the part of His Majesty's Government with the consent of the Governor General in Council. In each case so referred, the said Commission is authorized to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

A majority of the said Commission shall have power to render a decision or finding upon any of the questions or matters so referred.

If the said Commission is equally divided or otherwise unable to render a decision or finding as to any questions or matters so referred, it shall be the duty of the Commissioners to make a joint report to both Governments, or separate reports to their respective Governments, showing the different conclusions arrived at with regard to the matters or questions so referred, which questions or matters shall thereupon be referred for decision by the High Contracting Parties to an umpire chosen in accordance with the procedure prescribed in the fourth, fifth and sixth paragraphs of Article XLV. of The Hague Convention for the pacific settlement of international disputes, dated October 18, 1907. Such umpire shall have power to render a final decision with respect to those matters and questions so referred on which the Commission failed to agree.

ARTICLE 11.

A duplicate original of all decisions rendered and joint reports made by the Commission shall be transmitted to and filed with the Secretary of State of the United States and the Governor General of the Dominion of Canada, and to them shall be addressed all communications of the Commission.

ARTICLE 12.

The International Joint Commission shall meet and organize at Washington promptly after the members thereof are appointed, and when organized the Commission may fix such times and places for its meetings as may be necessary, subject at all times to special call or direction by the two Governments. Each Commissioner, upon the first joint meeting of the Commission after his appointment, shall before proceeding with the work of the Commission, make and subscribe a solemn declaration in writing that he will faithfully and impartially perform the duties imposed upon him under this Treaty, and such declaration shall be entered on the records of the proceedings of the Commission.

The United States and Canadian sections of the Commission may each appoint a secretary, and these shall act as joint secretaries of the Commission at its joint sessions, and the Commission may employ engineers and clerical assistants from time to time as it may deem advisable. The salaries and personal expenses of the Commission and of the Secretaries shall be paid by their respective Governments, and all reasonable and necessary joint expenses of the Commission, incurred by it, shall be paid in equal moieties by the High Contracting Parties.

The Commission shall have power to administer oaths to witnesses and to take evidence on oath whenever deemed necessary in any proceeding, or inquiry, or matter within its jurisdiction under this Treaty, and all parties interested therein shall be given convenient opportunity to be heard, and the High Contracting Parties agree to adopt such legislation as may be appropriate and necessary to give the Commission the powers above mentioned on each side of the boundary, and to provide for the issue of subpoenas and for compelling the attendance of witnesses in proceedings before the Commission. The Commission may adopt such rules of procedure as shall be in accordance with justice and equity, and may make such examination in person and through agents or employees as may be deemed advisable.

ARTICLE 13.

In all cases where special agreements between the High Contracting Parties hereto are referred to in the foregoing articles, such agreements are understood and intended to include not only direct agreements between the High Contracting Parties, but also any mutual arrangement between the United States and the Dominion of Canada expressed by concurrent or reciprocal legislation on the part of Congress and the Parliament of the Dominion.

ARTICLE 14.

The present Treaty shall be ratified by His Britannic Majesty and by the President of the United States of America, by and with the advice and consent of the Senate thereof. The ratifications shall be exchanged at Washington as soon as possible, and the Treaty shall take effect on the date of the exchange of its ratifications. It shall remain in force for five years, dating from the day of exchange of ratifications, and thereafter until terminated by twelve months' written notice given by either High Contracting Party to the other.

In faith whereof the respective plenipotentiaries have signed this Treaty in duplicate and have hereunto affixed their seal.

Done at Washington the 11th day of January, in the year of our Lord one thousand nine hundred and nine.

(L. S.) JAMES BRYCE.
(L. S.) ELIHU ROOT.

FEDERAL CHARTERS.

Permits granted by Congress for the construction of dams across navigable streams in Minnesota.[a]

River.	Location.	Grantee.	Date.	Time for completion.	Dam built.
Crow Wing	Near Jc. Gull R.	Judd Wright	June 16, 1906	June 16, 1909	no
Minnesota	Outlet Bigstone Lake Mouth Redwood River	Minn. R. Imp. & Power Co.	Feb. 24, 1911	Feb. 24, 1914	
Mississippi	Near Bemidji	Kirby Thomas et al.	Mar. 3, 1905 Feb. 1, 1908	Mar. 3, 1908 1 yr. exten.	yes
Mississippi	Near Bemidji	Morrison & Haines	June 4, 1906	June 4, 1909	no
Mississippi	Near Brainerd	Miss. Water Power & Boom Co.	Apr. 15, 1886	none specified	yes
Mississippi	Near Clearwater	Miss. R. Power Co.	June 14, 1906 Mar. 2, 1907	June 14, 1909 June 14, 1910	no
Mississippi	At Grand Rapids	Grand Rapids Water Power & Boom Co.	Feb. 27, 1899 Feb. 27, 1900	Feb. 27, 1902 Feb. 27, 1903	yes
Mississippi	Little Falls	Little F. Water Power Co.	July 3, 1886	none specified	yes
Mississippi	Between Coon Rapids and Mpls	Twin City Rapid Transit Co.	Mar. 5, 1898 Apr. 12, 1900	Mar. 5, 1903 July 1, 1904	no
Mississippi	Monticello	Miss. R. Power Co.	June 14, 1906 Mar. 2, 1907	Mar. 14, 1909 June 14, 1910	no
Mississippi	Between Sec. 20, T. 128, R. 29 and Sec. 17, T. 39, R. 32	Pike Rapids Power Co.	June 4, 1906 Mar. 2, 1907 Mar. 4, 1911	June 4, 1909 June 1, 1910 July 1, 1914	
Mississippi	Near Otsego	Minn. Power & Trolley Co.	Mar. 12, 1904 Mar. 22, 1906	Mar. 12, 1907 Dec. 31, 1908	no
Mississippi	St. Cloud	St. Cloud Water Power & Mill Co.	July 15, 1884	none specified	yes
Mississippi	Sauk Rapids	Sauk Rapids Water Power Co.	Feb. 26, 1904 Mar. 2, 1907 Feb. 13, 1911 Feb. 24, 1911	Feb. 26, 1910 Mar. 2, 1913 July 1, 1912 July 1, 1913	no
Mississippi	Between Sauk Rapids and St. Cloud	Sauk Rapids Mnfg. Co.	Feb. 20, 1905	Feb. 20, 1908	no
Mississippi	Augusta	St. Cloud Elec. Power Co.	June 28 1906	June 28, 1909	no
Mississippi	Near Watab River	Watab Rapids Power Co.	Apr. 23, 1904	Apr. 23, 1907	yes
Mississippi	Coon Creek Rapids	G. N. Development Co.	Jan. 12, 1911	Jan. 12, 1914	
Namakan Lake	Kettle Falls	Rainy R. Improvement Co.	Feb. 24, 1911	Feb. 24, 1914	
Rainy River	International Falls	Koochiching Co. & Rainy R. Improvement Co.	May 4, 1898 May 4, 1900 June 28, 1902 Feb. 25, 1905 May 23, 1908	May 4, 1901 May 5, 1903 May 4, 1907 July 1, 1908 July, 1911	yes

[a] From article by G. W. Mooney, entitled "Federal Statutes Relating to Water Power," published in the Final Report of the National Waterways Commission, Senate Document 469, 62d Congress, 2d Session. (This list does not include permits for dams which appear to have been intended for use otherwise than for the generation of mechanical power).

Permits granted by Congress for the construction of dams across navigable streams in Minnesota.[a]—Continued.

River.	Location.	Grantee.	Date.	Time for completion.	Dam built.
Red Lake River...	Near Jc. Black River...	Wm. J. Murphy......	Mar. 16, 1906	Mar. 16, 1909	no
St. Croix River...	St. Croix Falls, Wis....	St. Croix Falls Wis., Improvement Co. and St. Croix Falls Minn. Improvement Co....	Feb. 7, 1903	Feb. 7, 1908	yes

[a] From article by G. W. Mooney, entitled "Federal Statutes Relating to Water Power," published in the Final Report of the National Waterways Commission, Senate Document 469, 62d Congress, 2d Session. (This list does not include permits for dams which appear to have been intended for use otherwise than for the generation of mechanical power.)

EVAPORATION RECORDS.

So far as known no continuous records of evaporation have been made in the State of Minnesota prior to 1912 when a station was established at Sandy Lake Dam. Records, however, have been made at certain places in adjoining states which indicate something of the magnitude of evaporation in Minnesota. For this reason records of evaporation are given for observations made by the United States Geological Survey, U. S. Engineer Corps, and others, at University, North Dakota, Madison, Menasha and Grand River Lock, Wisconsin and Iowa City, Iowa.

EVAPORATION AT UNIVERSITY, NORTH DAKOTA.

The evaporation gage at University, N. D., was established April 17, 1905, by the U. S. Geological Survey. Daily observations have been made through the whole of the open seasons since that time.

The gage is located at a pool in a ravine called "English Coulee," which runs through the campus of the University of North Dakota, located immediately west of Grand Forks. This pool at extreme low stage, has a central depth of 6 feet and an area of at least 30 square rods. It is unshaded and there are no large trees in the vicinity. The water surface is ordjnarily about 15 feet below the level of the surrounding open prairie, but the banks of the ravine slope so gently from a top width of ten or twenty rods that the wind has nearly its normal effect at the gage.

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

A standard rain gage is located on the open prairie about ten rods distant. On days of rainfall the difference between the quantity measured by the rain gage and the surplus in the tank is considered the total evaporation for the day.

It has been found that the arrangement of this tank is such that the temperature of the water in the tank is always nearly identical with that of water outside; the difference usually being imperceptible and rarely more than a degree. The temperature of the water and of the air have been observed daily as well as the rainfall.

The following table shows the evaporation, the rainfall, and the approximate mean temperature of water and of air by months. In the years 1905 and 1906, the mean air temperatures were not observed.

During nearly all the remainder of each year when evaporation records were not taken, water surfaces were frozen.

The latitude of University is 48°, its altitude 830 feet, and its normal rainfall about 20 inches a year.

Evaporation at University, North Dakota.

Month.	Temperature °F.		Rainfall. Inches.	Evaporation. Inches.
	Air.	Water.		
1905.				
April 17 to 30		37	0.20	1.78
May		48	3.35	3.48
June		58	4.05	3.89
July		70	5.48	5.46
August		69	4.54	4.02
September		61	1.62	3.75
October 1 to 13		50	.01	1.37
Total			19.25	23.75
1906.				
April		52	2.09	3.52
May		57	3.06	3.68
June		69	3.09	4.13
July		73	2.56	4.83
August		73	1.09	4.92
September		67	1.61	4.04
October		47	.58	1.92
Total			14.08	27.04
1907.				
April 22 to 30	34	39	.05	.46
May	44	47	.63	3.48
June	63	65	4.63	4.55
July	66	79	2.91	5.99
August	65	72	1.87	4.53
September	53		3.86	3.17
October	44		.64	1.98
November 1 to 10	36		.05	.17
Total			14.64	24.33

Evaporation at University, N. Dak.—Continued.

Month.	Temperature °F. Air.	Temperature °F. Water.	Rainfall. Inches.	Evaporation. Inches.
1908.				
April 15 to 30	48	39	.68	2.26
May	51	54	3.77	3.83
June	66	67	2.70	3.22
July	69	76	2.47	6.32
August	65	68	2.41	5.77
September	62	58	.50	4.24
October	46	42	.62	1.58
November 1 to 10	35	32	.01	.19
Total			13.16	27.41
1909.				
April 20 to 30	35	41	.53	.89
May	54	51	2.60	3.84
[a]June			3.70	4.00
July	67	73	.96	5.02
August	69	72	2.59	4.19
September	58	58	.67	3.68
October	47	41	.45	1.51
Total			11.50	23.13
1910.				
April 3 to 30	46	42	1.13	2.81
May	50	52	.71	5.08
June	68	70	.68	6.95
July	72	70	.76	7.01
August	64	67	.90	4.76
September	55	58	3.04	3.03
October	48	48	.61	3.32
Total			7.83	32.96
1911.				
April 22 to 30	54	51	0.00	1.80
May	57	58	3.17	3.71
June	69	73	4.78	4.33
July	65	70	2.06	6.13
August	64	66	3.38	3.99
September	54	55	1.07	2.32
October	43	47	.94	1.29
Total			15.40	23.57
1912.				
April 19 to 30	44	52	.78	.94
May	54	58	2.92	4.98
June	63	72	.06	5.79
July	67	73	5.29	5.76
August	62	67	2.70	3.94
September	54	56	5.16	4.23
October	46	42	.29	1.66
November 1 to 9	33	32	.05	.15
Total			17.25	27.45

[a] Estimated.

EVAPORATION AT SANDY LAKE DAM, MINNESOTA.

An evaporation station was established at Sandy Lake Dam June 27, 1912, which is maintained in cooperation with the U. S. Engineer Corps, by whom the daily observations are taken during the open season.

A galvanized iron tank three feet square and eighteen inches deep is floated on Sandy Lake reservoir near the dam. The rainfall is determined from a rain gage located nearby.

The following table shows the maximum and minimum temperatures, rainfall, and evaporation since the establishment of the station:

Evaporation at Sandy Lake Dam, Minnesota.

Month.	Temperature °F of water.		Rainfall Inches.	Evaporation. Inches.
	Maximum.	Minimum.		
1912.				
June 27 to August 31	....	....	5.07	9.78
September	67	46	1.85	2.96
October	58	33	.63	1.99
Total	....	....	7.55	14.73

EVAPORATION AT MADISON, WIS.

At Madison, Wis., a standard evaporation pan three feet square is floated in a marsh on the south shore of Lake Mendota by means of two cylinders fastened to the pan. The reeds and grass have been cut in the vicinity of the pan so as to allow the wind to have free sweep. The apparatus besides the pan, consists of a rain gage, whirling psychrometer and thermometers. Professor L. S. Smith, of the University of Wisconsin, has direct supervision of this pan.

Observations have been made since July, 1906. The following tables show the evaporation, rainfall and approximate mean temperature of water and of air by months.

Evaporation at Madison, Wisconsin.

Month.	Temperature °F.		Rainfall Inches.	Evaporation Inches.
	Air.	Water.		
1906.				
July 15 to 31	70	68	1.32	1.59
August	71	70	7.71	2.52
September	64	64	2.24	2.04
October	46	49	2.84	1.85
November 1 to 18	38	41	.14	.64
Total	....	....	14.25	8.64
1907.				
April	39	43	2.37	2.15
May	51	52	2.64	3.36
June	66	67	3.18	2.89
July	74	73	6.09	2.59
August	69	66	3.91	2.90
September	60	60	4.04	2.47
Total	....	....	22.23	16.36
1908.				
June 20 to 30	72	70	1.07	1.36
July	72	69	3.36	2.51
August	70	65	1.69	3.03
September	65	62	.52	2.38
October	51	50	.16	2.34
November 1 to 10	33	41	.01	.58
Total	....	....	6.81	12.20

Evaporation at Madison, Wis.—Continued.

Month.	Temperature °F.		Rainfall Inches.	Evaporation Inches.
	Air.	Water.		
1909.				
April 22 to 30	44	45	.36	.74
May	58	58	2.52	3.67
June	70	69	3.08	3.04
July	70	67	.32	3.34
August	73	70	3.57	3.03
September	60	60	2.74	1.87
October 1 to 16	48	50	.49	.94
Total			13.08	16.63
1910.				
[a]April	50	49	3.39	2.15
May	55	55	3.71	3.01
June	70	64	1.33	3.35
July	75	69	.83	3.49
August	70	66	6.90	2.27
September	59	62	1.97	1.85
[b]October	51	54	.68	1.73
Total			18.81	17.85
1911.				
April 15 to 30	50	48	1.13	1.25
May	64	58	2.96	2.88
June	72	67	4.24	2.40
July	72	67	1.47	2.53
August	69	65	4.53	1.81
September	62	61	7.03	1.70
October	48	51	3.75	1.89
November 1 to 11	38	42	2.63	.40
Total			27.74	14.86

[a] Frozen April 24 and 25.
[b] Frozen October 27 to 29.

EVAPORATION AT MENASHA, WIS.

At Menasha, Wis., at the outlet of Lake Winnebago, a standard evaporation pan is floated in the water near the locks by means of timbers. The apparatus, besides the pan, consists of a rain gage and thermometers. The observations are made twice per day by the lockmaster under the direction of L. M. Mann, U. S. Assistant Engineer, Oshkosh, Wisconsin.

Observations have been made since August, 1905. The following table shows the evaporation, rainfall, and approximate mean temperature of water and of air by months.

Evaporation at Menasha, Wisconsin.

Month.	Temperature °F.		Rainfall Inches.	Evaporation Inches.
	Air.	Water.		
1905.				
August 16 to 31	73	74	1.89	2.51
September	68	64	3.07	3.42
October	58	53	2.87	1.80
Total			7.83	7. 7

Evaporation at Menasha, Wis.—Continued.

Month.	Temperature °F.		Rainfall Inches.	Evaporation. Inches.
	Air.	Water.		
1906.				
May	60	56	2.04	1.90
June	71	63	4.81	2.88
July	78	64	.79	3.69
August	80	69	1.38	3.91
September	75	66	1.57	2.28
October	58	52	3.24	1.29
November 1 to 14	43	40	.00	.28
Total			13.83	16.23
1907.				
April	42	43	2.87	1.77
May	45	47	3.08	2.32
June	66	58	1.72	2.60
July	74	66	3.84	3.16
August	74	63	2.44	2.52
September	73	64	2.45	2.09
October	59	52	.22	1.27
November 1 to 11	40	39	.49	.39
Total			16.91	16.12
1908.				
April	43	41	1.67	1.42
May	49	42	2.79	2.01
June	64	53	1.67	2.60
July	79	62	.50	3.30
August	73	63	1.69	2.39
September	70	62	1.45	2.24
October	49	53	.83	1.19
Total			10.60	15.15
1909.				
April 10 to 30	35	39	2.60	.63
May	46	42	.81	2.41
June	65	55	2.74	2.50
July	83	78	1.03	3.18
August	76	78	4.14	1.94
September	59	69	2.50	1.49
October	47	55	1.05	1.26
November 1 to 15	41	42	.95	.72
Total			15.82	14.13
1910.				
April	48	38	3.16	1.36
May	55	55	1.79	2.46
June	73	75	.28	4.71
July	80	84	1.11	4.67
August	66	78	3.53	3.22
September	60	64	7.13	1.78
October 1 to 28	53	54	.97	.91
Total			17.97	19.11
1911.				
April 13 to 30	48	37	.77	.70
May	62	56	3.95	2.33
June	71	77	3.85	1.98
July	77	80	1.73	4.51
August	72	74	1.97	4.40
September	58	62	9.12	2.69
October	48	50	4.15	1.10
November 1 to 11	37	40	2.31	.29
Total			27.85	18.00
1912.				
March 13 to 31	26	30	.47	.44
April	45	38	1.74	1.12
May	60	54	5.05	1.48
June	72	64	.65	2.15
July	72	75	10.17	2.17
August	66	72	5.79	1.39
September	59	66	3.72	1.25
October	47	55	1.37	1.14
November	38	43	.81	.91
Total			29.77	12.05

EVAPORATION AT GRAND RIVER LOCK, WISCONSIN.

At Grand River Lock, on the upper Fox River, Wis., a standard evaporation pan is floated in the water near the locks by means of timbers. The apparatus, besides the pan, consists of a rain gage and thermometers. The observations are made twice per day by the lockmaster under the direction of L. M. Mann, U. S. Assistant Engineer, Oshkosh, Wisconsin.

Observations have been made since August, 1905. The following table shows the evaporation, rainfall, and approximate mean temperature of water and of air by months.

Evaporation at Grand River Lock, Wisconsin.

Month.	Temperature °F.		Rainfall Inches.	Evaporation Inches.
	Air.	Water.		
1905.				
August 13 to 31	65	73	2.60	3.20
September	61	67	3.48	4.06
October	52	57	2.50	3.22
Total			8.58	10.48
1906.				
May	51	58	4.42	3.58
June	62	71	9.48	3.73
July	66	75	2.77	4.74
August	67	74	6.30	3.97
September	61	68	4.15	3.34
October	44	50	5.25	1.91
November 1 to 11	40	41	.07	.29
Total			32.44	21.56
1907.				
April	37	43	2.89	2.32
May	47	56	2.84	4.29
June	62	71	3.14	5.28
July	66	75	5.54	5.44
August	66	71	6.65	4.51
September	58	62	3.97	3.98
October	45	49	.93	2.44
November 1 to 12	39	43	.53	.46
Total			26.49	28.72
1908.				
April	46	49	4.59	2.54
May	55	59	4.95	4.01
June	61	71	3.26	5.37
July	68	76	1.88	5.60
August	63	71	2.54	5.17
September	61	68	1.28	4.21
October	47	51	1.13	1.92
November 1 to 10	39	39	.06	.29
Total			19.69	29.11
1909.				
April 6 to 30	39	42	4.14	1.06
May	54	59	2.10	4.59
June	64	73	3.30	5.69
July	66	76	.40	6.47
August	68	71	3.20	4.94
September	58	63	2.49	2.95
October	43	43	.86	1.84
November 1 to 12	45	47	.70	.71
Total			17.19	28.25

Evaporation at Grand River Lock, Wis.—Continued.

Month.	Temperature °F.		Rainfall Inches.	Evaporation. Inches.
	Air.	Water.		
1910.				
April	50	51	4.16	3.11
May	54	60	2.38	5.53
June	66	72	.83	5.84
July	70	74	.67	6.25
August	62	71	4.22	5.00
September	58	64	4.78	3.49
October 1 to 28	51	56	.87	2.63
Total	....	....	17.91	31.85
1911.				
April 10 to 30	49	53	1.16	1.96
May	61	66	5.33	3.88
June	71	73	3.55	4.58
July	68	72	2.38	5.45
August	65	71	2.96	3.89
September	59	62	4.35	2.66
October	46	48	5.60	1.14
November	46	48	5.65	1.16
Total	....	....	30.98	24.72
1912.				
April 8 to 30	47	51	1.20	2.91
May	56	61	8.25	4.08
June	60	70	.69	6.93
July	67	74	5.18	6.13
August	63	67	6.91	3.78
September	58	64	5.52	3.41
October	54	51	1.30	2.37
November 1 to 24	36	38	1.01	.62
Total	....	....	30.06	30.23

EVAPORATION AT IOWA CITY, IOWA.

At Iowa City, Iowa, there are two standard evaporation pans, one of which is floated in the Iowa River by means of timbers; the other is set in the ground at the top of the river bank. Besides the evaporation pans, the apparatus consists of a rain gage, whirling psychrometer and thermometers. The observations were made once or twice each day by Professor Arthur G. Smith.

Observations were made from July, 1906 to September, 1910. The following table shows the evaporation, rainfall, and approximate mean temperatures of water and air by months. The evaporation is given for the floating pan only.

Evaporation at Iowa City, Iowa.

Month.	Temperature °F. Air.	Temperature °F. Water.	Rainfall Inches.	Evaporation Inches.
1906.				
July 7 to 31	67	75	0.12	4.56
August	69	77	4.56	5.24
September	62	70	.32	4.35
October	44	52	1.47	2.80
November 1 to 17	35	40	.38	.56
Total	....	....	6.85	17.51
1907.				
April	41	48	1.69	2.57
May	53	59	5.53	3.30
June	64	71	6.29	3.08
July	72	77	9.08	4.90
August	69	75	2.78	4.76
September	60	68	2.55	3.19
October	47	55	.89	2.03
November 1 to 11	36	43	.19	.37
Total	....	....	29.00	24.20
1908.				
April	48	54	2.47	2.72
May	59	63	7.21	2.96
June	66	72	2.57	4.42
July	70	78	5.45	4.56
August	67	76	6.59	4.45
September	61	73	1.75	3.41
October	45	53	2.13	3.51
November 1 to 10	40	42	.10	.58
Total	....	....	28.27	26.61
1909.				
April	44	49	5.19	2.36
May	57	60	3.91	3.87
June	67	72	3.80	2.88
July	68	76	4.94	4.17
August	72	81	1.73	5.94
September	59	67	2.40	2.92
October	44	51	1.59	2.20
Total	....	....	23.56	24.34
1910.				
April	50	56	2.01	3.11
May	54	61	2.99	3.63
June	67	75	.98	5.30
July	73	80	2.17	6.47
August	69	76	4.13	5.03
September	60	67	3.27	3.19
Total	....	....	15.55	26.73

COMPARISON OF RECORDS.

To afford means for a direct comparison of the evaporation records at the various stations, the period May 1 to October 31st has been selected, as this is the longest period for which complete records are available. The rainfall and evaporation for the period are given in the following table:

Comparison of evaporations for months of complete observations.

Year.	University.		Madison.		Menasha.		Grand R. Lock.		Iowa City.	
	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.
1903	11.99	23.52	....	....	13.83	15.95	32.37	21.27	....	....
1907	14.54	23.70	....	....	13.75	13.96	23.07	25.94	27.12	21.26
1908	12.47	24.96	....	....	8.93	13.73	15.04	26.28	25.70	23.31
1909	11.50	23.13	....	....	12.27	12.78	12.35	26.48	18.37	21.98
1910	6.70	30.15	15.42	15.70	14.81	17.75	13.75	28.74	....	....
1911	15.40	21.77	23.98	13.21	24.77	17.01	24.17	21.60	....	....
1912	16.42	26.36	....	....	26.75	9.58	28.02	24.95	....	....
Average	12.72	24.80	....	....	16.44	14.39	21.25	25.04	....	....

In order to prepare a table showing annual evaporation at these five stations, the evaporation during the missing months has been estimated, according to the following amounts, applied equally to all stations: January, 0.9 inch; February, 0.9; March, 1.5; April 2.7; November, 2.0; December, 1.3.

These figures are based on evaporation records at Boston, Massachusetts, extending over a period of ten years; being about ninety per cent of those amounts; the reduction being made on account of the smaller annual evaporation in Minnesota than in Massachusetts.

Comparison of Annual Evaporation.

Year.	University.		Madison.		Menasha.		Grand R. Lock.		Iowa City.	
	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.	Rain.	Evap.
1905	25.3	33.2	....	....	....	....	....	....	....	....
1906	17.8	33.6	32.9	24.7	26.7	24.5	47.1	30.2	27.9	33.4
1907	16.1	33.0	31.8	25.0	23.3	22.0	36.4	34.6	34.9	30.2
1908	16.9	34.7	24.6	26.0	19.6	21.6	29.1	35.0	36.0	32.5
1909	15.4	31.1	31.0	26.2	25.1	20.6	23.1	34.6	....	30.9
1910	10.6	39.6	24.7	24.4	23.3	25.7	22.3	38.4	19.7	26.0
1911	22.2	32.1	36.7	22.0	32.5	24.9	[35.9	30.2	....	....
1912	....	34.7	....	....	....	15.6	....	33.8	....	....
Average	....	34.00	30.30	24.72	....	22.13	....	33.83	....	....

DISTRIBUTION OF RAINFALL.

UNITED STATES WEATHER BUREAU RECORDS.

With hardly an exception, all available rainfall records in Minnesota were compiled by the United States Weather Bureau. The rainfall stations of that bureau are divided into two classes: The regular stations, where the work is in charge of trained men who devote their entire time to Weather Bureau work; and the cooperative stations where the work is done by observers who are furnished the standard rain gage equipment but who devote only a small part of their time to the work. To the first class belong the stations at Minneapolis, St. Paul, Duluth and Moorhead (also LaCrosse, Wis., on the boundary). The remaining stations, of which there are a large number in the State are cooperative. There are fifty-eight stations in Minnesota and on the borders of adjacent States where records have been kept for at least ten years.

The longest rainfall records in the State are those at St. Paul (1837 to date), Minneapolis (1856 to date), Duluth (1871 to date), and on the northwestern border at Pembina, N. D. (1872 to date). Most of the records, however, cover periods ranging from fifteen to twenty-five years.

PREPARATION OF RAINFALL MAP.

A study of these longest records shows the twenty-five year average for the period 1885-1909 to be about 1.2 inches larger than the mean of the entire record at St. Paul, substantially the same at Minneapolis, and 2.3 inches smaller at Duluth. The twenty year mean (1890-1909) agrees closely with that for the twenty-five year period. In preparing the rainfall map which is given on plate 1, the mean for the twenty-five year period (1885-1909) has been taken as the basis, and those records which are less than twenty-five years in length have had their means corrected to the twenty-five year mean by a comparison with the records at neighboring stations. All records less than ten years in length have been discarded, and very few records for less than fifteen years used. In this way it is believed that the results represent the mean distribution of rainfall throughout the State during the twenty-five year period ending in 1909.

The lines of equal rainfall are shown for each inch of precipitation on the accompanying map, and indicate that the amount varies from 33 inches in the southeastern corner to 21 inches and less in Red River Valley. The uncertainty as to the rainfall in the extreme northern part of the State is indicated on the map by broken lines. The 27-inch line passes very nearly through the center of the State, beginning at the southwest corner and taking an irregular course in a general northeasterly direction. As the distribution of rainfall on either side of the line is fairly uniform, it may be said that the mean annual rainfall for the State for the past twenty-five years has been about twenty-seven inches.

GAZETTEER OF MINNESOTA STREAMS.

In compiling a gazetteer of the streams of the state which contains all streams except the smallest tributaries, the basis used was the reports of the Geological and Natural History Survey of Minnesota, the State Drainage Engineer's report on the Topographical Survey of Minnesota, the topographic sheets of the United States Geological Survey and the special river surveys made by this office.

Wherever elevations above sea level, of river source and mouth, were available they have been inserted in the gazetteer and denoted by figures in parenthesis following the points indicated. Elevations of Mississippi River points were obtained from the surveys of the Mississippi River Commission and those of Minnesota River, from the 1909-1910 survey made by the U. S. Engineer Office at St. Paul. There is some uncertainty regarding the exact datum of the elevations from the different sources and therefore some of these elevations cannot be considered exact.

Ada Brook rises in Little Norway Lake in Sec. 28, T. 139 N, R. 28 W., in Cass County and flows southwest into Pine River. (Mississippi River Drainage.)

Adley Creek rises in Birch Bark Lake on the boundary between Todd and Stearns counties and flows south into Sauk River two miles east of Melrose. (Mississippi River Drainage.)

Amity Creek rises in Sec. 14, T. 51 N., R. 14 W., in St. Louis County (about 1320) and flows southeast into Lake Superior (602) in Lester Park. (Lake Superior Drainage.)

Ann River rises in Ann Lake in T. 40 N., R. 25 W., in Kanabec County and flows southeast through Fish Lake into Snake River south of Mora. (Mississippi River Drainage.)

Armstrong River rises in the northwest corner of T. 62 N., R. 13 W., in St. Louis County and flows westward through a chain of lakes, emptying into the eastern end of Vermilion Lake. (Hudson Bay Drainage.)

Ash River rises in Ash Lake in T. 66 N., R. 20 W., St. Louis County, and flows northeast into Kabetogama Lake, an arm of Rainy Lake. Its chief tributary is Black Duck River. (Hudson Bay Drainage.)

Ashley Creek rises in T. 126 N., R. 36 W., in Pope County and flows northeast into Sauk River in T. 126 N., R. 34 W., in Stearns County. (Mississippi River Drainage.)

Badger Creek rises in a lake in T. 149 N., R. 42 W. (1,170), near Erskine in Polk County and flows northwest into Clearwater River, a few miles above Red Lake Falls. (Hudson River Drainage.)

Ball Club River rises in Sec. 28, T. 146 N., R. 26 W., in Itasca County and flows southeast through Ball Club Lake into Mississippi River in Sec. 31, T. 145 N., R. 25 W. (Mississippi River Drainage.)

Baptism River rises in Section 35, T. 59 N., R. 8 W. (about 1,850), in Lake County and flows southeast into Lake Superior (602) in T. 56 N., R. 7 W. (Lake Superior Drainage.)

Bassett Creek rises in Medicine Lake in the central part of Hennepin County and flows in an easterly direction into the Mississippi at Minneapolis. (Mississippi River Drainage.)

Battle Brook rises in the southwest corner of Mille Lacs County and flows south into St. Francis River in Sec. 1, T. 34 N., R. 27 W., in Sherburne County. (Mississippi River Drainage.)

Battle River rises in the southwest corner of Koochiching County and flows northwest into Red Lake. (Hudson Bay Drainage.)

Baudette River rises in northern Beltrami County, in T. 159 N., R. 32 W., and flows northeast into Rainy River. (Hudson Bay Drainage.)

Bear Creek rises in the northern part of T. 42 N., R. 19 W., in Pine County and flows south into St. Croix River in Sec. 35, T. 40 N., R. 19 W. (Mississippi River Drainage.)

Bear River rises in Grave Lake in T. 142 N., R. 26 W., Cass County and flows north into Mud Lake. (Mississippi River Drainage.)

Bearskin River rises in the southeastern corner of T. 61 N., R. 24 W., in Itasca County and flows northeast into Sturgeon River in Sec. 28, T. 62 N., R. 21 W., in St. Louis County. (Hudson Bay Drainage.)

Beaver Brook rises in the eastern part of Koochiching County in T. 66 N., R. 22 W., and flows northwest into Little Fork a short distance below Little Fork P. O. (Hudson Bay Drainage.)

Beaver Creek rises in T. 116 N., R. 36 W., Renville County and flows south into Minnesota River in T. 113 N., R. 35 W. (Mississippi River Drainage.)

Beaver Creek rises in the northwestern part of Murray County and flows eastward into Des Moines River just below Lake Shetek. (Mississippi River Drainage.)

Beaver Creek rises in Sec. 21, T. 137 N., R. 32 W., in Cass County and flows southwest into Crow Wing River in Sec. 10, T. 136 N., R. 33 W., in Wadena County. (Mississippi River Drainage.)

Beaver Creek rises in the southeastern part of T. 63 N., R. 20 W., in St. Louis County and flows southwest into Little Fork River in Sec. 12, T. 62 N., R. 21 W. (Hudson Bay Drainage.)

Beaver Creek rises in the center of T. 104 N., R. 45 W., in Rock County and flows southwest, entering Big Sioux River near E. Sioux Falls, S. Dak. (Mississippi River Drainage.)

Beaver River rises in the western part of T. 62 N., R. 13 W., in St. Louis County and flows east and south into Stuntz Lake, thence northeast through One Pine Lake into White Iron Lake. (Hudson Bay Drainage.)

Beaver Bay River rises in T. 57 N., R. 9 W. (about 1,700) in Lake County and flows southeast into Lake Superior (602) in T. 55 N., R. 8 W. (Lake Superior Drainage.)

Belle Creek rises in T. 111 N., R. 16 W., in Goodhue County and flows north into Cannon River near Welch. (Mississippi River Drainage.)

Belle River rises in T. 131 N., R. 36 W., in Ottertail County and flows south into Long Prairie River in T. 129 N., R. 36 W., in Douglas County. (Mississippi River Drainage.)

Bevens Creek rises in Washington Lake in northeastern Sibley County and flows northeast into Minnesota River in T. 114 N., R. 24 W., in Carver County. (Mississippi River Drainage.)

Big Swamp Creek. See Swamp Creek.

Big Fork River rises in Jessie Lake (1,320) in T. 147 N., R. 25 W., Itasca County. It flows into Bowstring Lake (1,315) and thence north through Wabatawangang Lake (1,315) then east and north, emptying into Rainy River (1,083) near Laurel P. O. Its chief tributaries are Caldwell Brook, Sturgeon River, Deer Lake Outlet and Rice River. (Hudson Bay Drainage.)

Big Rock Creek rises in a small lake in the southern part of T. 150 N., R. 35 W., in Beltrami County and flows north into Red Lake in Sec. 25, T. 151 N., R. 36 W. (Hudson Bay Drainage.)

Birch River. This name is given to the southern fork of Kawishiwi River between Copelands Lake (1,439) and Birch Lake (1,420) in Lake County. (Hudson Bay Drainage.)

Birch River rises in a small lake in Sec. 30, T. 61 N., R. 13 W., in St. Louis County and flows into Birch Lake. (Hudson Bay Drainage.)

Black River rises in the northern part of Beltrami County in T. 157 N., R. 28 W. It flows north and then east, emptying into Rainy River at Loman, Koochiching County. Near its mouth it is joined by the West Branch. (Hudson Bay Drainage.)

Black River rises in the northwestern part of Red Lake County and flows south into Red Lake River in T. 151 N., R. 45 W. (Hudson Bay Drainage.)

Black Duck River rises in Black Duck Lake in T. 66 N., R. 19 W., St. Louis County and flows northwest into Ash River in T. 68 N., R. 20 W. (Hudson Bay Drainage.)

Black Duck River rises in Black Duck Lake (1,345) in T. 149 N., R. 31 W., in Beltrami County and flows northwest into Red Lake (1,175). Its chief tributary is Cormorant River. (Hudson Bay Drainage.)

Black Hoof Creek rises in T. 48 N., R. 18 W., in Carlton County and flows south and east into Nemadji River in T. 47 N., R. 16 W. (Lake Superior Drainage.)

Blueberry River rises in T. 138 N., R. 37 W., in Becker County and flows east into Blueberry Lake and Shell River. (Mississippi River Drainage.)

Blue Earth River rises in Kossuth County, Iowa, and flows north into Minnesota River above Mankato. Its chief tributaries are West Branch, Center and Elm Creeks, Watonwan River, Le Sueur River. (Mississippi River Drainage.)

Blue Earth River (East Branch) rises in T. 103 N., R. 23 W., in Freeborn County and flows west through Walnut Lake into Blue Earth River near Blue Earth City, Faribault County. (Mississippi River Drainage.)

Bluff Creek rises in Sec. 36, T. 137 N., R. 37 W., in Ottertail County and flows south into Leaf River near Bluffton. (Mississippi River Drainage.)

Bogus Brook rises in T. 39 N., R. 26 W., in Mille Lacs County and flows south into Rum River in T. 37 N., R. 26 W. (Mississippi River Drainage.)

Bois des Sioux River rises in Lake Traverse (970), on the Minnesota-South Dakota line and flows north into Red River in T. 132 N., R. 47 W. (943). Throughout its length it forms the western boundary of Minnesota. Its chief tributary is Rabbit River. (Hudson Bay Drainage.)

Bolles Creek rises in Bass Lake in central Washington County and flows southeast into St. Croix River near Afton. (Mississippi River Drainage.)

Boot Creek rises in the northwestern part of T. 104 N., R. 22 W., in Freeborn County and flows north into Le Sueur River, Sec. 31, T. 106 N., R. 22 W., in Waseca County. (Mississippi River Drainage.)

Borden Creek rises in the northwest corner of T. 114 N., R. 24 W., in Aitkin and flows west into Mille Lac at Malmo P. O. (Mississippi River Drainage.)

Boulder Creek rises in the central part of T. 54 N., R. 14 W., in St. Louis County, and flows southwest into Cloquet River in Sec. 2, T. 52 N., R. 15 W. (Lake Superior Drainage.)

Boundary waters.

Bowstring River (now applied to upper Big Fork).

Boy River rises in Ten Mile Lake (1,381) in T. 140 N., R. 31 W., Cass County and flows east and north through Fourteen Mile Lake (1,380), Whitefish Lake (1,363), Woman Lake (1,327), Girl Lake (1,327), Rice Lake (1,311), Inguadona Lake (1,311), Boy Lake (1,299), emptying into Leech Lake (1,299). Its chief tributaries are Laura Brook and Swift River. (Mississippi River Drainage.)

Bradbury Brook rises in T. 42 N., R. 27 W., in Mille Lacs County and flows southeast into Rum River in T. 41 N., R. 26 W. (Mississippi River Drainage.)

Brown Creek rises in Sec. 1, T. 30 N., R. 21 W., in Washington County and flows southeast into St. Croix River one mile above Stillwater. (Mississippi River Drainage.)

Brule River has its source in the South Branch which heads in Brule Lake (1,851) in T. 63 N., R. 3 W., in Cook County. From Brule Lake it flows eastward through a number of small lakes, the largest of which is Elephant, and then flows south into Lake Superior (602) in T. 62 N., R. 3 E. The chief tributary is North Branch which heads in North Brule Lake (1,854), in Sec. 19, T. 64 N., R. 1 W., in Cook County. (Lake Superior Drainage.)

Buffalo Creek rises in T. 116 N., R. 32 W., in Renville County and flows east into South Branch of Crow River in the western part of Carver County. (Mississippi River Drainage.)

Buffalo River rises in Rock Lake near Richwood, Becker County, and flows northward into Buffalo Lake. From there it flows in a generally westward direction, emptying into Red River near Georgetown, Clay County. Its chief tributaries are Hay and Moose Creeks, and the South Branch. (Hudson Bay Drainage.)

Buffalo (South Branch) rises in T. 135 N., R. 46 W., in Wilkin County and flows northward, emptying into Buffalo River in T. 140 N., R. 47 W. (Hudson Bay Drainage.)

Bug Creek rises in T. 54 N., R. 14 W., in St. Louis County and flows southwest and north into Whiteface River in T. 54 N., R. 16 W. (Lake Superior Drainage.

Burntland Brook. See Stony Brook.

Burntside River rises in Burntside Lake (1,370) in T. 63 N., R. 13 W., St. Louis County and flows northeast through Long Lake (1,337) into Fall Lake (1,313), which is a part of Kawishiwi River. (Hudson Bay Drainage.)

Calamas Creek rises in a small lake in T. 128 N., R. 36 W., in Douglas County and flows north into Long Prairie River in T. 129 N., R. 36 W. (Mississippi River Drainage.)

Caldwell Brook rises in T. 151 N., R. 28 W., in the southern part of Koochiching County and flows northeast into Big Fork River in T. 151 N., R. 25 W. (Hudson Bay Drainage.)

Canby Creek rises in Sec. 29, T. 114 N., R. 46 W., in Yellow Medicine County and flows northeast into the East Branch of Lac Qui Parle River in Sec. 3, T. 115 N., R. 44 W. (Mississippi River Drainage.)

Cannon River rises in Tufts or Shields Lake (1,090) in Rice County and flows through Rice Lake, Gorman Lake, Saber Lake, Lake Tetonka, Lake Sakata, Morristown Lake and Cannon Lake (977), emptying into Mississippi River (665) near Red Wing, Goodhue County. Its chief tributaries are Little Cannon River and Straight River. (Mississippi River Drainage.)

Carver Creek rises in Rice Lake in T. 115 N., R. 25 W., in Carver County and flows southeast into Minnesota River near Carver. (Mississippi River Drainage.)

Cascade River rises in a lake in Sec. 30, T. 63 N., R. 1 W. (about 1,950) in Cook County and flows west and then south, emptying into Lake Superior (602) in T. 60 N., R. 2 W. (Lake Superior Drainage.)

Cat River rises in T. 137 N., R. 35 W., in Wadena County and flows southeast into Crow Wing River, a short distance below Nimrod P. O. (Mississippi River Drainage.)

Cedar Creek rises in Sec. 34, T. 35 N., R. 23 W., in Isanti County and flows southwest into Rum River in Sec. 6, T. 32 N., R. 24 W., in Anoka County. (Mississippi River Drainage.)

Cedar River rises in T. 105 N., R. 17 W., in Dodge County and flows southward into Mississippi River in Iowa. Its chief tributaries in Minnesota are Turtle and Dobbins Creeks. (Mississippi River Drainage.)

Center Creek rises in Summit Lake, the southernmost lake of the central chain of lakes in Martin County and flows north and then east into Blue Earth River in T. 103 N., R. 28 W., in Faribault County. (Mississippi River Drainage.)

Chain River (see Elm Creek).

Champepadan Creek rises in T. 105 N., R. 43 W., in Murray County and flows southwest into Rock River in T. 103 N., R. 44 W., in Rock County. (Mississippi River Drainage.)

Chanarambic Creek rises in Sand Lake in T. 106 N., R. 42 W., in Murray County and flows southwest into Rock River near Edgerton, Pipestone County. (Mississippi River Drainage.)

Cherry Creek rises in a small lake in T. 110 N., R. 24 W., in Le Sueur County and flows northwest through Scotch Lake into Minnesota River near Ottawa. (Mississippi River Drainage.)

Chester Brook (see Little Snake River).

Chetamba Creek or North Branch of Hawk Creek rises in T. 118 N., R. 35 W., in Kandiyohi County, and flows southwest into Hawk Creek in T. 117 N., R. 38 W., in Chippewa County. (Mississippi River Drainage.)

Chippewa River rises in T. 131 N., R. 38 W., in Ottertail County and flows south through Lake Moses, Lake Aaron, Stowe Lake and Long Lake, emptying into Minnesota River at Montevideo. Its chief tributaries are Little Chippewa River, East Branch and Shakopee Creek. (Mississippi River Drainage.)

Chippewa River (East Branch) rises in Lake Villard in T. 126 N., R. 37 W., in Pope County and flows south and west through a number of small lakes into Chippewa River in T. 122 N., R. 39 W., Swift County. (Mississippi River Drainage.)

Chub Creek rises in Chub Lake in T. 113 N., R. 20 W., in Dakota County and flows south and east into Cannon River near Randolph. (Mississippi River Drainage.)

Clearwater River rises in the western part of Clearwater County near Ebro (1,440) and flows northwest and southwest, emptying into Red Lake River (955) at Red Lake Falls. Its chief tributaries are Lost River and Badger Creek. (Hudson Bay Drainage.)

Clearwater River rises in Clearwater Lake in T. 121 N., R. 30 W., in Meeker County and flows northeast through Lake Mary, Lake Caroline, Lake Augusta and Clearwater Lake, emptying into Mississippi River near Clearwater. (Mississippi River Drainage.)

Cloquet River rises in T. 57 N., R. 9 W., in Lake County and flows southwest through Alden Lake (1,385) and Island Lake (1,330), emptying into St. Louis River in Sec. 36, T. 51 N., R. 18 W. (1,206). Its chief tributaries are Pequaywan Lake and Boulder Lake outlets, and Beaver, West Branch and Ushkabwakka Rivers. (Lake Superior Drainage.)

Cloquet River (West Branch) rises in a lake (1,579) in Sec. 6, T. 56 N., R. 12 W., in St. Louis County and empties into Cloquet River in T. 55 N., R. 12 W. (1,460). (Lake Superior Drainage.)

Cobb River rises in Freeborn Lake in the northwestern part of Freeborn County and flows northwest into Le Sueur River in T. 107 N., R. 26 W., in Blue Earth County. Its chief tributary is Little Cobb River. (Mississippi River Drainage.)

Coon Creek rises in T. 32 N., R. 23 W., in Anoka County and flows west and south into Mississippi River near Coon Creek station. (Mississippi River Drainage.)

Cormorant River rises in T. 151 N., R. 30 W., in Beltrami County and flows northwest into Black Duck River in Sec. 3, T. 151 N., R. 32 W. (Hudson Bay Drainage.)

Cottonwood River rises in Black Rush Lake in T. 110 N., R. 42 W., in Lyon County and flows east into Minnesota River near New Ulm, Brown County. Its chief tributaries are Sleepy Eye, Plum, and Pell Creeks. (Mississippi River Drainage.)

Cowan Brook rises in Sec. 2, T. 43 N., R. 23 W., in Aitkin County and flows south into Snake River in Sec. 4, T. 42 N., R. 23 W., in Kanabec County. (Mississippi River Drainage.)

Crane Creek rises in Rice Lake in T. 107 N., R. 22 W., in Steele County and flows east into Straight River near Clinton Falls. (Mississippi River Drainage.)

Credit River rises in T. 113 N., R. 21 W., in Scott County and flows north into Minnesota River in T. 115 N., R. 21 W. (Mississippi River Drainage.)

Crooked Creek rises in T. 44 N., R. 17 W., in Pine County and flows south into St. Croix River in T. 40 N., R. 17 W. (Mississippi River Drainage.)

Cross River rises in a lake in T. 60 N., R. 6 W., in Lake County and flows southeast into Lake Superior at Schroeder P. O. in Cook County. (Lake Superior Drainage.)

Cross River rises in Kaskadinna Lake (1,767) in T. 64 N., R. 4 W., in Cook County and flows northward through Sucker Lake (1,740) and Ham Lake (1,706), emptying into Gunflint Lake (1,547), on the International Boundary (a tributary of Rainy Lake). Its chief tributaries are Tucker River and Narrow Lake and Little Copper Lake outlets. (Hudson Bay Drainage.)

Crow River is formed by the junction of the North Branch and South Branch near Rockford, Wright County. From this point it flows northeast into Mississippi River, forming the boundary between Wright and Hennepin counties. (Mississippi River Drainage.)

Crow River (Middle Branch) rises in Crow Lake in T. 123 N., R. 35 W., in Stearns County and flows southeast through Green Lake, emptying into North Branch at Manannah in Meeker County. (Mississippi River Drainage.)

Crow River (North Branch) rises in McCloud Lake in T. 125 N., R. 36 W., in Pope County and flows southeast through Rice Lake and Cedar Lake, to its junction with South Branch on the eastern edge of Wright County. Its chief tributaries are Middle Branch, Jewett, and Twelve Mile Creeks. (Mississippi River Drainage.)

Crow River (South Branch) rises in Dog Lake in T. 117 N., R. 33 W., in Kandiyohi County and flows northeast to its junction with North Branch in the eastern edge of Wright County. (Mississippi River Drainage.)

Crow Wing River rises in a chain of lakes in the southeastern part of Hubbard County known as Crow Wing Lakes. From these lakes it flows south and then east, emptying into Mississippi River in the southeastern corner of Cass County. Its chief tributaries are Shell, Leaf, Partridge, Long Prairie and Gull Rivers. (Mississippi River Drainage.)

Crystal Creek rises in Sec. 19, T. 103 N., R. 5 W., in Houston County and flows north into Root River in Sec. 31, T. 104 N., R. 5 W. (Mississippi River Drainage.)

Daggett Brook rises in Leavitt Lake (1,279) in T. 139 N., R. 26 W., Cass County and flows southwest through Crooked Lake (1,276), Mitchell Lake, Eagle Lake and Daggett Lake, emptying into Cross Lake (Pine River). (Mississippi River Drainage.)

Daggett Brook rises in Sec. 1, T. 43 N., R. 29 W., in Crow Wing County and flows southwest and north into Nokasippi River in Sec. 3, T. 43 N., R. 30 W. (Mississippi River Drainage.)

Dam Brook rises in T. 45 N., R. 24 W., in Aitkin County and flows northwest and north through Long Lake (1,227), Dam Lake (1,226), into Rice Lake, a short distance east of Kimberly. (Mississippi River Drainage.)

Dead River rises in Dead Lake in the central part of Ottertail County and flows southeast into Ottertail Lake. (Hudson Bay Drainage.)

Dead Moose River rises in T. 47 N., R. 22 W., in Aitkin County and flows southeast into Kettle River in T. 46 N., R. 20 W., in Carlton County. (Mississippi River Drainage.)

Dean Brook rises in Upper Dean Lake in Sec. 31, T. 137 N., R. 25 W., in Cass County and flows south through Dean Lake into Mississippi River. (Mississippi River Drainage.)

Deer Creek rises in the northwestern part of T. 102 N., R. 15 W., in Mower County and flows northeast into the Middle Branch of Root River in Sec. 8, T. 103 N., R. 12 W., in Fillmore County. (Mississippi River Drainage.)

Deer River rises in Deer Lake in T. 57 N., R. 26 W., in Itasca County and flows west into Mississippi River near Deer River P. O. (Mississippi River Drainage.)

Deer River rises in Sec. 36, T. 58 N., R. 27 W., in Itasca County and flows south into Mississippi River near Deer River P. O. (Mississippi River Drainage.)

Deerhorn Creek rises in T. 136 N., R. 44 W., in Ottertail County and flows northwest into South Branch of Buffalo River in Sec. 8, T. 137 N., R. 47 W., in Clay County. Its principal tributary is Mushroom Creek (Hudson Bay Drainage.)

Des Moines River rises in the northern part of Murray County and flows southeast through Lake Shetek and Talcott Lake, into Mississippi River in Iowa. Its chief tributaries in Minnesota are Heron Lake Outlet and Beaver Creek. (Mississippi River Drainage.)

Des Moines River (East Branch) rises in T. 102 N., R. 33 W., in Martin County and flows southeast into Des Moines River in Iowa. (Mississippi River Drainage.)

Devil Creek rises in Cedar Lake in T. 110 N., R. 22 W., in Rice County and flows west into Mud Lake and then south into Cannon River in T. 109 N., R. 22 W. (Mississippi River Drainage.)

Devil Track River rises in Round Lake (1,920) in Sec. 34, T. 63 N., R. 1 W., in Cook County and flows south through Little Pine Lake (1,837), Devil Track Lake (1,636), and empties into Lake Superior (602) a few miles east of Grand Marais. Its chief tributaries are Elbow Lake Outlet, and South Devil Track River. (Lake Superior Drainage.)

Dorrigans Creek rises in a small lake in Sec. 23, T. 149 N., R. 32 W., in Beltrami County and flows north into Black Duck River in Sec. 35, T. 151 N., R. 32 W. (Hudson Bay Drainage.)

Dunka River rises in Sec. 4, T. 59 N., R. 12 W., in St. Louis County and flows north into Birch Lake in T. 61 N., R. 12 W. (Hudson Bay Drainage.)

Dutch Charleys Creek rises in a small lake in Sec. 19, T. 107 N., R. 38 W., in Cottonwood County, and flows northeast into Cottonwood River in Sec. 19, T. 109 N., R. 36 W., in Redwood County. (Mississippi River Drainage.)

Eagle Creek rises in Sec. 5, T. 131 N., R. 34 W., Todd County and flows southeast into Long Prairie River near Browerville. (Mississippi River Drainage.)

East Savanna River rises in T. 50 N., R. 22 W., in Aitkin County and flows northeast into St. Louis River at Floodwood. (Lake Superior Drainage.)

East Swan River rises in T. 58 N., R. 20 W., in St. Louis County and flows southeast into St. Louis River in T. 55 N., R. 19 W. (Lake Superior Drainage.)

East Two Rivers rises in the northeast corner of T. 61 N., R. 15 W., in St. Louis County and flows east into Vermilion Lake near Tower. (Hudson Bay Drainage.)

East Two Rivers rises in T. 58 N., R. 17 W., in St. Louis County and flows south through Mashkenode Lake (1,406) into St. Louis River (1,277) in T. 56 N., R. 18 W. (Lake Superior Drainage.)

Echo Lake Outlet rises in Echo Lake in T. 66 N., R. 17 W., St. Louis County and flows north into Crane Lake, a tributary of Rainy Lake. (Hudson Bay Drainage.)

Elbow River rises in Elbow Lake in T. 64 N., R. 18 W., St. Louis County and flows westward through Rice Lake into Pelican River in T. 64 N., R. 19 W. (Hudson Bay Drainage.)

Elk Creek rises in Sec. 8, T. 103 N., R. 43 W., in Nobles County and flows southwest into Rock River in Sec. 35, T. 104 N., R. 45 W., in Rock County. (Mississippi River Drainage.)

Elk River rises in T. 38 N., R. 29 W. (about 1,150), in Benton County and flows south and southeast into Mississippi River (858) near Elk River P. O. in Sherburne County. Its chief tributaries are Snake and St. Francis Rivers, Rice and Mayhew Creeks and Tibbetts Brook. (Mississippi River Drainage.)

Elm Creek rises in the eastern part of T. 120 N., R. 23 W., in Hennepin County and flows northeast through Rice and Hayden lakes into Mississippi River opposite Anoka. (Mississippi River Drainage.)

Elm Creek (or Chain River) rises in T. 104 N., R. 35 W., in Jackson County and flows eastward into Blue Earth River in T. 103 N., R. 28 W., in Faribault County. (Mississippi River Drainage.)

Embarrass River rises in Sec. 3, T. 60 N., R. 13 W., St. Louis County and flows west and south through Upper Embarrass Lake (1,366), Lower Embarrass Lake (1,360), Esquagama Lake (1,353), emptying into St. Louis River (1,317) in T. 57 N., R. 16 W. (Lake Superior Drainage.)

Encampment River rises in Sec. 9, T. 54 N., R. 10 W., in Lake County and flows southeast into Lake Superior in Sec. 10, T. 53 N., R. 10 W. (Lake Superior Drainage.)

Estes Brook rises in T. 38 N., R. 28 W., in Benton County and flows southeast into West Branch of Rum River in T. 37 N., R. 27 W., in Mille Lacs County. (Mississippi River Drainage.)

Farnham Creek rises in Sec. 35, T. 137 N., R. 32 W., in Cass County and flows southwest into Crow Wing River in Sec. 13, T. 135 N., R. 33 W., in Wadena County. (Mississippi River Drainage.)

Fish Hook River rises in a small lake in T. 142 N., R. 37 W., in Becker County and flows southeast through Island Lake, Eagle Lake, Potato Lake, and Fish Hook Lake, emptying into Straight River in T. 139 N., R. 35 W., in Hubbard County. (Mississippi River Drainage.)

Fish Trap River rises in Lake Alexander in T. 132 N., R. 31 W., in Morrison County and flows northwest into Long Prairie River in T. 133 N., R. 32 W., in Todd County. (Mississippi River Drainage.)

Flandreau Creek rises in Sec. 6, T. 108 N., R. 46 W., in Pipestone County and flows southwest into Big Sioux River near Flandreau, South Dakota. (Mississippi River Drainage.)

Fletcher Boundary Creek rises in the northeastern part of T. 42 N., R. 31 W., in Morrison County and flows southwest into Mississippi River two miles above Belle Prairie. (Mississippi River Drainage.)

Floodwood River rises in Floodwood Lake (1,270) in T. 54 N., R. 21 W., St. Louis County and flows southeast into St. Louis River at Floodwood (1,225). (Lake Superior Drainage.)

Florida Creek rises in the southwestern part of T. 115 N., R. 46 W., in Yellow Medicine County and flows north into Lac qui Parle River in Sec. 17, T. 117 N., R. 45 W., in Lac qui Parle County.

Flute Reed River rises in the southern part of T. 63 N., R. 3 E., Cook County and flows southeast into Lake Superior. (Lake Superior Drainage.)

Fourteen Mile Creek name given to upper portion of Boy River in Cass County.

French River rises in Sec. 9, T. 52 N., R. 13 W., in St. Louis County and flows southeast into Lake Superior at French River P. O. (Lake Superior Drainage.)

Frog Rock River rises in Big Round Lake (1,702) located in the northwestern corner of T. 64 N., R. 4 W., in Cook County and flows south and west through Little Saganaga Lake (1,600) Gabemichigama Lake (1,587) Ogishke Munice Lake (1,488) Frog Rock Lake (1,470) West Gull Lake (1,450) and Sea Gull Lake (1,440). It empties into the boundary waters in Saganaga Lake (1,434). (Hudson Bay Drainage.)

Getchell Creek rises in a small lake in T. 126 N., R. 31 W., in Stearns County and flows southwest into Sauk River in T. 124 N., R. 33 W. (Mississippi River Drainage.)

Gillespie Brook rises in the eastern part of T. 47 N., R. 19 W., in Carlton County and flows southwest into Split Rock River in Sec. 32, T. 46 N., R. 20 W. (Mississippi River Drainage.)

Goose Creek rises in Goose Lake in the northern part of T. 36 N., R. 21 W., in Chisago County and flows southeast into St. Croix River in Sec. 30, T. 36 N., R. 20 W. (Mississippi River Drainage.)

Gooseberry River rises in T. 56 N., R. 10 W. (about 1,700), in Lake County and flows south and east into Lake Superior (602) in T. 54 N., R. 9 W. (Lake Superior Drainage.)

Grand Marais in the northwestern part of Polk County is an old channel of Red Lake River but no longer receives any water from that source. It is the outlet for a number of drainage ditches in that section and discharges into Red River in T. 153 N., R. 50 W. (Hudson Bay Drainage.)

Grant Creek rises in Sec. 3, T. 147 N., R. 35 W., in Beltrami County and flows south through Manomin Lake into Mississippi River. (Mississippi River Drainage.)

Green Lake Brook rises in Green Lake in Sec. 35, T. 36 N., R. 25 W., in Isanti County and flows east into Rum River in Sec. 31, T. 36 N., R. 24 W. (Mississippi River Drainage.)

Greenwood River rises in a lake in T. 62 N., R. 2 E., Cook County and flows south into Lake Superior. (Lake Superior Drainage.)

Grindstone River rises in Grindstone Lake in T. 42 N., R. 21 W., in Pine County and flows southeast into Kettle River in T. 41 N., R. 20 W. (Mississippi River Drainage.)

Groundhouse River rises in T. 40 N., R. 26 W., in Mille Lacs County and flows southeast into Snake River near Brunswick P. O. in Kanabec County. Its chief tributary is the South Branch. (Mississippi River Drainage.)

Gull River, which is the outlet of Gull Lake, has its source in Mayo Brook, which heads in Moose Lake, in T. 136 N., R. 31 W., in Cass County. Mayo Brook flows east from Moose Lake into Lake Sibley and thence south through Mayo Lake, Upper Gull Lake (1,200) into Gull Lake (1,195). Gull River empties into Crow Wing River, (1,156) in T. 133 N., R. 29 W. (Mississippi River Drainage.)

Hawk Creek rises in Foot Lake in T. 119 N., R. 35 W., in Kandiyohi County, and flows southwest through Lone Tree Lake, emptying into Minnesota River in T. 115 N., R. 38 W., in Renville County. (Mississippi River Drainage.)

Heath Creek rises in Knowles Lake in T. 112 N., R. 21 W., in Rice County and flows east through Union Lake into Cannon River in T. 111 N., R. 20 W. (Mississippi River Drainage.)

Heron Lake Outlet, whose source is Jack Creek and Okabena Creek, which flows into Heron Lake in Jackson County, flows into Des Moines River in T. 105 N., R. 37 W., in Cottonwood County. (Mississippi River Drainage.)

High Island Creek rises in High Island Lake in T. 114 N., R. 25 W., in Sibley County and flows southeast into Minnesota River in T. 113 N., R. 26 W. (Mississippi River Drainage.)

Highwater Creek rises in T. 106 N., R. 38 W., in Cottonwood County and flows northeast into Dutch Charley's Creek in T. 109 N., R. 37 W., in Redwood County. (Mississippi River Drainage.)

Hill River rises in Hill Lake in T. 52 N., R. 26 W., in Aitkin County and flows south and east into Willow River. Its chief tributary is Little Hill River. (Mississippi River Drainage.)

Hill River rises in T. 148 N., R. 39 W., and flows in a generally north westerly direction, emptying into Lost River a short distance above its mouth. (Hudson Bay Drainage.)

Home Brook rises in Little Long Lake in Sec. 9, T. 134 N., R. 30 W., in Cass County and flows northeast into Gull Lake. (Mississippi River Drainage.)

Iron Creek rises in the central part of T. 134 N., R. 32 W., in Cass County and flows southwest into Crow Wing River in Sec. 28 of the same township. (Mississippi River Drainage.)

Isabelle River rises in Lake Isabelle (1,570) in Sec. 35, T. 62 N., R. 7 W., in Lake County and flows westward into Bald Eagle Lake (1,478) in T. 62 N., R. 10 W. Its chief tributaries are Bellisima Lake Outlet, and South Branch of Isabelle River. (Hudson Bay Drainage.)

Isabelle River (South Branch) rises in Sec. 23, T. 59 N., R. 8 W., in Lake County and flows northwest and north into Isabelle River in Sec. 34, T. 62 N., R. 9 W. (Hudson Bay Drainage.)

Jack Creek rises in T. 104 N., R. 41 W., in Nobles County and flows east into Heron Lake in Jackson County. (Mississippi River Drainage.)

Jewett Creek rises in Lake Chicken and Lake Ripley in T. 119 N., R. 31 W., in Meeker County and flows north into North Branch of Crow River in T. 120 N., R. 31 W. (Mississippi River Drainage.)

Jones Creek rises in Sec. 32, T. 102 N., R. 23 W., in Freeborn County and flows northwest into Walnut Lake, and thence into the East Branch of Blue Earth River. (Mississippi River Drainage.)

Kabekona River rises in T. 143 N., R. 33 W., in Hubbard County and flows southeast through Kabekona Lake (1,298) into Leech Lake (1,298). (Mississippi River Drainage.)

Kanaranzi Creek rises in the western part of Nobles County and flows southwest into Iowa, where it unites with Rock River. (Mississippi River Drainage.)

Kawishiwi River rises in Syenite Lake (1,777) in T. 62 N., R. 6 W., Lake County and flows in a generally westward direction through a chain of lakes, the chief ones being Polly (1,617), Boulder (1,587), Alice (1,544,) Wilder (1,540) and Crab (1,487). In the southeast corner of T. 63 N., R. 10 W.; the river divides, one fork continuing westward through Friday Lake (1,388) and Farm Lake (1,386), into Garden Lake (1,384), where it is joined by the other fork which flows through Copeland Lake (1,439), Birch Lake (1,420) and White Iron Lake (1,395). Below Garden Lake the flow is northward through Fall Lake (1,313) and Newton Lake (1,307) into Basswood Lake (1,300), a tributary of Rainy River. The chief tributaries are Isabelle, Stoney, Birch, and Beaver rivers. (Hudson Bay Drainage.)

Kettle River rises in T. 49 N., R. 19 W., in Carlton County and flows south into St. Croix River in T. 39 N., R. 19 W., in Pine County. Its chief tributaries are Moose, Willow, Moose Horn, Dead Moose, Split Rock, Pine and Grindstone Rivers. (Mississippi River Drainage.)

Kimball Creek rises in a small lake in Sec. 12, T. 62 N., R. 1 E., in Cook County and flows southeast into Lake Superior. (Lake Superior Drainage.)

Knife River rises in T. 42 N., R. 25 W., in Mille Lacs County and flows southeast into Snake River in T. 40 N., R. 24 W., in Kanabec County. (Mississippi River Drainage.)

Knife River rises in Sec. 5, T. 52 N., R. 12 W., in St. Louis County and flows east and south into Lake Superior at Knife River P. O. (Lake Superior Drainage.)

Lac Qui Parle River rises in a small lake in the southeastern part of Deuel County, South Dakota, and flows northeast into Minnesota River in T. 118 N., R. 42 W., in Lac Qui Parle County. Its chief tributaries are East Branch, Florida and Three Mile Creeks. (Mississippi River Drainage.)

Lac Qui Parle River (East Branch) rises in Lake Hendricks in T. 112 N., R. 46 W., in Lincoln County and flows northeast into Lac Qui Parle River, in T. 117 N., R. 43 W. (Mississippi River Drainage.)

Laura Brook rises in Lake Laura (since the flow from Thunder Lake has been turned into Big Rice Lake), in T. 141 N., R. 26 W., in Cass County, and flows west into Boy River. (Mississippi River Drainage.)

Lazarus Creek. (see Canby Creek.)

Leaf River rises in Leaf Lake in T. 134 N., R. 38 W., in Ottertail County and flows east into Crow Wing River in T. 134 N., R. 33 W., in Wadena County. Its chief tributaries are Red Eye and Wing Rivers. (Mississippi River Drainage.)

Leech Lake River rises in Leech Lake (1298) and flows eastward through Mud Lake (1287), into Mississippi River (1285). Its chief tributary is Bear River. (Mississippi River Drainage.)

Le Sueur Creek rises in T. 111 N., R. 23 W., in Le Sueur County and flows west into Minnesota River near Le Sueur. Its chief tributary is Little Le Sueur Creek. (Mississippi River Drainage.)

Le Sueur River rises in Le Sueur Lake, in the northern part of Freeborn County, and flows northwest into Blue Earth River in T. 108 N., R. 27 W., in Blue Earth County. Its chief tributaries are Cobb and Maple Rivers. (Mississippi River Drainage.)

Lester River rises in T. 52 N., R. 14 W. (about 1,400), in St. Louis County and flows southeast into Lake Superior (602), in T. 50 N., R. 13 W. (Lake Superior Drainage.)

Lily Creek rises in Fox Lake in the southwest corner of T. 103 N., R. 32 W., in Martin County, and flows east through Eagle Lake into Lake George in Sec. 6, T. 102 N., R. 30 W. (Mississippi River Drainage.)

Little Cannon River rises in T. 110 N., R. 18 W., in Goodhue County and flows north into Cannon River at Cannon Falls. (Mississippi River Drainage.)

Little Cannon River rises in T. 109 N., R. 23 W., in Le Sueur County and flows northwest into Saber Lake (Cannon River), in T. 110 N., R. 23 W. (Mississippi River Drainage.)

Little Cedar River rises in Sec. 9, T. 102 N., R. 16 W., in Mower County and flows south into Cedar River near Nashna, Iowa. (Mississippi River Drainage.)

Little Chippewa River rises in Maple Lake in T. 127 N., R. 38 W., in Douglas County and flows southwest through several small lakes, into Chippewa River in T. 125 N., R. 40 W., in Pope County. (Mississippi River Drainage.)

Little Cloquet River rises in a chain of lakes in the northwestern part of T. 54 N., R. 12 W., in St. Louis County and flows southwest into Cloquet River in Sec. 5, T. 53 N., R. 13 W. (Lake Superior Drainage.)

Little Cobb River rises in Sec. 14 T. 105 N., R. 24 W., in Waseca County and flows west into Cobb River in Sec. 11, T. 106 N., R. 26 W., in Blue Earth County. (Mississippi River Drainage.)

Little Cottonwood River rises in T. 107 N., R. 36 W., in Cottonwood County and flows northeast into Minnesota River, in T. 109 N., R. 29 W., in Blue Earth County. (Mississippi River Drainage.)

Little Elk River rises in T. 131 N., R. 32 W., in Todd County, and flows southeast into Mississippi River near Belle Prairie. Its chief tributary is South Branch. (Mississippi River Drainage.)

Little Fork River rises in the central part of St. Louis County (1,444), a few miles south of Vermilion Lake. It flows west and then takes a northwesterly course emptying into Rainy River (1,085), about twelve miles below International Falls. Its chief tributaries are Rice, Sturgeon, Valley, Cross and Net Lake Rivers and Beaver and Willow Creeks. (Hudson Bay Drainage.)

Little Le Sueur Creek rises in School Section Lake in Sec. 36, T. 112 N., R. 24 W., in Le Sueur County, and flows northwest and southwest into Minnesota River 1 mile below Le Sueur. (Mississippi River Drainage.)

Little Pine River rises in Little Pine Lake in T. 138 N., R. 25 W., in Cass County and flows southwest through Duck Lake, Lake Mary and Lake Emily, into Pine River in T. 136 N., R. 27 W. (Mississippi River Drainage.)

Little Pine River rises in Pine lakes in T. 43 N., R. 22 W., in Aitkin County and flows northeast into Pine River in Sec. 3, T. 44 N., R. 21 W., in Pine County. (Mississippi River Drainage.)

Little Rock Creek rises in T. 39 N., R. 30 W., in Morrison County and flows southwest through Little Rock Lake into Mississippi River near Watab P. O. (Mississippi River Drainage.)

Little Rock River rises in a lake in T. 102 N., R. 41 W., in Nobles County and flows southwest into Rock River in Iowa. (Mississippi River Drainage.)

Little Sioux River rises in T. 103 N., R. 37 W., in Jackson County and flows southwest into Missouri River in Iowa. (Mississippi River Drainage.)

Little Snake River rises in T. 44 N., R. 22 W., in Aitkin County and flows south into Snake River in T. 42 N., R. 22 W., in Kanabec County. (Mississippi River Drainage.)

Little Swamp Creek rises in Sec. 12, T. 137 N., R. 33 W., in Wadena County and flows southwest into Crow Wing River in Sec. 4, T. 136 N., R. 33 W. (Mississippi River Drainage.)

Little Willow River rises in Esquagama Lake (1,245), Aitkin County, and flows south into Mississippi River (1,192), a few miles below Aitkin. (Mississippi River Drainage.)

Long Prairie River rises in Lake Irene and flows through Lakes Miltona, Ida, Louise, Darling, Le Homme Dieu and Carlos, thence east and north into Crow Wing River just east of Motley. Its chief tributaries are Belle and Fish Trap Rivers and Eagle, Calamas and Turtle Creeks. (Mississippi River Drainage.)

Loon River rises in a small lake on the southern boundary of T. 64 N., R. 15 W., in St. Louis County and flows north into Loon Lake which forms a portion of the International boundary. From Loon Lake the river flows westward into Little Vermilion Lake. (Hudson Bay Drainage.)

Lost River rises in the western part of Clearwater County a few miles north of Clearwater River and flows north and west emptying into Clearwater River in T. 150 N., R. 42 W. Its chief tributaries are Hill and Poplar rivers. (Hudson Bay Drainage.)

Mackenzie Creek rises in T. 109 N., R. 21 W., in Rice County and flows north into Cannon Lake. (Mississippi River Drainage.)

Manitou River rises in a lake in section 2, T. 59 N., R. 7 W., in Lake County and flows southeast into Lake Superior in T. 57 N., R. 6 W. (Lake Superior Drainage.)

Maple River rises in T. 104 N., R. 24 W., in Faribault County and flows northwest and north into Le Sueur River in T. 107 N., R. 27 W., in Blue Earth County. Its chief tributary is Rice Creek. (Mississippi River Drainage.)

Marsh River rises in a slough a short distance from Ada, Norman County and flows northwest, emptying into Red River near Shelby P. O. At ordinary stage there is no connection with Wild Rice River, but during flood periods some of the water from Wild Rice River enters Marsh River. (Hudson Bay Drainage.)

Mawskiquawcawndu River rises in a lake of the same name in Sec. 7, T. 63 N., R. 5 E., in Cook County and flows south into Lake Superior in Sec. 6, T. 62 N., R. 5 E. It forms the western boundary of the Pigeon River Indian Reservation. (Lake Superior Drainage.)

Mayhew Creek rises in T. 38 N., R. 30 W., in Benton County and flows south into Elk River in T. 36 N., R. 30 W. (Mississippi River Drainage.)

Mayo Brook (see Gull River.)

Mesaba Creek rises in Sec. 10, T. 59 N., R. 14 W., in St. Louis County and flows southwest into Partridge River in Sec. 11, T. 58 N., R. 15 W. (Lake Superior Drainage.)

Middle River rises in T. 157 N., R. 43 W., in Marshall County and flows westward into Snake River in the western part of Marshall County. (Hudson Bay Drainage.)

Midway Creek rises in the northwestern part of T. 50 N., R. 15 W., in St. Louis County and flows south into St. Louis River 1 mile above Thompson. (Lake Superior Drainage.)

Mike Dreur Brook rises in Sec. 17, T. 39 N., R. 26 W., in Mille Lacs County and flows southwest into Rum River in Sec. 2, T. 38 N., R. 27 W. (Mississippi River Drainage.)

Mill Creek rises in Sec. 35, T. 106 N., R. 12 W., in Olmstead County and flows southeast into North Branch of Root River near Chatfield. (Mississippi River Drainage.)

Minnehaha Creek rises in Lake Minnetonka in Hennepin County and flows southeast into Mississippi River above Fort Snelling. (Mississippi River Drainage.)

Minneopa Creek rises in T. 108 N., R. 29 W., in Blue Earth County and flows east into Minnesota River near Minneopa Falls. (Mississippi River Drainage.)

Minnesota River rises in Bigstone Lake (966) on the western boundary of Minnesota and flows southeast through Marsh Lake (936), Lac Qui Parle (926), to Mankato and then flows northeast into Mississippi River (960) at Fort Snelling. Its chief tributaries are Pomme de Terre, Lac Qui Parle, Chippewa, Yellow Medicine, Redwood, Cottonwood and Blue Earth rivers.

Missaieh River rises in a large lake in the center of T. 63 N., R. 3 E., in Cook County and flows east and then north into Pigeon River in T. 64 N., R. 4 E. (Lake Superior Drainage.)

Missagany Creek (see Sisabagama Creek.)

Mission Creek rises in T. 41 N., R. 21 W., in Pine County and flows south into Snake River in T. 39 N., R. 32 W. (Mississippi River Drainage.)

Mississippi River rises in a small lake above Lake Itasca (1,472) in Itasca State Park, in the southeastern corner of Clearwater County and flows north, east and finally south through Minnesota, forming the boundary line between Minnesota and Wisconsin below St. Croix River. It leaves the state at elevation 615 feet, and its total length in the state is 658 miles.

Money Creek rises in Sec. 33, T. 105 N., R. 10 W., in Winona County and flows south into North Branch of Root River in Sec. 27, T. 104 N., R. 10 W., in Fillmore County. (Mississippi River Drainage.)

Moose River rises in T. 67 N., R 19 W., in St. Louis County and flows through two lakes on its northward course, emptying into Namekan Lake, a tributary of Rainy Lake. (Hudson Bay Drainage.)

Moose River rises in T. 139 N., R. 25 W., in Cass County and flows northeast into Willow River in T. 52 N., R. 25 W., in Aitkin County. (Mississippi River Drainage.)

Moose River rises in Moose Lake in T. 46 N., R. 20 W., in Carlton County and flows west into Kettle River in T. 45 N., R. 20 W., in Pine County. (Mississippi River Drainage.)

Money Creek rises in Sec. 2, T. 105 N., R. 7 W., in Winona County and flows south into Root River in Sec. 30, T. 104 N., R. 6 W., in Houston County. (Mississippi River Drainage.)

Moose River rises in the Big Swamp in the western part of Beltrami County and flows west into Thief Lake in the northeastern part of Marshall County. (Hudson Bay Drainage.)

Moose Horn River rises in T. 48 N., R 21 W., in Carlton County and flows southeast into Kettle River in T. 47 N., R. 20 W. (Mississippi River Drainage.)

Moran Brook rises in Sec. 12, T. 133 N., R. 34 W., in Todd County and flows southeast into Long Prairie River in Sec. 23, T. 132 N., R. 33 W. (Mississippi River Drainage.)

Morrison Brook rises in the southern part of T. 53 N., R. 26 W., in Itasca County and flows southeast into Hill Lake in T. 52 N., R. 26 W., in Aitkin County. (Mississippi River Drainage.)

Mosquito Creek rises in T. 135 N., R. 31 W., in Cass County and flows south into Crow Wing River in T. 133 N., R. 31 W. (Mississippi River Drainage.)

Mud Creek rises in T. 41 N., R. 22 W., in Kanabec County and flows south through Mud Lake into Snake River in T. 38 N., R. 23 W. (Mississippi River Drainage.)

Mud Creek rises in Sec. 13, T. 124 N., R. 44 W., in Stevens County and flows northeast and southeast into Pomme de Terre River in Sec. 23, T. 124 N., R. 42 W. (Mississippi River Drainage.)

Mud River rises in Sec. 12, T. 149 N., R. 34 W., in Beltrami County and flows north into Red Lake at Redby. (Hudson Bay Drainage.)

Mud River rises in Farm Island Lake (1,257) in T. 46 N., R. 27 W. Aitkin County and flows northward through lakes Pine (1,256), Hickory (1,256), Elm Island, Mud (1,230) and Hanging Kettle (1,228), emptying into Mississippi River (1,193) at Aitkin. (Mississippi River Drainage.)

Mud Hen River rises in Sec. 19, T. 57 N., R. 14 W., in St. Louis County and flows southwest through Mud Hen Lake into St. Louis River in Sec. 3, T. 56 N., R. 17 W. (Lake Superior Drainage.)

Mustinka River rises in Lightning Lake in the northern part of Grant County, and flows south and then west into Lake Traverse. Its chief tributaries are West Branch and South Branch.

Namekan River rises in Johnson Lake in the southeast corner of T. 68 N., R. 18 W., in St. Louis County and flows north through Spring Lake into Namekan Lake, one of the boundary waters. (Hudson Bay Drainage.)

Nemadji River rises in a small lake in T. 45 N., R. 17 W. (about 1,200), in Pine County and flows northeast into Lake Superior (602) in Wisconsin. Its chief tributaries are Net River and Black Hoof Creek. (Lake Superior Drainage.)

Net River rises in T. 45 N., R. 16 W., in Pine County and flows northeast through Net Lake, emptying into Nemadji east of the Minnesota-Wisconsin line. (Lake Superior Drainage.)

Net Lake River rises in the western part of St. Louis County in T. 66 N., R. 20 W., and flows westward into Net Lake. From Net Lake the river flows northwest into Little Fork River in T. 66 N., R. 24 W. (Hudson Bay Drainage.)

Nicollet Creek rises in Swan Lake in the central part of Nicollet County and flows south into Minnesota River 1 mile above Hebron. (Mississippi River Drainage.)

Nine Mile Creek rises in a marsh near West Minneapolis in Hennepin County and flows southwest into Minnesota River in Sec. 26, T. 27 N., R. 24 W. (Mississippi River Drainage.)

Nokasippi River rises in Boy Lake (about 1,300) in T. 45 N., R. 27 W., Crow Wing County and flows southwest through Grave Lake and Long Lake, into Mississippi River a short distance above Fort Ripley. Its chief tributaries are Daggett Brook and Little Nokasippi River. (Mississippi River Drainage.)

North Brule River (see Brule River).

North Two River rises in a small lake in T. 127 N., R. 31 W., in Morrison County and flows east into Mississippi River. (Mississippi River Drainage.)

Norway Brook (name given to upper portion of Pine River in Cass County.)

Oak Ridge Creek rises in Sec. 35, T. 133 N., R. 36 W., in Ottertail County and flows north into Leaf River 1 mile east of Bluffton. (Mississippi River Drainage.)

Okabena Creek rises in T. 102 N., R. 40 W., in Nobles County and flows northeast into Heron Lake in Jackson County. (Mississippi River Drainage.)

O'Neill Brook rises in Sec. 6, T. 39 N., R. 26 W., in Mille Lacs County and flows southwest into Rum River in Sec. 23, T. 38 N., R. 27 W. (Mississippi River Drainage.)

Otter Brook rises in Sec. 6, T. 46 N., R. 21 W., in Carlton County and flows southeast into Kettle River in Sec. 16, T. 46 N., R. 20 W. (Mississippi River Drainage.)

Otter Creek rises in T. 48 N., R. 18 W., in Carlton County and flows east into St. Louis River near Thomson. (Lake Superior Drainage.)

Otter River rises in a lake in the northern part of T. 57 N., R. 17 W., in St. Louis County and flows southwest into St. Louis River in Sec. 36, T. 57 N., R. 18 W. (Lake Superior Drainage.)

Ottertail River. The source of Red River, which is called Ottertail, rises in the southwestern part of Clearwater County. Its course is southward, through many lakes, the chief of which are Elbow, Many Point, Round, Height of Land, Little Pine, Pine (1,390), Rush (1,375) and Ottertail (1,340) lakes. Below Ottertail Lake the river flows in a generally westerly direction until it unites with Pelican River four miles west of Fergus Falls. Below this point the river is usually called Red River. (See Red River for further description.)

Paleface River rises in T. 56 N., R. 15 W., in St. Louis County and flows southwest into Whiteface River in T. 54 N., R. 17 W. (Lake Superior Drainage.)

Partridge River rises in Sec. 36, T. 46 N., R. 19 W., in Carlton County and flows north and west into Moose River at Moose Lake P. O. (Mississippi River Drainage.)

Partridge River rises in T. 131 N., R. 34 W., in Todd County and flows northeast into Crow Wing River in T. 134 N., R. 33 W., in Wadena County. Its chief tributaries are Little Partridge and Egly creeks. (Mississippi River Drainage.)

Partridge River rises in Iron Lake (about 1,750) in T. 60 N., R. 13 W., St. Louis County and flows southwest through Partridge Lake, emptying into St. Louis River (1,372) in T. 58 N., R. 15 W. (Lake Superior Drainage.)

Pelican River rises in Rice Lake near Richwood, Becker County and flows southward through a chain of lakes, the chief of which are: Floyd, Little Floyd, Elsa (1,345), Detroit (1,335), Sallie, Melissa (1,330), Pelican (1,320), Lizzie (1,315) and Lida lakes. It empties into Ottertail (1,118) or Red River four miles west of Fergus Falls. (Hudson Bay Drainage.)

Pelican River rises in Pelican Lake (1,291), T. 64 N., R. 20 W., St. Louis County and flows northeast into Vermilion River in T. 66 N., R. 18 W. Its chief tributary is Elbow River. (Hudson Bay Drainage.)

Perch Creek rises in Perch Lake in T. 104 N., R. 30 W., in Martin County and flows northeast into Watonwan River in T. 106 N., R. 29 W., in Blue Earth County. (Mississippi River Drainage.)

Pigeon River, which forms a portion of the northern boundary between Minnesota and Ontario, rises in Mountain Lake (1,652) and flows southeastward through lakes Upper Lilly (1,636), Lower Lilly (1,625), Moose (1,492), North Fowl (1,440) and South Fowl (1,436), emptying into Lake Superior (602) at the extreme eastern point of Minnesota. Its chief tributaries are Pine, Stump and Missaieh Rivers and Portage Brook on the Minnesota side and Arrow River on the Ontario side. (Lake Superior Drainage.)

Pigeon River rises in Island Lake (1,348) in T. 150 N., R. 28 W., Itasca County and flows south through Round Lake (1,315) into Lake Winnibigoshish (1,304). (Mississippi River Drainage.)

Pike Creek rises in a small lake in Sec. 35, T. 150 N., R. 34 W., in Beltrami County and flows north into Red Lake at Red Lake Agency. (Hudson Bay Drainage.)

Pike Creek rises in Sec. 2, T. 129 N., R. 31 W., in Morrison County and flows southeast into Mississippi River two miles below Little Falls. (Mississippi River Drainage.)

Pike River rises in T. 58 N., R. 17 W., in St. Louis County and flows north into Vermilion Lake, a few miles west of Tower. (Hudson Bay Drainage.)

Pillager Creek rises in a small lake in Sec. 32, T. 134 N., R. 30 W., in Cass County and flows south into Crow Wing River in Sec. 16, T. 133 N., R. 30 W. (Mississippi River Drainage.)

Pine Creek rises in Sec. 12, T. 105 N., R. 6 W., in Winona County and flows southeast into Mississippi River opposite LaCrosse. (Mississippi River Drainage.)

Pine River rises in Pine Lake in T. 43 N., R. 21 W., in Pine County and flows north and east into Kettle River in T. 44 N., R. 20 W. Its chief tributary is Little Pine River. (Mississippi River Drainage.)

Pine River rises in Jack Pine Lakes (1,394) in T. 140 N., R. 31 W., Cass County and flows southeast through lakes Pine Mountain (1,324), Rice (1,310), Hattie (1,308), Norway (1,284), Whitefish (1,236), Cross (1,236) and Pine, emptying into Mississippi River (1,180) near Mission P. O. Its chief tributaries are Little Pine River, South Branch, Pelican Creek and Ada and Daggett brooks. (Mississippi River Drainage.)

Pine River rises in a large lake (1,699) in T. 64 N., R. 1 E., Cook County and flows eastward through lakes Pine (1,489), McFarland (1,488), John (1,487) and Roy (1,443), into North Ford Lake (1,440). (Lake Superior Drainage.)

Pioneer Creek rises in Schmitz Lake in Sec. 4, T. 118 N., R. 23 W., in Hennepin County and flows southwest through Spurzem, Halfmoon, Independence and Oxyoke lakes, thence northwest into South Branch of Crow River in Sec. 29, T. 118 N., R. 25 W., in Wright County. (Mississippi River Drainage.)

Pipestone Creek rises in the western part of Pipestone County and flows southwest into Big Sioux River in South Dakota. (Mississippi River Drainage.)

Platte River rises in Platte Lake (about 1,250) on the Crow Wing-Morrison County line and flows southwest and south into Mississippi River (1,022), near Royalton. Its chief tributary is Skunk River. (Mississippi River Drainage.)

Plum Creek rises in Sec. 3, T. 122 N., R. 28 W., in Stearns County and flows northeast into Mississippi River in Sec. 21, T. 123 N., R. 27 W. (Mississippi River Drainage.)

Plum Creek rises in T. 108 N., R. 39 W., in Murray County and flows northeast into Cottonwood River in T. 109 N., R. 38 W., in Redwood County. (Mississippi River Rrainage.)

Pokegama Creek rises in Sec. 14, T. 41 N., R. 22 W., in Kanabec County and flows south through Pokegama Lake into Snake River near Pine City. (Mississippi River Drainage.)

Pomme de Terre River rises in a small lake in T. 132 N., R. 41 W., in Ottertail County and flows south through lakes Stalker, Ten Mile, Pomme de Terre and Little Pomme de Terre, emptying into Minnesota River in T. 120 N., R. 43 W., in Swift County. (Mississippi River Drainage.)

Poplar River rises in a lake in Sec. 30, T. 62 N., R. 3 W., in Cook County and flows in a generally southward direction, emptying into Lake Superior in T. 60 N., R. 3 W. Its chief tributary is Sucker Lake Outlet. (Lake Superior Drainage.)

Poplar River rises in Poplar Lake (1,859) in T. 64 N., R. 1 W., in Cook County and flows southeast into North Branch Brule River in the same township. (Lake Superior Drainage.)

Poplar River rises in the northeastern part of Mahnomen County near Lengby at an elevation of 1,205 feet and flows northwest into Lost River, a short distance above Clearwater River. (Hudson Bay Drainage.)

Portage Brook rises in Sec. 18, T. 64 N., R. 3 E., in Cook County and flows north and then east into Pigeon River in Sec. 19, T. 64 N., R. 4 E. (Lake Superior Drainage.)

Porter Creek rises in Sec. 4, T. 112 N., R. 21 W., in Rice County and flows northwest through a number of small lakes into Sand Creek near Helena, Scott County. (Mississippi River Drainage.)

Prairie River rises in T. 49 N., R. 19 W., in Carlton County and flows westward into Sandy Lake in Aitkin County. (Mississippi River Drainage.)

Prairie River rises in a small lake (1,379) in T. 60 N., R. 24 W., Itasca County and flows southeast through lakes Long (1,363), Laurence and Prairie (1,281), emptying into Mississippi River (1,146) near Grand Rapids. (Mississippi River Drainage.)

Prairie Creek rises in Sec. 23, T. 110 N., R. 20 W., in Rice County and flows northeast into Cannon River in Sec. 10, T. 112 N., R. 18 W., in Goodhue County. (Mississippi River Drainage.)

Puckwunge River (see Stump River).

Rabbit River rises in Rabbit Lake in T. 47 N., R. 29 W., in Crow Wing County and flows southwest through a number of small lakes into Mississippi River. (Mississippi River Drainage.)

Rabbit River rises in the northwestern corner of Grant County and flows westward into Bois des Sioux River in Sec. 34, T. 131 N., R. 47 W., in Wilkin County. (Hudson Bay Drainage.)

Rainy River rises in Rainy Lake (1,113), which forms a portion of the boundary between Minnesota and Ontario and flows westward into Lake of of Woods (1,054), finally emptying into Hudson Bay. Throughout its entire length it forms the boundary between Minnesota and Ontario. Its chief tributaries on the Minnesota side are Big Fork, Little Fork and Rapid rivers. (Hudson Bay Drainage.)

Rapid River rises in northern Beltrami County in T. 157 N., R. 35 W., and flows northeast into Rainy River, falling from 20 to 25 feet near its mouth. It has two important tributaries, North Branch, and a stream entering from the south near its mouth. (Hudson Bay Drainage.)

Rat Root River rises in the northwestern part of St. Louis County in T. 66 N., R. 21 W. It flows northwest and then northeast, emptying into Rat Root Lake, an arm of Rainy Lake. Its chief tributary is the East Branch. (Hudson Bay Drainage.)

Raven Stream rises in a small lake in Sec. 7, T. 112 N., R. 23 W., in Le Sueur County and flows northeast into Sand Creek near Helena, Scott County. (Mississippi River Drainage.)

Red River. The upper portion of Red River is called Ottertail River (which see for source). Below Pelican River, Red River flows south, then west till it joins Bois des Sioux River on the western boundary of Minnesota. From that point (943) it flows northward into Lake Winnipeg, leaving Minnesota at elevation of 748 feet. Its chief tributaries are Buffalo, Wild Rice, Sand Hill, Snake and Two Rivers from the Minnesota side, and Wild Rice, Sheyenne, Goose, Turtle and Park Rivers from North Dakota. (Hudson Bay Drainage.)

Red Eye River rises in T. 139 N., R. 38 W., in Becker County and flows southeast into Leaf River in T. 135 N., R. 33 W., in Wadena County. (Mississippi River Drainage.)

Red Lake River rises in Red Lake (1,175) and flows in a generally westward course, emptying into Red River (about 800) at East Grand Forks, Polk County. Its chief tributaries are Thief, Clearwater and Black rivers. (Hudson Bay Drainage.)

Redwood River rises in T. 108 N., R. 44 W., in Pipestone County and flows northeast and east into Minnesota River in T. 113 N., R. 35 W., in Redwood County. Its chief tributary is Three Mile Creek. (Mississippi River Drainage.)

Rice Creek rises in Rice Lake in Sec. 5, T. 37 N., R. 23 W., in Isanti County and flows north into Snake River in Sec. 10, T. 38 N., R. 23 W., in Kanabec County. (Mississippi River Drainage.)

Rice Creek rises in Sec. 36, T. 37 N., R. 29 W., in Benton County and flows southwest into Elk River in Sec. 32, T. 35 N., R. 29 W., in Sherburne County. (Mississippi River Drainage.)

Rice Creek rises in a small lake in T. 31 N., R. 21 W., in Washington County and flows north and then southwest through lakes Peltier (880), George Watch (880), Marshan (880), Rice (880), Baldwin and Long (864), and empties into Mississippi River near Fridley station. (Mississippi River Drainage.)

Rice River rises in a small lake (1,286) in T. 45 N., R. 24 W., Aitkin County, and flows northwest into Mississippi River (1,194), near Aitkin. Its chief tributaries are the outlets of Rice, Portage, Flemming and Gun lakes. (Mississippi River Drainage.)

Riceford Creek rises in the southeast corner of Fillmore County and flows northeast into South Root River in Sec. 28, T. 103 N., R. 7 W., in Houston County. (Mississippi River Drainage.)

Rock River rises in the northeastern part of Pipestone County and flows south into Big Sioux River in Iowa. Its chief tributaries in Minnesota are Chanarambic, Champepadan and Kanaranzi creeks. (Mississippi River Drainage.)

Rollingstone Creek is formed by the junction of the West and South Branches at Minnesota City in Winona County. It flows northeast into Mississippi River in Sec. 1, T. 107 N., R. 8 W. (Mississippi River Drainage.)

Rollingstone Creek (South Branch) rises in Sec. 26, T. 106 N., R. 8 W., in Winona County and flows north to its junction with the West Branch at Minnesota City. (Mississippi River Drainage.)

Rollingstone Creek (West Branch) rises in Sec. 2, T. 106 N., R. 9 W., in Winona County and flows northeast to its junction with the South Branch at Minnesota City. Its chief tributaries are the North and Middle Branches. (Mississippi River Drainage.)

Root River is formed by the North Branch and South Branch which unite near Lanesboro. North Branch rises in T. 103 N., R. 16 W., in Mower County and flows eastward, joining the South Branch in T. 103 N., R. 9 W., in Fillmore County, and then flowing eastward, empties into Mississippi River in Houston County, opposite La Crosse, Wis. Its chief tributaries are Middle Branch, South Branch, Rush Creek and South Root River. (Mississippi River Drainage.)

Root River (Middle Branch) rises in T. 102 N., R. 13 W., in Fillmore County and flows northeast into North Branch in T. 104 N., R. 11 W. Its chief tributaries are Bear and Deer creeks. (Mississippi River Drainage.)

Root River (South) rises in T. 101 N., R. 10 W., in Fillmore County and flows northeast into Root River near Houston. (Mississippi River Drainage.)

Root River (South Branch) rises in T. 102 N., R. 14 W., in Mower County and flows northeast, joining North Branch near Lanesboro. (Mississippi River Drainage.)

Rose Creek rises in T. 103 N., R. 16 W., in Mower County and flows southwest into Cedar River below Austin. (Mississippi River Drainage.)

Roseau River rises in western Beltrami County in the big swamp. It flows in a generally northwesterly direction and empties into Red River about 12 miles north of the International boundary. Its chief tributary is the South Branch. (Hudson Bay Drainage.)

Rum River rises in Mille Lac Lake (1,152), in Aitkin and Mille Lacs counties and flows south through lakes Ogechie, Nessawae and Onamia (1,150). Below this chain of lakes Rum River flows south, east and south, emptying into Mississippi River (827) at Anoka. Its chief tributaries are Bradbury, Tibbetts, Bogus, Whitney, Spencer and Trott brooks and West Branch of Rum River. (Mississippi River Drainage.)

Rum River (West Branch) rises in T. 40 N., R. 28 W., in Morrison County and flows east into Rum River at Princeton, Mille Lacs County. Its chief tributary is Estes Brook. (Mississippi River Drainage.)

Rush Creek rises in Sec. 22, T. 106 N., R. 9 W., in Winona County and flows southeast into Root River at Rushford, Fillmore County. (Mississippi River Drainage.)

Rush Creek rises in Jubert Lake in Sec. 31, T. 119 N., R. 23 W., in Hennepin County and flows northeast into Elm Creek in Sec. 35, T. 120 N., R. 22 W. (Mississippi River Drainage.)

Rush River is formed by the North and South branches, which both rise in T. 112 N., R. 30 W., in Sibley County and flow eastward uniting in T. 112 N., R. 26 W. Rush River empties into Minnesota River near Henderson. (Mississippi River Drainage.)

St. Augusta Creek rises in Sec. 8, T. 122 N., R. 28 W., in Stearns County and flows northeast into Mississippi River at St. Augusta. (Mississippi River Drainage.)

St. Croix River rises in St. Croix Lake, Wisconsin (1,010,) twenty miles south of Lake Superior and flows southwest then south into Mississippi River (672), opposite Hastings. The lower two-thirds of its length forms a part of the Minnesota-Wisconsin boundary. Its chief tributaries are Tamarack, Kettle, Snake and Sunrise rivers from the Minnesota side; and Namakagon, Yellow, Apple and Willow rivers from the Wisconsin side. (Mississippi River Drainage.)

St. Francis River rises in T. 38 N., R. 28 W. (about 1,150), in Benton County and flows south into Elk River, in T. 33 N., R. 27 W., in Sherburne County. Its chief tributary is Battle Brook. (Mississippi River Drainage.)

St. Louis River rises in a small lake (about 1,700), in Sec. 15, T. 59 N., R. 11 W., in Lake County and flows southwest through Seven Beaver Lake (1,675), then west, southwest, south and southeast, emptying into Lake Superior (602), near Fond du Lac, Minn. Its chief tributaries are Water Hen, Stone, Whiteface, Cloquet, Partridge, Embarrass, Swan and Floodwood rivers. (Lake Superior Drainage.)

Sand Creek rises in Sec. 35, T. 45 N., R. 30 W., in Crow Wing County and flows northwest into Mississippi River in Sec. 27, T. 46 N., R. 30 W. (Mississippi River Drainage.)

Sand Creek rises in Sec. 32, T. 55 N., R. 20 W., in St. Louis County and flows southeast into St. Louis River in Sec. 17, T. 54 N., R. 19 W. (Lake Superior Drainage.)

Sand Creek rises in Cody's Lake in the northwestern part of Rice County, and flows north into Minnesota River in T. 114 N., R. 23 W., in Scott County. Its chief tributaries are Raven Stream and Porter Creek. (Mississippi River Drainage.)

Sand River rises in T. 44 N., R. 18 W., in Pine County and flows south into St. Croix River in T. 40 N., R. 18 W. (Mississippi River Drainage.)

Sandy River rises in T. 48 N., R. 22 W., in Aitkin County and flows west and north into Sandy Lake and thence into Mississippi River near Libby P. O. (Mississippi River Drainage.)

Sandy River rises in a small lake in Sec. 26, T. 149 N., R. 35 W., in Beltrami County and flows northwest into Red Lake in Sec. 22, T. 151 N., R. 36 W. (Hudson Bay Drainage.)

Sand Hill River rises in the southeastern part of Polk County (1,245) near Fosston and flows westward, emptying into Red River near Climax P. O. (Hudson Bay Drainage.)

Sauk River rises in Osakis Lake (1,310), in Todd County, and flows southeast through lakes Gurney, Roberts, Little Sauk (1,240), Sauk (1,220) and Horseshoe, then northeast into Mississippi River (992) near St. Cloud. Its chief tributaries are Adley, Getchell, Stony, Silver and Ashley creeks. (Mississippi River Drainage.)

Savanna River rises in Rice Lakes in T. 51 N., R 23 W., in Aitkin County and flows south into Prairie River near Sandy Lake. (Mississippi River Drainage.)

Seely Brook rises in German or Sawyer Lake in Sec. 36, T. 35 N., R. 25 W., in Isanti County and flows southeast into Rum River in Sec. 8, T. 33 N., R. 24 W., in Anoka County. (Mississippi River Drainage.)

Seven Mile Creek rises in Sec. 2, T. 134 N., R. 31 W., in Cass County and flows south into Crow Wing River in Sec. 20, T. 133 N., R. 31 W. (Mississippi River Drainage.)

Schoolcraft River (see Yellow Head River).

Shakopee Creek rises in Swan Lake in T. 122 N., R. 36 W., in Kandiyohi County and flows west into Chippewa River in T. 120 N., R. 40 W., in Swift County. (Mississippi River Drainage.)

Shanaska Creek rises in Lake Washington in T. 109 N., R. 25 W., in Le Sueur County and flows northwest into Minnesota River in Sec. 29, T. 110 N., R. 26 W. (Mississippi River Drainage.)

Shell River rises in Shell Lake in T. 140 N., R. 38 W., in Becker County and flows southeast into Crow Wing River at the Hubbard-Wadena County line. Its chief tributaries are Straight and Blueberry rivers. (Mississippi River Drainage.)

Shell Rock River rises in the northern part of Freeborn County and flows south through Fountain Lake and Lake Albert Lea, emptying into Cedar River in Iowa. (Mississippi River Drainage.)

Shingle Creek rises in Sec. 1, T. 118 N., R. 22 W., in Hennepin County and flows northeast, and southeast through Palmer Lake into Mississippi within the limits of Minneapolis. (Mississippi River Drainage.)

Shingobi Creek rises in the northern part of T. 140 N., R. 32 W., in Hubbard County and flows northeast into Leech Lake in Sec. 11, T. 141 N., R. 31 W., in Cass County. (Mississippi River Drainage.)

Silver Creek rises in Mary Lake in Sec. 30, T. 121 N., R. 26 W., in Wright County and flows north into Mississippi River in Sec. 10, T. 120 N., R. 26 W. (Mississippi River Drainage.)

Silver Creek rises in Sec. 28, T. 105 N., R. 6 W., in Winona County and flows south into Root River in Sec. 25, T. 104 N., R. 6 W., in Houston County. (Mississippi River Drainage).

Sisabagama Creek rises in a small lake (1,277), Sec. 31, T. 46 N., R. 25 W., Aitkin County, and flows northwest through Rabbit Lake (1,270), into Mississippi River (1,194), a short distance above Aitkin. (Mississippi River Drainage.)

Skunk River rises in T. 42 N., R. 27 W., in Morrison County and flows southwest into Platte River in T. 40 N., R. 31 W. (Mississippi River Drainage.)

Skunk River rises in Skunk Lake in Sec. 16, T. 123 N., R. 35 W., in Stearns County and flows northeast into North Branch of Crow River in Sec. 3, T. 123 N., R. 34 W. (Mississippi River Drainage.)

Sleepy Eye Creek rises in T. 110 N., R. 38 W., in Redwood County and flows east into Cottonwood River in T. 109 N., R. 33 W., in Brown County. (Mississippi River Drainage.)

Split Rock Creek rises in T. 106 N., R. 47 W., in Pipestone County and flows southwest into Big Sioux River in South Dakota. (Mississippi River Drainage.)

Split Rock River rises in T. 45 N., R. 22 W., in Aitkin County and flows east into Kettle River in T. 46 N., R. 20 W., in Carlton County. (Mississippi River Drainage.)

Split Rock River rises in T. 56 N., R. 10 W. (about 1,700) in Lake County and flows southeast into Lake Superior (602), near Two Harbor Bay. (Lake Superior Drainage.)

Spring Creek rises in Sec. 17, T. 111 N., R. 19 W., in Rice County and flows north into Cannon River 1 mile below Northfield. (Mississippi River Drainage.)

Spunk Brook rises in T. 125 N., R. 30 W., in Stearns County and flows northeast into Mississippi River in T. 127 N., R. 29 W., in Morrison County. (Mississippi River Drainage.)

Snake River rises in T. 34 N., R. 28 W., in Sherburne County and flows south into Elk River in T. 33 N., R. 27 W. (Mississippi River Drainage.)

Snake River rises in T. 45 N., R. 23 W., in Aitkin County and flows south and east into St. Croix River in T. 39 N., R. 19 W., in Pine County. Its chief tributaries are Knife, Ann, Groundhouse, and Little Snake rivers. (Mississippi River Drainage.)

Snake River rises near Ellerth in T. 156 N., R. 45 W., in Marshall County, and flows southwest and then north and empties into Red River in T. 157 N., R. 50 W. Its chief tributary is the South Branch. (Hudson Bay Drainage.)

South Brule River (see Brule).

South Creek rises in the East Chain of Lakes in Martin County and flows northeast into Blue Earth River in T. 103 N., R. 28 W., in Faribault County. (Mississippi River Drainage.)

South Two River rises in T. 125 N., R. 31 W., in Stearns County and flows northeast into Mississippi River in T. 127 N., R. 29 W., in Morrison County. Its chief tributary is North Two Rivers. (Mississippi River Drainage.)

Spruce River rises in Sec. 35, T. 43 N., R. 16 W., in Pine County and flows south into St. Croix River in Sec. 36, T. 42 N., R. 16 W. (Mississippi River Drainage.)

Stanchfield Creek rises in T. 37 N., R. 25 W., in Isanti County and flows east and south into Rum River. (Mississippi River Drainage.)

Steamboat River rises in T. 145 N., R. 32 W., in Hubbard County and flows south and east into Leech Lake. (Mississippi River Drainage.)

Stewarts River rises in a lake in T. 54 N., R. 11 W. (about 1,650), in Lake County and flows south into Lake Superior (602), a few miles east of Two Harbors. (Lake Superior Drainage.)

Stone River rises in Sec. 16, T. 55 N., R. 18 W., in St. Louis County and flows west into St. Louis River in Sec. 29, T. 55 N., R. 19 W. (Lake Superior Drainage.)

Stony Brook rises in Perch Lake in T. 49 N., R. 19 W., in Carlton County and flows north into St. Louis River (1,206), a short distance west of Cloquet River. (Lake Superior Drainage.)

Stony Brook rises in Sec. 35, T. 136 N., R. 31 W., in Cass County and flows east into Gull Lake. (Mississippi River Drainage.)

Stony Brook rises in Sec. 7, T. 40 N., R. 27 W., in Mille Lacs County and flows east into Rum River in Sec. 13 of the same township. (Mississippi River Drainage.)

Stony River rises in Muck Lake (1,755), in T. 58 N., R. 10 W., in Lake County and flows northeast and northwest into Slate Lake (1,640), thence it flows west into Birch Lake (1,420), in the eastern part of St. Louis County. Its chief tributary is Stony Lake Outlet. (Hudson Bay Drainage.)

Stony Run rises in T. 114 N., R. 42 W., in Yellow Medicine County and flows northeast into Minnesota River, in T. 116 N., R. 40 W. (Mississippi River Drainage.)

Stony Run rises in a group of lakes in Bigstone County and flows south into Minnesota River west of Odessa. (Mississippi River Drainage.)

Straight River rises in the southern part of Steele County and flows north into Cannon River near Faribault, Rice County. Its chief tributaries are Crane, Turtle, Maple and Rush creeks. (Mississippi River Drainage.)

Straight River rises in T. 141 N., R. 37 W., in Becker County and flows southeast into Shell River in T. 139 N., R. 34 W., Hubbard County. Its chief tributary is Fish Hook River. (Mississippi River Drainage.)

Strong Creek (see Rice Creek.)

Stump (Puckwunge) River rises in a lake in Sec. 9, T. 64 N., R. 2. E., Cook County, and flows east into Pigeon River. (Lake Superior Drainage.)

Sturgeon River rises in the western part of Koochiching County in T. 155 N., R. 28 W., and flows eastward into Big Fork River, a few miles west of Big Falls. (Hudson Bay Drainage.)

Sturgeon River rises in the western part of St. Louis County in Sturgeon Lake (1,340) and flows east and then north, emptying into Little Fork River in T. 62 N., R. 21 W. Its chief tributary is Bear River. (Hudson Bay Drainage.)

Sucker Creek rises in Sec. 19, T. 118 N., R. 28 W., in Wright County and flows north through Cokato Lake into the North Branch of Crow River. (Mississippi River Drainage.)

Sucker River rises in T. 54 N., R. 12 W. (about 1,500), in St. Louis County and flows south into Lake Superior (602) in T. 51 N., R. 12 W. (Lake Superior Drainage.)

Sunrise River rises in Forest Lake, in the northern part of Washington County, and flows north into St. Croix River near Sunrise. Its chief tributaries are North, Middle and West branches. (Mississippi River Drainage.)

Swamp River rises in Sec. 27, T. 63 N., R. 4 E., in Cook County and flows south into Lake Superior in Sec. 11, T. 62 N., R. 4 E. (Lake Superior Drainage.)

Swamp River rises in Sec. 29, T. 139 N., R. 31 W., in Cass County and flows southwest into Crow Wing River in Sec. 21 T., 137 N., R. 33 W., in Wadena County. (Mississippi River Drainage.)

Swan Creek rises in T. 136 N., R. 32 W., in Cass County and flows south into Crow Wing River in T. 134 N., R. 32 W. (Mississippi River Drainage.)

Swan River rises in T. 130 N., R. 32 W., in Todd County and flows east into Mississippi River near Little Falls. (Mississippi River Drainage.)

Swan River rises in T. 57 N., R. 21 W., in St. Louis County and flows southwest into Swan Lake (1,330), then west and south into Mississippi River (1,228), near Jacobson P. O., Aitkin County. (Mississippi River Drainage.)

Swift River rises in a lake in T. 141 N., R. 26 W., in Cass County and flows northwest into Boy River. (Mississippi River Drainage.)

Tamarack River rises in Eagle Lake in Sec. 8, T. 48 N., R. 20 W., in Carlton County and flows west through Island and Tamarack lakes into Prairie River in Sec. 31, T. 50 N., R. 22 W., in Aitkin County. (Mississippi River Drainage.)

Tamarack River rises in the central part of T. 153 N., R. 29 W., in Koochiching County and flows northwest into Red Lake in Sec. 5, T. 154 N., R. 30 W., in Beltrami County. (Mississippi River Drainage.)

Tamarack River rises in T. 158 N., R. 45 W., in Marshall County and flows southwest and then northwest, emptying into Red River near Mattson P. O. in Kittson County. (Hudson Bay Drainage.)

Tamarack River rises in T. 45 N., R. 16 W., in Pine County and flows south into St. Croix River in T. 41 N., R. 16 W. (Mississippi River Drainage.)

Temperance River rises in Brule Lake (1,851), which is also the source of Brule River and flows southward, emptying into Lake Superior (602), in T. 59 N., R. 4 W. (Lake Superior Drainage.)

Thief River, which is the outlet of Thief Lake, in the northeastern part of Marshall County, has its ultimate source in Moose River, which rises in western Beltrami County and flows into Thief Lake. From Thief Lake (1,165) Thief River flows south into Red Lake River (1,115), at Thief River Falls. (Hudson Bay Drainage.)

Third River rises in a small lake in Sec. 7, T. 148 N., R. 29 W., in Itasca County and flows southeast into Lake Winnibigoshish in Sec. 33, T. 147 N., R. 28 W. (Mississippi River Drainage.)

Thompson Creek rises in Sec. 21, T. 103 N., R. 5 W., in Houston County and flows northeast into Root River near Hokah P. O. (Mississippi River Drainage.)

Three Mile Creek rises in T. 111 N., R. 43 W., in Lyon County and flows northeast into Redwood River in T. 112 N., R. 40 W. (Mississippi River Drainage.)

Tibbetts Brook rises in T. 40 N., R. 28 W., in Morrison County and flows southeast into Rum River in T. 39 N., R. 27 W., in Mille Lacs County. (Mississippi River Drainage.)

Tibbetts Brook rises in Lake Fremont in T. 34 N., R. 26 W., in Sherburne County and flows south into Elk River in T. 33 N., R. 27 W. (Mississippi River Drainage.)

Toad River rises in Toad Lake in T. 139 N., R. 38 W., in Becker County and flows south into Pine Lake in T. 136 N., R. 38 W., in Ottertail County. (Hudson Bay Drainage.)

Trott Brook rises in Twin Lake in Sec. 24, T. 33 N., R. 26 W., in Sherburne County and flows south and east into Rum River in Sec. 1, T. 32 N., R. 25 W., in Anoka County. (Mississippi River Drainage.)

Trout Brook rises in Sec. 14, T. 113 N., R. 17 W., in Dakota County and flows southeast into Cannon River in Sec. 36 of the same township. (Mississippi River Drainage.)

Trout Creek rises in the northern part of T. 105 N., R. 11 W., in Olmsted County and flows southeast into North Branch of Root River in Sec. 20, T. 104 N., R. 10 W., in Fillmore County. (Mississippi River Drainage.)

Tucker River rises in Tucker Lake (1,847), in T. 64 N., R. 3 W., in Cook County and flows westward into Cross River in T. 64 N., R. 4 W. (1,713). (Hudson Bay Drainage.)

Turtle Creek rises in Geneva Lake in T. 104 N., R. 20 W., in Freeborn County and flows southeast into Cedar River near Austin, Mower County. (Mississippi River Drainage.)

Turtle Creek rises in T. 129 N., R. 33 W., in Todd County and flows north into Long Prairie River in T. 131 N., R. 33 W. (Mississippi River Drainage.)

Turtle River rises in Long Lake in T. 148 N., R. 34 W., in Beltrami County, and flows southeast through lakes Campbell (1,352), Turtle (1,346) and Turtle River (1,335), into Cass Lake (1,304). (Mississippi River Drainage.)

Twelve Mile Creek rises in Rice Lake in Sec. 12, T. 118 N., R. 28 W., in Wright County and flows northeast through Anna and Little Waverly lakes into the North Branch of Crow River in Sec. 20, T. 119 N., R. 26 W. (Mississippi River Drainage.)

Twelve Mile Creek rises in Echo or Fish Lake in Sec. 1, T. 125 N., R. 44 W., in Stevens County and flows northwest into the West Branch of Mustinka River in Sec. 31, T. 127 N., R. 45 W., in Traverse County. (Hudson Bay Drainage.)

Twenty Mile Creek (see Norway Brook).

Two River is formed by the North and South Branches which unite in Sec. 2, T. 161 N., R. 50 W., in Kittson County. It flows west into Red River near Juliètte P. O. The North Branch rises in T. 163 N., R. 47 W., and the South Branch in the western part of Roseau County. (Hudson Bay Drainage.)

Two River is formed by the North and South Branches in Sec. 14, T. 127 N., R. 30 W., in Morrison County and flows northeast into Mississippi River. (Mississippi River Drainage.)

Two Island River rises in Sec. 12, T. 59 N., R. 6 W., in Lake County and flows southeast into Lake Superior in Sec. 11, T. 58 N., R. 5 W., in Cook County. (Lake Superior Drainage.)

Ushkabwakka River rises in Rush Lake in T. 54 N., R. 15 W., in St. Louis County and flows southwest into Cloquet River in T. 52 N., R. 16 W. (Lake Superior Drainage.)

Vandell Brook rises in Sec. 3, T. 38 N., R. 26 W., in Mille Lacs County and flows south into Rum River in Sec. 9, T. 37 N., R. 26 W. (Mississippi River Drainage.)

Vermilion River rises in Vermilion Lake in St. Louis County (1,366) and flows north into Crane Lake (1,185), a tributary of Rainy Lake. Its chief tributaries are Pelican River, Elephant Lake and Echo Lake outlets. (Hudson Bay Drainage.)

Vermilion River rises in Upper Vermilion Lake in T. 142 N., R. 25 W., in Cass County and flows northeast through a number of small lakes into Mississippi River in T. 144 N., R. 25 W. (Mississippi River Drainage.)

Vermilion River rises in T. 113 N., R. 21 W., in Scott County and flows east into Mississippi River near Hastings. (Mississippi River Drainage.)

Warroad River rises in the eastern part of Roseau County and flows north into Lake of the Woods. (Hudson Bay Drainage.)

Washburn Brook rises in Lake George (1,326) in T. 139 N., R. 26 W., in Cass County and flows through Lake Washburn (1,322) into Mitchell Lake. (Mississippi River Drainage.)

Watab River rises in T. 124 N., R. 30 W., in Stearns County and flows northeast into Mississippi River, near Watab P. O. (Mississippi River Drainage.)

Water Hen River rises in T. 57 N., R. 14 W., in St. Louis County and flows west into Mudhen Creek which flows into St. Louis River in T. 56 N., R. 17 W. (Lake Superior Drainage.)

Watonwan River rises in the western part of Cottonwood County and flows east into Blue Earth River in T. 107 N., R. 27 W., in Blue Earth County. Its chief tributaries are South Branch and Perch Creek. (Mississippi River Drainage.)

Watonwan River (South Branch) rises in T. 105 N., R. 35 W., in Cottonwood County and flows northeast into Watonwan River in T. 107 N., R. 30 W., in Watonwan County. (Mississippi River Drainage.)

Wells Creek rises in T. 111 N., R. 14 W., in Goodhue County and flows northeast into Mississippi River near Frontenac. (Mississippi River Drainage.)

West Two River rises in Sec. 14, T. 61 N., R. 15 W., in St. Louis County and flows northwest into Vermilion Lake near Tower. (Hudson Bay Drainage.)

West Two River rises in T. 58 N., R. 20 W., in St. Louis County and flows south into St. Louis River (1,276), in T. 56 N., R. 18 W. (Lake Superior Drainage.)

Whetstone River rises in the northeastern corner of South Dakota and flows southeast into Minnesota River just below Bigstone Lake. (Mississippi River Drainage.)

Whiskey Creek rises in Sec. 2, T. 137 N., R. 45 W., in Clay County and flows northwest into the South Branch of Buffalo River in Sec. 16, T. 138 N., R. 47 W. (Hudson Bay Drainage.)

White Earth River rises in Tullaby Lake (about 1,600) in the southeast corner of Mahnomen County and flows westward into White Earth Lake. From White Earth Lake it flows northwest into Wild Rice Lake at a point near Mahnomen. (Hudson Bay Drainage.)

White Elk Brook rises in Little White Elk Lake (1,345), in T. 50 N., R. 27 W., in Aitkin County and flows into White Elk Lake (1,328), thence east and south into Mississippi River (1,193), near Willow River. (Mississippi River Drainage.)

Whiteface River rises in Jack Pine Lake (1,660), in T. 57 N., R. 12 W., in St. Louis County and flows southwest into St. Louis River (1,226), in Sec. 24, T. 52 N., R. 20 W. Its chief tributaries are North Branch and Paleface rivers. (Lake Superior Drainage.)

White Pine Creek rises in Canosia Lake (1,397), in T. 51 N., R. 16 W., in St. Louis County and flows southwest into St. Louis river (1,176), in T. 50 N., R. 17 W. (Lake Superior Drainage.)

Whitewater River rises in T. 106 N., R. 12 W., in Olmsted County and flows northeast into Mississippi River in the southeastern part of Wabasha County. (Mississippi River Drainage.)

Whitney Brook rises in Sec. 6, T. 39 N., R. 26 W., in Mille Lacs County and flows southwest into Rum River in Sec. 22, T. 39 N., R. 27 W. (Mississippi River Drainage.)

Wild Rice River rises in Upper Rice Lake (1,500), in T. 145 N., R. 37 W., in the southern part of Clearwater County. It flows southwest into Rice Lake, and from there takes a generally westward course, emptying into Red River (about 870), near Hendrum P. O., Norman County. Its chief tributaries are Simon Lake Outlet, Twin Lake Outlet, White Earth River and South Branch. (Hudson Bay Drainage.)

Wild Rice (South Branch) rises in T. 142 N., R. 41 W., and flows northwest into Wild Rice in T. 143 N., R. 47 W.

Willow River rises in North Fork Lake in Sec. 1, T. 142 N., R. 25 W., in Cass County and flows southwest into Big Rice Lake (1,308), thence eastward and south, emptying into Mississippi River near Waldeck P. O. (1,202). Its chief tributaries are Hill and Moose rivers and Birch Brook. (Mississippi River Drainage.)

Willow River rises in T. 45 N., R. 17 W., in Pine County and flows southwest into Kettle River in T. 44 N., R. 20 W. (Mississippi River Drainage.)

Willow River rises in the western part of St. Louis County in T. 63 N., R. 19 W., and flows west into Little Fork River in T. 63 N., R. 22 W. (Hudson Bay Drainage.)

Willow River (name given upper part of South Branch Buffalo River in Clay County.)

Wing River rises in T. 132 N., R. 37 W., in Ottertail County and flows east and north into Leaf River in T. 135 N., R. 34 W., in Wadena County. (Mississippi River Drainage.)

Winnebago Creek rises in Sec. 7, T. 101 N., R. 5 W., in Houston County and flows southeast into Mississippi River near the Iowa-Minnesota line. (Mississippi River Drainage.)

Winter Road River rises in T. 160 N., R. 34 W., in northern Beltrami County and flows eastward into Rainy River. (Hudson Bay Drainage.)

Wolf Creek rises in Mazaska Lake in T. 110 N., R. 21 W., in Rice County and flows through Fox Lake and Circle Lake, emptying into Cannon River in T. 111 N., R. 20 W. (Mississippi River Drainage.)

Woodbury Brook rises in Sec. 31, T. 102 N., R. 19 W., in Freeborn County and flows southeast into Cedar River in Sec. 33, T. 101 N., R. 18, W., in Mower County. (Mississippi River Drainage.)

Yellow Bank River rises in the southern part of Grant County, South Dakota, and flows northeast into Minnesota River near Odessa. (Mississippi River Drainage.)

Yellow Head River rises in T. 142 N., R. 34 W. (1,425), and flows north through Lake Plantagenet (1,364) and Lake Irving (1,364) into Mississippi River near Bemidji. Its chief tributaries are the outlets of Lake Assawa and Lake Niawa. (Mississippi River Drainage.)

Yellow Medicine River rises in T. 112 N., R. 45 W., in Lincoln County and flows northeast into Minnesota River in T. 115 N., R. 38 W., in Yellow Medicine County. Its chief tributaries are South Branch and Mud Creek. (Mississippi River Drainage.)

Zumbro River is formed by the North and South branches which unite in the western part of Wabasha County. North Branch rises in T. 109 N., R. 19 W., in Rice County and flows eastward until it joins South Branch and then continues eastward, emptying into Mississippi River near Wabasha. The chief tributaries are South Branch and West Albany Creek.

Zumbro River (Middle Branch) rises in T. 108 N., R. 18 W., in Dodge County and flows east into the South Branch in T. 108 N., R. 14 W., in Olmsted County. The South Fork of the Middle Branch rises in T. 107 N., R. 18 W., and flows northeast into Middle Branch in T. 108 N., R. 14 W. (Mississippi River Drainage.)

Zumbro River (South Branch) rises in T. 105 N., R. 15 W., in Olmsted County and flows north, joining North Branch in the western part of Wabasha County. Its chief tributaries are Middle Branch, Willow and Silver creeks and Badger River. (Mississippi River Drainage.)

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The following publications show more fully the methods used by the United States Geological Survey in obtaining records of stream flow:

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Length of records necessary for determining stream flow: Eng. News, April 23, 1908, p. 459.

STREAM GAGING RECORDS.

The base data (comprising the actual discharge measurements and daily gage heights, as well as the monthly estimates) will be found in the following Water Supply Papers of the United States Geological Survey copies of which may be obtained free by addressing the Director, United States Geological Survey, Washington, D. C.

Mississippi and Hudson Bay drainage basins:

1901 W 66	1906 W 207
1902 W 85	1907 W 245
1903 W 100	1908 W 245
1904 W 130	1909 W 265
1905 W 171	1910 W 285

1911 W 305

Lake Superior drainage basin: 1909 W 264, 1910 W 284, 1911 W 304.

Discharge measurements of Mississippi at St. Paul prior to 1909 in publications of Mississippi River Commission.

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Report of the State Drainage Commission—State Drainage Work in Minnesota. This report is issued biennially and contains a general summary of all drainage work in the State.

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