Low-Flow Characteristics of Streams in the St. Croix River Basin, Wisconsin

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CONTENTS

ILLUSTRATIONS

TABLES

Low-Flow Characteristics of Streams in the St. Croix River Basin, Wisconsin

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ABSTRACT

The purpose of this report is to describe low-flow characteristics of streams in the St. Croix River basin where streamflow data have been collected and to present equations for estimating low-flow characteristics at ungaged sites. Included are estimates of low-flow frequency and flow duration at 7 gaging stations, and low-flow frequency characteristics at 26 low-flow partial-record stations and 75 miscellaneous sites.

Four equations are provided to estimate low-flow characteristics at ungaged sites and at sites where one base-flow discharge measurement is available. The low-flow characteristics determined were the annual minimum 7-day mean flow below which the flow will fall on an average of once in 2 years ($Q_{7,2}$) and once in 10 years ($Q_{7,10}$). The equations were determined from multiple-regression analyses that related the low-flow characteristics at gaging stations and low-flow partial-record stations to basin characteristics. Drainage area (A) was the most significant characteristic in explaining the variations in low flow for ungaged sites. The equations and standard error of estimates (SE) for ungaged sites are:

$$Q_{7,2} = 3.75 \times 10^{-2} A^{1.30} \qquad SE_{7,2} = 110 \text{ percent}$$

$$Q_{7,10} = 1.05 \times 10^{-2} A^{1.47} \qquad SE_{7,10} = 150 \text{ percent}$$

For sites where one base-flow measurement has been made drainage area (A) and base-flow index (Bf) were the most significant characteristics. The equations and standard error of estimate are:

$$Q_{7,2} = 0.492 A^{1.14} Bf^{1.01} \qquad SE_{7,2} = 38 \text{ percent}$$

$$Q_{7,10} = 0.235 A^{1.28} Bf^{1.21} \qquad SE_{7,10} = 52 \text{ percent}$$

1

INTRODUCTION

The purpose of this report is to describe low-flow characteristics of streams in the St. Croix River basin where streamflow data have been collected and to present equations for estimating low-flow characteristics at ungaged sites.

This study was done in cooperation with the Wisconsin Department of Natural Resources. This report is part of a series of 12 planned reports to describe low-flow characteristics of the major basins in Wisconsin (fig. 1).

Note: WRI numbers indicate reports previously published.

Figure 1. Location of the St. Croix River basin in Wisconsin.

The report includes: estimates of the magnitude and frequency of recurrence of low flow for various sites where streamflow information has been collected, low-flow discharge measurements that have been obtained at numerous sites throughout the basin, and a method to estimate low-flow characteristics at ungaged sites.

In recent years, a great demand has been placed on water resources in Wisconsin by increased multiple uses such as: maintenance of fish and wildlife habitat, irrigation of crops, dilution and assimilation of wastes, production of hydroelectric power, construction of impoundments for real-estate developments, and maintenance of adequate flow for boating. This increased demand requires an accurate determination of water resources during low-flow periods to ensure proper consideration of all users.

Low-flow frequency analyses and flow-duration analyses are presented for all current and discontinued gaging stations in the St. Croix River basin. These analyses have been completed for 7 gaging stations through water year 1977. Low-flow frequency data are included in the report for 26 low-flow partial-record stations and for 75 miscellaneous sites.

Previous reports by Gebert and Holmstrom (1974, p. 63-66) and Gebert (1971) contain preliminary information on low-flow characteristics of this basin.

For the convenience of readers who prefer metric units, the data may be converted by using the following factors:

Multiply	By	To obtain
mile (mi)	1.609	kilometer (km)
foot (ft)	3.048×10^{-1}	meter (m)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot per second (ft^3/s)	2.832×10^{-2}	cubic meter per second (m^3/s)
foot per mile (ft/mi)	1.894×10^{-1}	meter per kilometer (m/km)
inch (in.)	2.54	centimeter (cm)
cubic foot per second per square mile $\{(ft^3/s)/mi^2\}$	1.094×10^{-2}	cubic meter per second per square kilometer $\{(m^3/s)/km^2\}$
gallon per day (gal/d)	3.786×10^{-3}	cubic meter per day (m^3/d)
gallon per day per square foot $\{(gal/d)/ft^2\}$	3.517×10^{-4}	cubic meter per day per square meter $\{(cm^3/d)/m^2\}$

BASIN DESCRIPTION

The St. Croix River basin is in northwestern Wisconsin and includes the part of the St. Croix River basin in Wisconsin and 488 mi^2 of drainage to the Mississippi River between the St. Croix and Chippewa River basin. The basin has a drainage area of approximately 8,082 mi^2, of which about 3,254 mi^2 is in Minnesota. The drainage area of the basin in Wisconsin is 4,828 mi^2 or about 8.6 percent of the State.

3

The 1970 population of the basin was approximately 109,000. The largest cities are River Falls, Hudson, and New Richmond with 1976 populations of about 7,850, 5,909, and 4,057 (Wisconsin Legislative Reference Bureau, 1977).

The mean annual precipitation for the basin is 29.3 in., ranging from less than 28 in. in the east-central part of the basin to more than 32 in. in the northeast (Wisconsin Statistical Reporting Service, 1967, p. 18). Snowfall is 15 percent of the mean annual precipitation. The mean annual runoff from the basin is 9.0 in. and the mean annual evapotranspiration is 20.3 in. (Young and Hindall, 1973, sheet 1).

The topography of the basin is primarily rolling glacial terrane. It ranges from flat outwash plains to knob and kettle end moraines. The drift is ground moraine in the southern one-fourth and parts of the northern one-fourth of the basin; end moraines along the northern and northeastern basin divide with broad belts near the center of the basin; and pitted outwash in the northern two-thirds of the basin and in the St. Croix and Mississippi River valleys (Young and Hindall, 1973, sheet 1).

The average gradient of the St. Croix River is about 2.0 ft/mi and ranges from near 0 ft/mi on Lake St. Croix to 8.5 ft/mi in the Kettle River rapids. Average gradients of major tributaries to the St. Croix River are: 6 to 8 ft/mi for the Namekagon River except for an 11-mi reach with a fairly low gradient of 1 ft/mi near the mouth; 2 ft/mi for the Clam River in the outwash area; and 6 ft/mi for upper reaches of the Apple, Willow, and Kinnickinnic Rivers and relatively steep gradients of 15 to 40 ft/mi near the mouths (Young and Hindall, 1973, sheet 1).

LOW-FLOW CHARACTERISTICS

Low flow refers to the low range of stream discharge. A probability of occurrence and a time period can be specified for a more precise definition. Low flow is usually ground-water discharge (base flow) although a 30-, 60-, or 90-day low flow could contain some surface runoff.

A typical low-flow period is illustrated by the discharge hydrograph for St. Croix River near Danbury gaging station (fig. 2). The annual 90-day low flow occurred from July 26 to October 23. Although this was the lowest flow for 90 consecutive days during the year, direct runoff occurred many times. Except for the rises resulting from direct runoff, the streamflow for the period was base flow or ground-water discharge.

Table 1 contains low-flow data for 141 sites in the St. Croix River basin. Each site is identified by station number and station name. The site location, drainage area, type of site, and other pertinent data are included. Low-flow data included for each site depend upon the type of site: gaging station, low-flow partial-record station, or miscellaneous sites. The locations of the sites are shown on plate 1.

ANALYTICAL TECHNIQUES

Low-flow characteristics in table 1 were determined by three methods of analysis. These methods depended on the three types of basic data available:

4
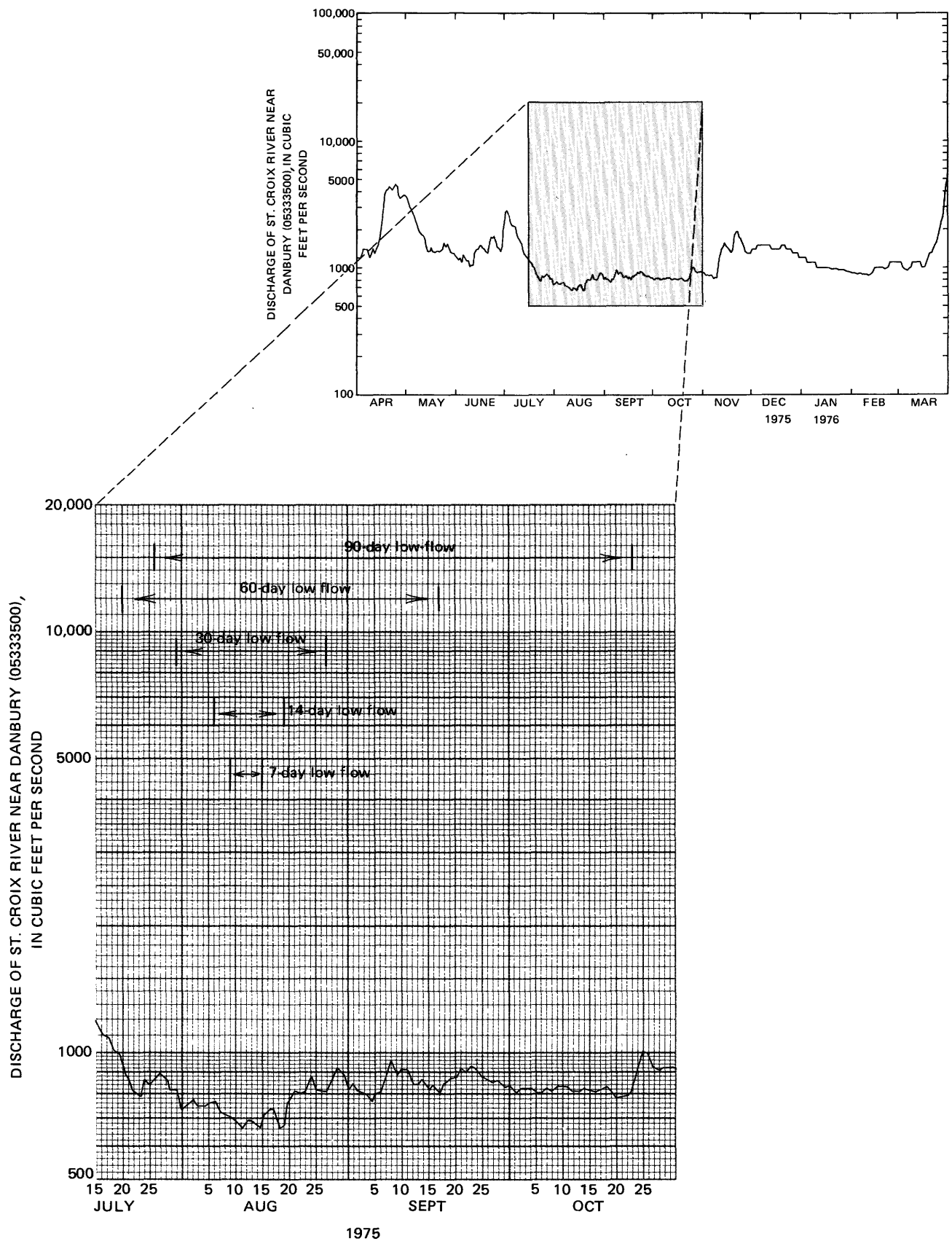
Figure 2. Daily discharge of St. Croix River for 1976 climatic year showing annual low-flow periods for various number of days

5

(1) continuous record of daily streamflows (continuous-record gaging stations);
(2) 8 to 25 base-flow discharge measurements (low-flow partial-record stations);
(3) 1 to 7 base-flow discharge measurements (miscellaneous sites).

Gaging stations

Low-flow characteristics of a stream where systematic streamflow records have been collected can be determined by flow-duration analysis and frequency analysis. The two analyses serve different purposes. The flow-duration curve indicates the percentage of time that a daily mean flow exceeds a given discharge, and the low-flow frequency curve indicates the probability that a 7, 14, 30, 60, and 90 consecutive day mean flow will be exceeded in any given year. The recommended and more generally used analysis for most low-flow applications is the low-flow frequency analysis. In the St. Croix River basin the annual minimum 7-day mean flow below which the flow will fall on the average of once in 2 years $(Q_{7,2})$ is approximately equal to 90 percent flow duration. The annual minimum 7-day mean flow below which the flow will fall on the average of once in 10 years $(Q_{7,10})$ is about equal to 99 percent flow duration.

Low-flow frequency and flow-duration analyses were completed for all continuous-record gaging stations that have 10 or more years of record. Values
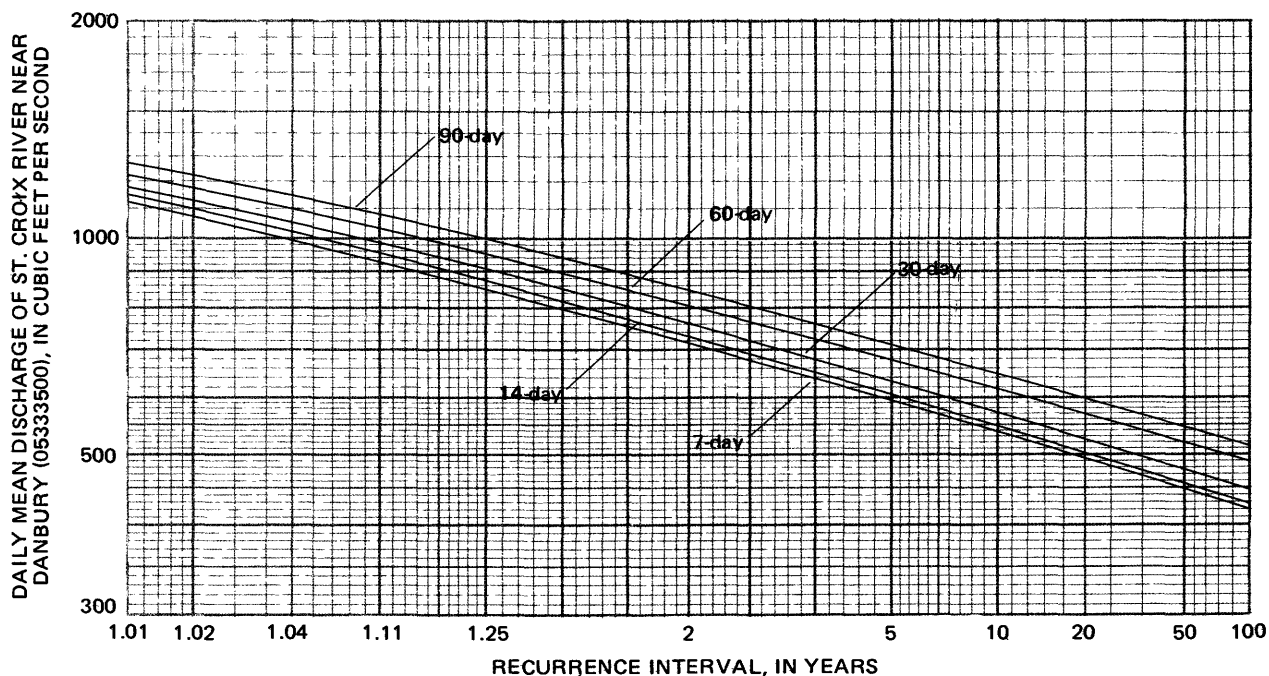
Figure 3. Low-flow frequency curves showing magnitude and frequency
of the annual minimum mean discharge for the indicated number
of consecutive days at St. Croix River near Danbury.

6

for the magnitude and frequency of annual low flows for 7, 14, 30, 60, and 90 consecutive days are listed in table 1. Table 1 also lists flow-duration values showing the percentage of time that specified discharges were exceeded.

The low-flow frequency characteristics were determined from the daily discharge records using a log-Pearson Type III probability distribution or a plotting position analysis (Riggs, 1972, p. 1-8). If results of the two analyses were substantially different, the plotting position analysis was used. Figure 3 is an example of a low-flow frequency curve for the St. Croix River near Danbury gaging station, and figure 4 is a flow-duration curve for the same site.

For gaging stations that have insufficient data for low-flow frequency analysis or flow duration, the low-flow characteristics were determined by a procedure similar to that outlined in the following section for low-flow partial-record stations.
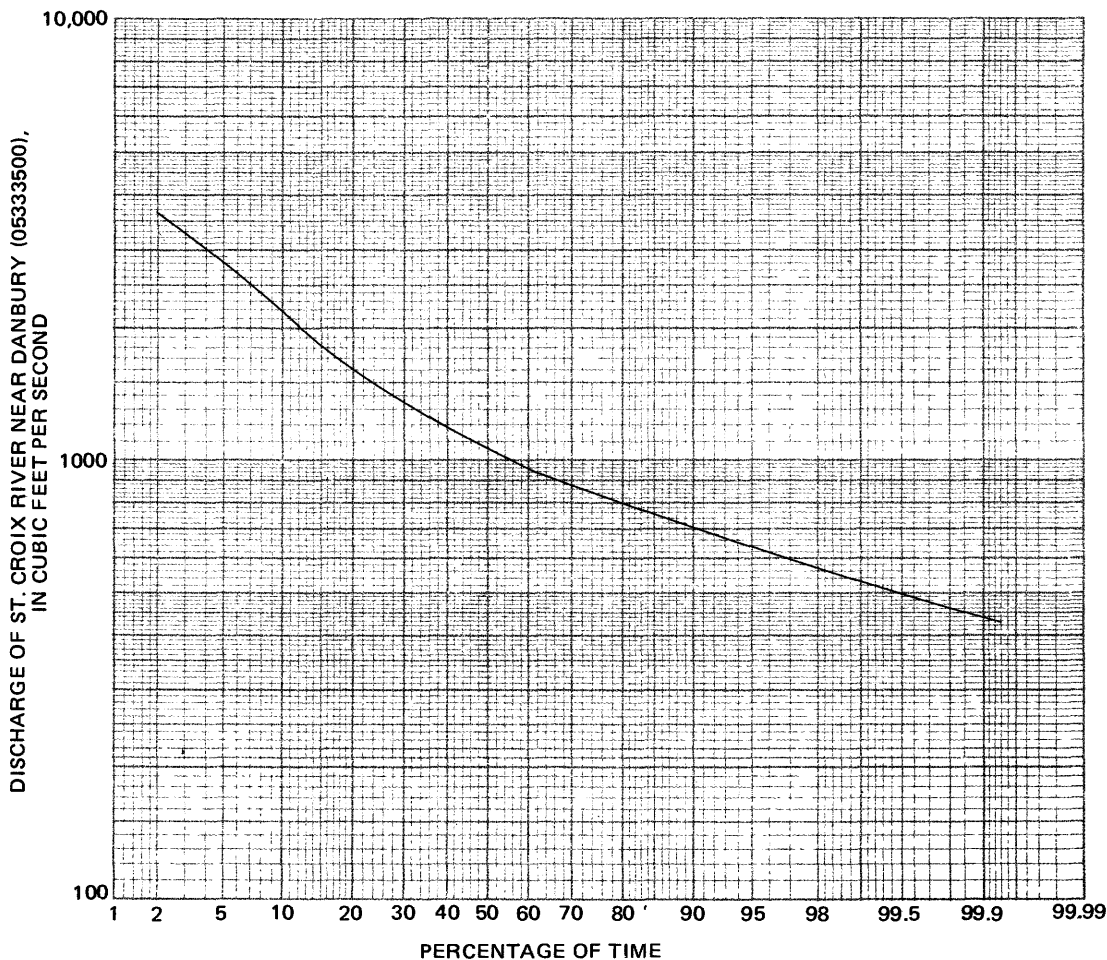
Figure 4. Flow-duration curve showing the percentage of time a given discharge was exceeded for St. Croix River near Danbury

7

Figure 5. Method of estimating $Q_{7,2}$ and $Q_{7,10}$ at low-flow partial-record stations.

Low-flow partial-record stations

Low-flow characteristics determined for low-flow partial-record stations are $Q_{7,2}$ and $Q_{7,10}$. Estimates of $Q_{7,2}$ and $Q_{7,10}$ are presented in table 1 for 26 low-flow partial-record stations. Characteristics were determined graphically from the relationship established by plotting 8 to 25 base-flow discharge measurements at low-flow partial-record stations against concurrent discharges at continuous-record gaging stations in the area (Gebert, 1971).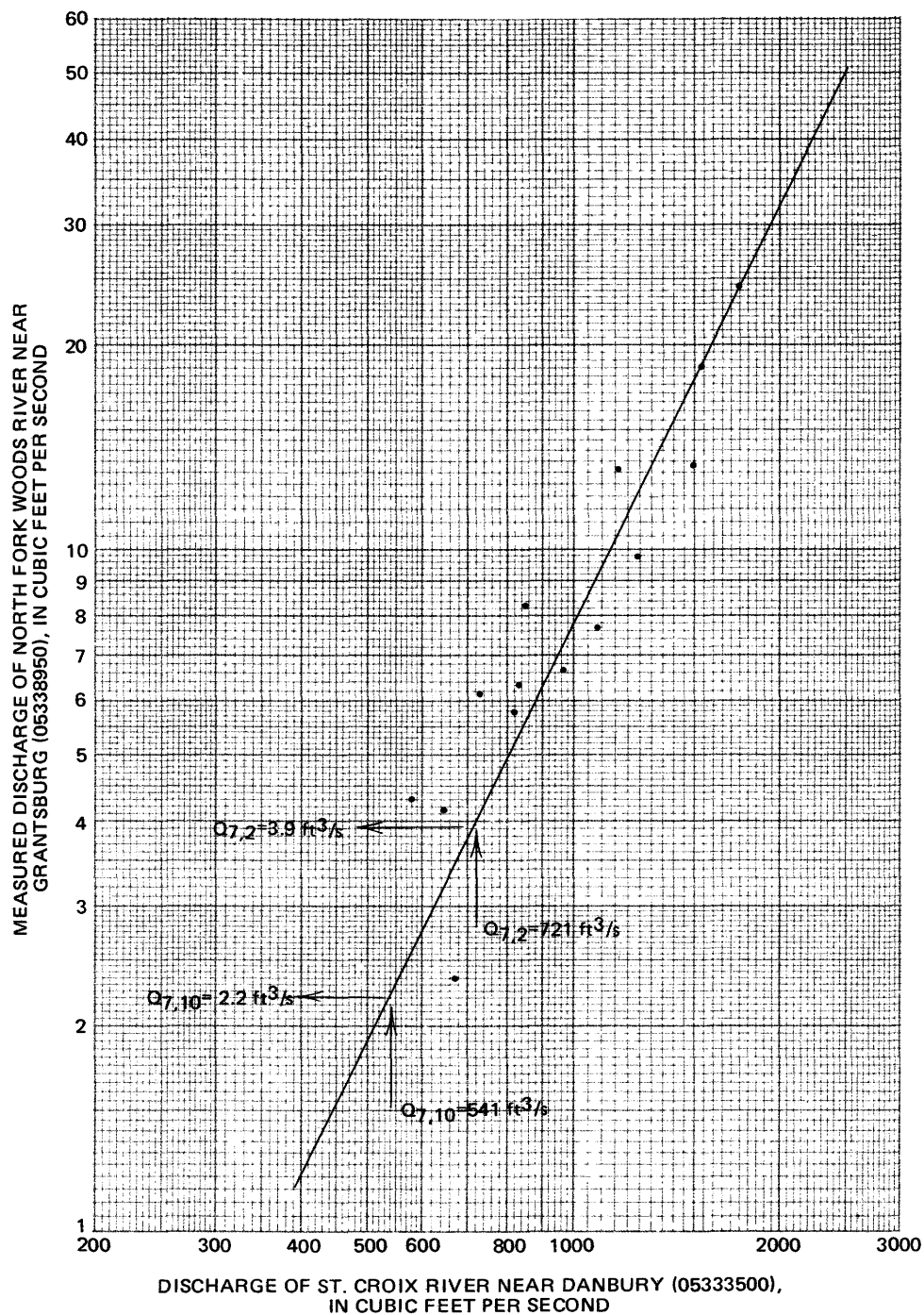 The $Q_{7,2}$ and $Q_{7,10}$ at the continuous-record gaging station then were transferred through the relation line to estimate $Q_{7,2}$ and $Q_{7,10}$ for the partial-record station. Figure 5 is an example of this type of analysis for North Fork Woods River near Grantsburg.

Miscellaneous sites

Base-flow measurements have been obtained at 104 miscellaneous sites in the St. Croix River basin as part of other water-resources investigations. Low-flow characteristics were estimated for most of these sites (table 1) by one of two methods.

Low-flow characteristics were estimated at 35 sites where at least 3 base-flow discharge measurements were available and a well-defined relationship existed between the measured discharge and the concurrent daily mean discharge at a nearby gaging station. Estimates of $Q_{7,2}$ and $Q_{7,10}$ were made by the same type of analysis that was used for partial-record stations (Gebert and Holmstrom, 1974, p. 3-4). Figure 6 illustrates this type of analysis for Wood River tributary near Frederic. The slope of the relation line for miscellaneous sites was compared to established relation lines of nearby low-flow partial-record stations and other miscellaneous sites for uniformity. Generally the relation line should have approximately the same slope if the factors that influence low flow are uniform for the area. If the relation line at the site being studied was defined by three discharge measurements that had significant scatter, the line was adjusted to agree more closely with the better established relation line at a low-flow partial-record station.

For 40 miscellaneous sites that have less than 3 discharge measurements, the low-flow characteristics were estimated by regression equations and are listed in table 1. The regression equations used and discussion of their development is presented later in the report.

Low-flow characteristics were not estimated at 29 miscellaneous sites for the following reasons: discharge measurements were affected by upstream regulation or continued substantial effluent from industrial or sewage-treatment plant discharge, less than 3 discharge measurements were available but the site had a drainage area greater than 150 mi^2, or regression equations provided estimates that were obviously poor when compared to existing data at nearby sites. Base-flow discharge measurements are listed for these sites.

ACCURACY

The low-flow characteristics in table 1 are estimates of flow expected in the future. Low-flow characteristics like other streamflow characteristics are only estimates; their true value being difficult or impossible to determine. Each estimate has an error associated with it, dependent on the amount and kind
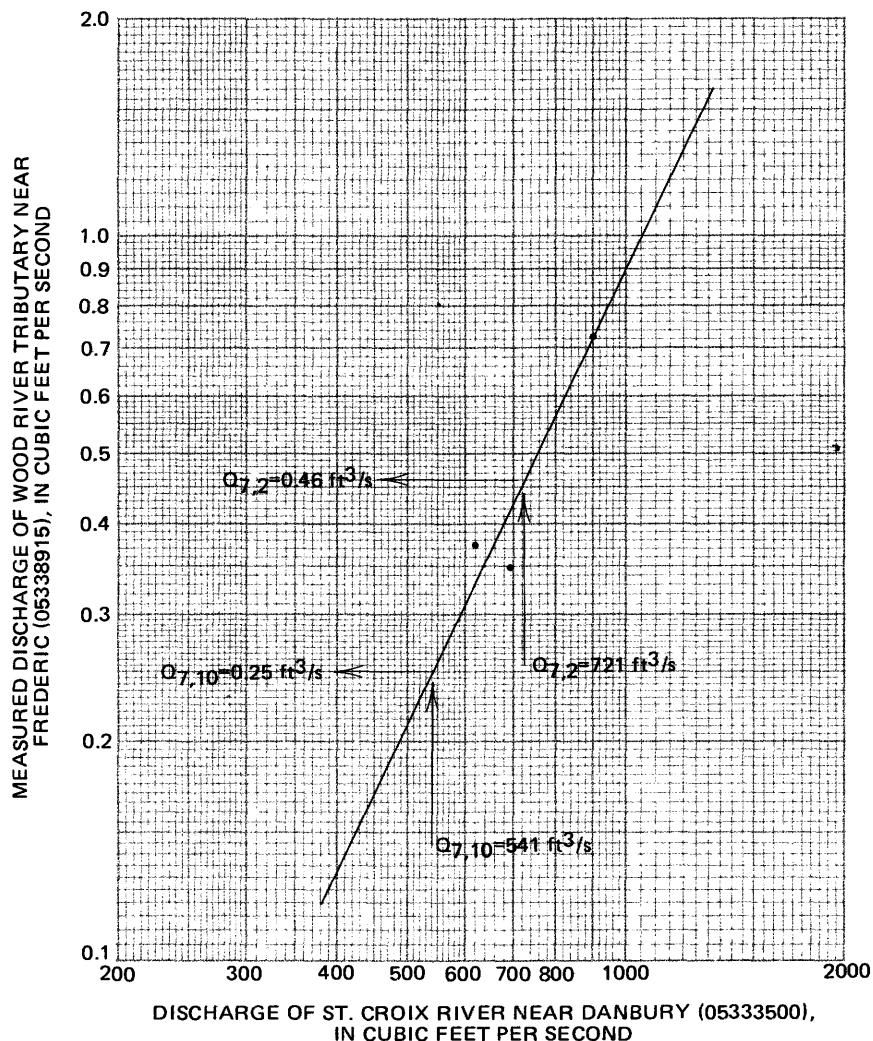
Figure 6. Method of estimating $Q_{7,2}$ and $Q_{7,10}$ at miscellaneous sites.

of data, and the analytical method. Two major sources of error are the time-sampling error in streamflow records and the error in the analytical method.

The accuracy of the low-flow estimates are approximated by the standard error of estimate. The standard errors associated with the $Q_{7,2}$ estimate $(SE_{7,2})$ and $Q_{7,10}$ estimate $(SE_{7,10})$ are presented in table 1 for selected sites. One standard error above and below an estimate defines a range which should include the true value at 67 percent of the sites.

The method used to obtain the standard errors are not precise, and the standard errors presented in the table should be used as a relative guide to indicate only a general level of confidence. In addition, there may be larger errors associated with low-flow estimates that approach 0 ft^3/s.

Gaging stations

Accuracy of low-flow characteristics at gaging stations was determined according to Hardison and Moss (1972, p. 38). A common length of record was used to compare the accuracy of low-flow characteristics determined from recorded discharge at gaging stations in the St. Croix River basin with that of gaging stations throughout the State. This analysis assumed that 10 years of record was available at each gaging station to determine the $Q_{7,10}$ discharge. An $SE_{7,10}$ of 13 percent was determined for the St. Croix River basin as compared to an $SE_{7,10}$ of 16 percent for gaging stations throughout the State. This indicates that low-flow characteristics can be determined with about the same degree of accuracy in the St. Croix River basin.

Low-flow partial-record stations

The accuracy of low-flow characteristics at low-flow partial-record stations was determined by a method developed by Hardison and Moss (1972, p. 28). Using this method, an average $SE_{7,10}$ of 27 percent was found for the 26 low-flow partial-record stations in the St. Croix River basin. This compares to an average $SE_{7,10}$ of 29 percent for 265 low-flow partial-record stations throughout the State.

Miscellaneous sites

The accuracy of low-flow characteristics at miscellaneous sites was determined as an average value for the entire basin by analyzing data collected at low-flow partial-record stations. Three random base-flow measurements were selected from the 8 to 25 measurements available at the 26 low-flow partial-record stations. Low-flow characteristics were determined from these three measurements using the same procedure used for miscellaneous sites. Then low-flow characteristics determined by this method were plotted against the low-flow characteristics based on 8 to 25 measurements. The SE between the two methods was determined from this plotted relationship. The overall SE includes the SE determined by the plotted relationship and the SE associated with the low-flow estimates based on 8 to 25 measurements. Assuming the two errors are independent, the overall SE can be approximated by taking the square root of the sum of the squares of the two different SE's. For the St. Croix River basin this resulted in an $SE_{7,10}$ of 50 percent which is listed in table 1 as the average basin accuracy.

The average $SE_{7,10}$ value should be used cautiously for any particular site because the actual value for a subbasin could be significantly different from the mean for the basin. If the low-flow characteristics are based on more than three discharge measurements, the accuracy probably will be improved and should approach the accuracy at low-flow partial-record stations as additional measurements are obtained.

The accuracy of the low-flow characteristics that were determined by regression equations at the other 40 miscellaneous sites is also an average value for the basin. It was determined as part of the regression analysis and is discussed later in the report.

ESTIMATING LOW-FLOW CHARACTERISTICS AT UNGAGED SITES

A method is required to transfer low-flow characteristics from gaged sites to ungaged sites because it is impossible to obtain actual streamflow data for all sites where the information is needed. The most practical transfer method relates low-flow characteristics to topographic, climatic, and aquifer characteristics of the drainage basin by multiple-regression analysis. Characteristics used in the multiple-regression analysis and the equations determined are discussed in the following paragraphs. The method is outlined in detail by Thomas and Benson (1970).

STREAMFLOW CHARACTERISTICS

Streamflow characteristics that were studied are the $Q_{7,2}$ and $Q_{7,10}$ which are widely used to describe low flow. The multiple-regression analysis included low-flow characteristics for 23 low-flow partial-record stations in the St. Croix River basin. The streamflow characteristics are the dependent variable in the multiple-regression analysis.

BASIN CHARACTERISTICS

Differences in streamflow for various locations and times are caused by the differences in precipitation patterns and the differences in runoff characteristics. Climatic, topographic, and aquifer characteristics are quantified to explain the variation in low flow. These indices are the independent variables in the multiple-regression analysis.

Basin characteristics were selected for the analyses because of their known influence on the rainfall-runoff process. The following list of the drainage-basin characteristics contains a brief discussion of their effect on low flow and how the indices were determined.

Values for these basin characteristics for low-flow partial-record stations in the St. Croix River basin are listed in table 2.

Drainage area (A).--Size of the drainage area is the most significant characteristic in explaining differing streamflow between sites. The drainage area of a stream is that area, measured in a horizontal plane, that is enclosed by a drainage divide. Drainage areas, in square miles, were computed from U.S. Geological Survey topographic maps. Most drainage-area data for this study were obtained from Holmstrom (1972, p. 39-40).

Main-channel slope (S).--Main-channel slope (Benson, 1962 and 1964) is a characteristic that relates to the change in streamflow for different basins. The index of slope used in this analysis is the average slope in feet per mile between points 10 percent and 85 percent of the distance upstream from the gaged site to the drainage-basin divide.

Main-channel length (L).--Main-channel length is another landform characteristic that indicates basin shape in conjunction with drainage area of the basin. In estimating ground-water runoff to the stream, L can be viewed as describing the length of the vertical cross-sectional area of the porous aquifer material through which the flow occurs. Channel length was obtained from the U.S. Geological Survey topographic maps by measuring the total indicated blue-line length by a digitizer, divider, or other means.

Basin storage (Bs).--Basin storage is that part of total drainage area occupied by lakes and marshes. Variations in streamflow can be caused by retention and release of water from basin storage. For some streams, runoff is delayed by storage, but total runoff may not be reduced; whereas on other streams prolonged retention allows increased evapotranspiration that results in decreased runoff. Essentially, the basin storage index is used in the analysis to reflect the effect of evapotranspiration on low flow.

The basin storage area was obtained from U.S. Geological Survey topographic maps. A value of 1.00 percent was added to all values of basin storage to avoid problems of using zero in the regression analysis.

Forest cover (F).--Forests affect streamflow in several ways. Their major influences on low flow are intercepting precipitation before it reaches the ground and transpiration.

The forest cover index used in this analysis is the percentage of drainage area covered by forests as shown on U.S. Geological Survey topographic maps. A value of 1.00 percent was added to all values of forest cover to avoid problems of using zero in the regression analysis.

Mean annual precipitation (P).--Mean annual precipitation of a basin expresses the amount of water available for potential runoff. The precipitation that infiltrates the soil and passes through the unsaturated zone to the ground-water supply is the source of base flow for a stream. The mean annual precipitation, in inches, for each basin was computed from an isohyetal map determined from precipitation recorded at U.S. Weather Bureau stations (Wisconsin Statistical Reporting Service, 1967, p. 18).

A constant of 20 in. was subtracted from each value for use in the regression analysis. This reduction provides constants and exponents in the regression equation that are more manageable.

Soil-infiltration rate (I).--Soil permeability influences the amount of direct runoff from a storm and the amount of water that infiltrates the soil. The permeability used is an average rate for the basin under average soil and moisture conditions.

Soil types and average permeability, in inches per hour, for each basin were determined from maps by Young and Hindall (1973, sheet 1).

Mean annual snowfall (Sn).--Mean annual snowfall, like mean annual precipitation, is an indicator of water available for runoff. For each basin an average mean annual snowfall, in inches, was determined from an isohyetal map determined from snowfall recorded in the period 1930-59 (Wisconsin Statistical Reporting Service, 1970, p. 1) and average snowfall values from National Weather Service weather stations in the basin (Wisconsin Crop Reporting Service, 1961). A constant of 20 in. was subtracted from each value to provide more manageable constants and exponents in the equations.

Base-flow index (Bf).--A good indicator of a stream's low-flow potential is a discharge measurement made during base-flow conditions. Base-flow measurements provide considerable information about the characteristics of the aquifers

supplying outflow to the stream. To use base-flow measurements, it is necessary to convert them to a uniform basis because measurements generally are obtained at various points on the base-flow recession curves. Discharge at the 90 percent flow duration was selected to represent the base-flow index value. To evaluate the technique and develop the necessary relationships for this study, sites were selected that had discharge measurements obtained for a low-flow investigation during August 19-21, 1969.

Measured discharges (Q_m) at low-flow partial-record stations and miscellaneous sites were converted to a unit discharge by dividing the values by their respective drainage areas (A). These values then were adjusted by a basin ratio to determine the base-flow index for each site. Basin ratios were determined for gaging stations on unregulated streams within the St. Croix River basin by dividing the discharge at 90 percent flow duration (Q_{90}) by the observed average daily discharge during August 19-21, 1969 (Q_r). Thus, base-flow index values were determined by the equation:

$$Bf = \frac{Q_m}{A} \frac{Q_{90}}{Q_r}$$

Plate 2 shows the locations of 70 sites with base-flow index values, their respective drainage-area outlines, and their computed base-flow index values.

Hydraulic conductivity (K).--Hydraulic conductivity of an aquifer is the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Average values of hydraulic conductivity were given to the glacial drift in the St. Croix River basin and are:

	Hydraulic conductivity $\{(gal/d)/ft^2\}$
Lake basins (clay, silt, and sand)	1
Ground moraine (till; consists of clay, silt, sand, gravel, and boulders)	10
End moraine (till; sand and gravel)	100
Outwash (sand and gravel)	2,500

Average values of hydraulic conductivity were obtained for each of the subbasins by the following procedures: (1) outline subbasin divide on glacial geology map (Young and Hindall, 1973, sheet 1), (2) determine the subbasin for each of the glacial drift types, (3) multiply these subareas by the hydraulic conductivity values assigned to the glacial drift, and (4) divide the sum of these products by the sum of the subareas.

Drift thickness (H).--Glacial drift serves as an aquifer that stores water for release to streams in the basin. The thickness of glacial drift ranges from less than 50 ft in parts of northern, central, and southern areas of the basin to 350 ft in the southwestern part of the basin. An average drift thickness for each subbasin was determined from the glacial geology and drift thickness map by Young and Hindall, (1973, sheet 1).

14

<u>Transmissivity (T)</u>.--The water-transmitting capability of an aquifer is expressed in terms of transmissivity. Values of transmissivity were obtained by the product of hydraulic conductivity and drift thickness.

REGRESSION ANALYSIS

Multiple-regression analysis was used to determine the relationship between the low-flow characteristics (dependent variables) and the basin characteristics (independent variables). The analysis provides an equation, or series of equations, relating the dependent to the independent variables. This analysis defined mathematical equations of the form:

$$Q_T = a\, A^{b_1} B^{b_2} C^{b_3} \ldots\ldots\ldots\ldots\ldots N^{b_n},$$

where:

Q_T is a 7-day low-flow characteristic having a T-year recurrence interval, in cubic feet per second;

a is a regression constant defined by the regression analysis;

ABC.....N are drainage-basin characteristics; and

$b_1 b_2 b_3 \ldots\ldots b_n$ are coefficients defined by regression analysis.

The analysis also defined the standard error of estimate (SE) of the dependent variables and the statistical significance of each variable in the equation.

The standard error of estimate is a measure of the accuracy of the regression relationships. It describes a range in error between the defined relationship and the data included in the analysis. One standard error above and below an estimate defines a range which should include the true value at about 67 percent of the sites.

Step-backward regression analyses were performed by digital computer using procedures outlined by Thomas and Benson (1970, p. 26-31). The equations with the lowest standard error of estimate with all variables significant at the 95 percent confidence level were selected as the best equations for prediction.

Two separate sets of analyses were performed to develop equations for sites without streamflow data available and for sites with minimum streamflow data available. One analysis included all drainage-basin characteristics except for base-flow index, and the other analysis contained all drainage-basin characteristics including the base-flow index.

Sites without streamflow data

Two equations were selected from the analyses for sites without streamflow data. The equations and their respective standard error of estimates are:

Equation	Standard error	

$$Q_{7,2} = 3.75 \times 10^{-2} A^{1.30}$$ $\quad$ $SE_{7,2} = 110$ percent $\quad$ (1)

$$Q_{7,10} = 1.05 \times 10^{-2} A^{1.47}$$ $\quad$ $SE_{7,10} = 150$ percent $\quad$ (2)

$Q_{7,2}$ is the 7-day, 2-year low flow, in cubic feet per second;

$Q_{7,10}$ is the 7-day, 10-year low flow, in cubic feet per second; and

$\quad$ A is drainage area, in square miles.

Equations 1 and 2 apply to sites without streamflow data and for drainage areas less than 150 mi^2.

Sites with minimum streamflow data

Two equations were selected from the analyses for sites with minimum streamflow data available. The equations and their respective standard errors of estimate are:

Equation	Standard error	

$$Q_{7,2} = 0.492 A^{1.14} Bf^{1.01}$$ $\quad$ $SE_{7,2} = 38$ percent $\quad$ (3)

$$Q_{7,10} = 0.235 A^{1.28} Bf^{1.21}$$ $\quad$ $SE_{7,10} = 52$ percent $\quad$ (4)

$Q_{7,2}$, $Q_{7,10}$, and A are as defined for equations 1 and 2; and

$\quad$ Bf is the base-flow index, in cubic feet per second per square mile.

Equations 3 and 4 should provide estimates of $Q_{7,2}$ and $Q_{7,10}$ at approximately the SE indicated for sites where base-flow discharge measurements with flow durations greater than 60 percent have been made. In addition, for sites without streamflow data and not on small tributaries, equations 3 and 4 should provide more reliable estimates than equations 1 and 2 for the following conditions:

1. For ungaged sites that are located in an area where the degree of uniformity among Bf values is high, as shown on plate 2.

2. For ungaged sites that are located within the indicated subbasins on plate 2.

Equations 3 and 4 are applicable for use at sites with drainage areas less than 150 mi^2.

Verification of regression equations that use base-flow index

To test the validity of equations 3 and 4 for other flow conditions and time periods, the following comparison was performed using streamflow data

16

collected at low-flow partial-record stations. Periods selected for analyses were: a low base-flow period (flow durations greater than 80 percent); a medium base-flow period (flow durations 60 to 80 percent); and two high base-flow periods (flow duration less than 60 percent). Values of Bf were obtained as outlined previously. Substituting these new values of Bf into equations 3 and 4, estimates of $Q_{7,2}$ and $Q_{7,10}$ were determined for low-flow partial-record stations. When compared to the $Q_{7,2}$ and $Q_{7,10}$ values listed in table 1 the following SE's were determined for the estimated low-flow characteristics.

Regression analysis equations	SE from regression analysis	SE using various flow conditions to determine Bf		
		Low base flow	Medium base flow	High base flow
Equation 3	38 percent	27 percent	32 percent	[1]55 percent
Equation 4	52 percent	35 percent	50 percent	[1]86 percent

[1]Average of two high base-flow periods

As illustrated, equations 3 and 4 provide satisfactory results for low and medium base-flow conditions. For high base-flow conditions equations 3 and 4 provide estimates with a significantly higher SE than indicated from the regression analysis. Base-flow measurements should be obtained at low to medium base-flow conditions (flow durations greater than 60 percent) to develop base-flow index values for use in equations 3 and 4.

Use of base-flow index values from plate 2 in equation 4 was also tested for application at sites without base-flow discharge measurements. The $Q_{7,10}$ values were computed for miscellaneous sites (three or more discharge measurements) using Bf values from plate 2 and equation 4 and compared to the observed $Q_{7,10}$ values (determined by graphical regressions) for these sites. The percent difference between the computed $Q_{7,10}$ values were within the $SE_{7,10}$ of 52 percent for equation 4 at seven of the eight stations tested. Although a limited number of stations were tested, it appears that using the conditions given on page 16 to determine Bf for ungaged sites and equation 4 will give results which are within the $SE_{7,10}$ predicted by equation 4.

APPLICATION OF ESTIMATING PROCEDURES

Sites without streamflow data

Computation of low-flow characteristics at an ungaged site may be made as follows:

1. If the conditions listed on page 16 are met, use equations 3 and 4 (page 16) to determine the low-flow characteristics at ungaged sites.

2. Determine base-flow index from plate 2.

3. Compute drainage area as indicated on page 12.

4. Substitute these values into equations 3 and 4 and solve for the low-flow characteristics.

5. Use equations 1 and 2 (page 16) to determine low-flow characteristics for sites where the conditions outlined on page 16 cannot be met.

6. Compute the drainage area as indicated on page 12.

7. Substitute the drainage-area value into equations 1 and 2 and solve for the low-flow characteristics.

For ungaged sites where the degree of uniformity of base-flow index values is high, Bf can be determined from plate 2 and equations 3 and 4 can be used to determine the low-flow characteristics. For example, to determine the low-flow characteristics for Cedar Creek at mouth near Star Prairie the applicable equations are:

$$Q_{7,2} = 0.492A^{1.14}Bf^{1.01} \qquad\qquad (3)$$

$$Q_{7,10} = 0.235A^{1.28}Bf^{1.21} \qquad\qquad (4)$$

Drainage area was determined as outlined on page 12 and is 55.1 mi^2.

The base-flow index is determined from plate 2 and is a weighted average based on drainage area:

$$Bf = \frac{A_1 Bf_1 + A_2 Bf_2}{A_1 + A_2}$$

where:　A_1 = drainage area at station 05341450 = 32.6 mi^2,

　　　Bf_1 = base-flow index at station 05341450 = 0.24,

　　　A_2 = intervening drainage area between site of interest and station 05341450 = 22.5 mi^2,

　　　Bf_2 = base-flow index for intervening area between site of interest and station 05341450 = 0.21.

$$Bf = \frac{A_1 Bf_1 + A_2 Bf_2}{A_1 + A_2}$$

$$Bf = \frac{32.6(0.24) + 22.5(0.21)}{32.6 + 22.5}$$

$$Bf = \frac{7.8 + 4.7}{55.1} = \frac{12.5}{55.1}$$

$$Bf = 0.23$$

18

Substituting these values into their respective equations:

$$Q_{7,2} = 0.492A^{1.14}Bf^{1.01}$$
$$= 0.492(55.1)^{1.14}(0.23)^{1.01}$$
$$= 0.492(96.6)(0.23)$$
$$= 11 \text{ ft}^3/\text{s}$$

$$Q_{7,10} = 0.235A^{1.28}Bf^{1.21}$$
$$= 0.235(55.1)^{1.28}(0.23)^{1.21}$$
$$= 0.235(169)(0.17)$$
$$= 6.8 \text{ ft}^3/\text{s}$$

Low-flow characteristics for ungaged sites in which conditions on page 16 are not met can be determined by regression equations 1 and 2. The low-flow characteristics of East Branch Hay Creek at Douglas-Pine County line near Moose Junction are determined to illustrate the application of equations 1 and 2:

The applicable equations for an ungaged area are:

$$Q_{7,2} = 3.75 \times 10^{-2} A^{1.30} \tag{1}$$

$$Q_{7,10} = 1.05 \times 10^{-2} A^{1.47} \tag{2}$$

The drainage area for this site as outlined on page 12 is 6.61 mi^2. Substituting these values into the respective equation:

$$Q_{7,2} = 3.75 \times 10^{-2} A^{1.30}$$
$$= (3.75 \times 10^{-2})(6.61)^{1.30}$$
$$= (3.75 \times 10^{-2})(11.6)$$
$$= 0.44 \text{ ft}^3/\text{s}$$

$$Q_{7,10} = 1.05 \times 10^{-2} A^{1.47}$$
$$= (1.05 \times 10^{-2})(6.61)^{1.47}$$
$$= (1.05 \times 10^{-2})(16.1)$$
$$= 0.17 \text{ ft}^3/\text{s}$$

Sites with minimum streamflow data available

Computation of the low-flow characteristics at sites with minimum streamflow data available is made as follows:

1. Use equations 3 and 4 listed on page 16 to determine the low-flow characteristics.

2. Determine from plate 1 and table 1 the type of streamflow data that are available.

3. If the streamflow measurements are made during base-flow conditions, the Bf should be determined as outlined on pages 13 and 14.

4. Compute drainage area as outlined on page 12.

5. Substitute values determined in steps 3 and 4 into equations 3 and 4.

To determine low-flow characteristics at sites using streamflow measurements, the following procedure at the site, Sucker Branch near Deronda (station number 05341426), is used as an example.

The applicable equations are:

$$Q_{7,2} = 0.492A^{1.14}Bf^{1.01}$$

$$Q_{7,10} = 0.235A^{1.28}Bf^{1.21}$$

Drainage area (A) obtained from table 1, page 51, is 102 mi^2.

Following the same general procedure indicated on pages 13 and 14, a Bf value was determined by the equation:

$$Bf = \frac{Q_m \; Q_{90}}{A \; Q_r}$$

where: Q_m is the measured discharge, 17.9 ft^3/s, of Sucker Branch near Deronda on August 19, 1969;

   A is the drainage area, 102 mi^2, of Sucker Branch near Deronda;

   Q_r is the recorded discharge at a nearby continuous-record gaging station. Referring to plate 1, station 05341500, Apple River near Somerset is the closest gaging station. From Water Resources Data for Wisconsin (1969) the average daily discharge for August 19, 1969, was 172 ft3/s; and

   Q_{90} for Apple River near Somerset is 140 ft^3/s, obtained from table 1.

Substituting these values in the equation:

$$Bf = \frac{Q_m \, Q_{90}}{A \, Q_r}$$

$$= \frac{(17.9)(140)}{(102)(172)}$$

$$= 0.143$$

The low-flow characteristics then can be determined by substituting these values in their respective equations.

$$Q_{7,2} = 0.492A^{1.14}Bf^{1.01}$$

$$= (0.492)(102)^{1.14}(0.143)^{1.01}$$

$$= (0.492)(195)(0.140)$$

$$= 13 \, ft^3/s$$

$$Q_{7,10} = 0.235A^{1.28}Bf^{1.21}$$

$$= (0.235)(102)^{1.28}(0.143)^{1.21}$$

$$= (0.235)(372)(0.095)$$

$$= 8.3 \, ft^3/s$$

COMPARISON OF METHODS

If estimates of low-flow characteristics are required at sites other than those presented in this report, the user interested in the data should evaluate the urgency of the need for the low-flow information and then select a method based on following criteria. Generally the most important criteria in choosing a method are: accuracy requirements of the low-flow characteristics; time available to collect and analyze data; and cost of data collection and analyses.

Table 3 compares the methods available and provides: type of data required; number of sites where required data are available; time required to collect data; analytical method used to determine the low-flow characteristics; and standard error of estimate associated with the method. If a high degree of reliability is required of low-flow characteristics and sufficient time is available for data collection, a gaging station or low-flow partial-record station should be operated. If a lesser degree of reliability is acceptable at a site, or time and money are limited, three base-flow discharge measurements can be obtained during a low-flow season, or one of the regression equations may be used.

SUMMARY

Low-flow characteristics are given in table 1 for 10 gaging stations, 26 low-flow partial-record stations, and 75 miscellaneous sites in the St. Croix River basin.

The method used in estimating the low-flow characteristics was dependent on the amount of discharge data available at the site. The low-flow characteristics at a gaging station with 10 or more years of record was determined by a log-Pearson type III frequency analysis or plotting-position analysis. At a low-flow partial-record station (8 or more discharge measurements) or miscellaneous site (3 to 7 discharge measurements) a graphical correlation was used to determine the $Q_{7,2}$ and $Q_{7,10}$. At miscellaneous sites (1 or 2 discharge measurements) and ungaged sites (no discharge measurements) multiple-regression equations were developed to determine the low-flow characteristics. The standard error of estimate of the 7-day, 10-year low flow ($SE_{7,10}$) ranged from 6 to 150 percent, depending on the type of data available. The methods used to determine the standard errors are not precise and should be used as a relative guide to indicate a general level of confidence.

Two sets of multiple-regression equations were developed to determine the low-flow characteristics at ungaged sites (no discharge measurements) and at sites with minimum streamflow data (1 or 2 base-flow discharge measurements). The latter equations had an $SE_{7,10}$ of 52 percent compared to 150 percent for the former. The most significant characteristics in explaining the variation in low flow were drainage area and base-flow index.

REFERENCES

Benson, M. A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

_____1964, Factors affecting the occurrence of floods in the Southwest: U.S. Geological Survey Water-Supply Paper 1580-D, 72 p.

Gebert, W. A., 1971, Low-flow frequency of Wisconsin streams: U.S. Geological Survey Hydrologic Investigations Atlas HA-390.

Gebert, W. A., and Holmstrom, B. K., 1974, Low-flow characteristics of Wisconsin streams at sewage-treatment plants: U.S. Geological Survey Water-Resources Investigations 45-74, 101 p.

Hardison, C. H., and Moss, M. E., 1972, Accuracy of low-flow characteristics estimated by correlation of base-flow measurements: U.S. Geological Survey Water-Supply Paper 1542-B, 55 p.

Holmstrom, B. K., 1972, Drainage-area data for Wisconsin streams: U.S. Geological Survey open-file report.

Riggs, H. C., 1972, Low-flow investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chapter B1, 18 p.

Thomas, D. M., and Benson, M. A., 1970, Generalization of streamflow characteristics from drainage-basin characteristics: U.S. Geological Survey Water-Supply Paper 1975, 55 p.

U.S. Geological Survey, 1971, Water resources data for Wisconsin, 1969: U.S. Geological Survey Annual Report, 253 p.

Wisconsin Crop Reporting Service, 1961, Wisconsin climatological data: Madison, Wisconsin Department of Agriculture, 166 p.

Wisconsin Legislative Reference Bureau, 1977, The State of Wisconsin 1977 Blue Book: Madison, Department of Administration, Document Sales and Distribution, 986 p.

Wisconsin Statistical Reporting Service, 1967, Wisconsin weather: Madison, Wisconsin Statistical Reporting Service, 31 p.

_____1970, Snow and frost in Wisconsin: Madison, Wisconsin Statistical Reporting Service, 28 p.

Young, H. L., and Hindall, S. M., 1973, Water resources of Wisconsin--St. Croix River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-451.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin
_____

05331582 St. Croix River near Solon Springs, Wis.

Location.--NW¼SE¼ sec. 7, T. 44 N., R. 11 W., Douglas County, at bridge on country road, 3.6 mi southeast
          of Solon Springs.

Drainage area.--36.9 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 23, 1974, 11.5 ft^3/s; June 8, 1976, 18.7 ft^3/s; Aug. 4, 1976, 10.3 ft^3/s;
          Sept. 29, 1976, 17.0 ft^3/s; Aug. 24, 1977, 21.7 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 15 ft^3/s, $Q_{7,10}$ = 11 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05331590 Lower Ox Creek near Gordon, Wis.

Location.--NE¼SE¼ sec. 16, T. 44 N., R. 11 W., Douglas County, at country road, 4.6 mi northeast of Gordon.

Drainage area.--89.1 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--14.6 ft^3/s, Aug. 26, 1970.

Low-flow frequency.--$Q_{7,2}$ = 15 ft^3/s, $Q_{7,10}$ = 12 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 14 discharge measurements made
          during the period 1946-76.

Accuracy.--$SE_{7,2}$ = 9 percent, $SE_{7,10}$ = 10 percent.

05331592 St. Croix River at Gordon, Wis.

Location.--SW¼NW¼ sec. 31, T. 44 N., R. 11 W., Douglas County, at Soo Line Railroad bridge just upstream
          from Eau Claire River, 0.6 mi north of Gordon.

Drainage area.--171 mi^2.   Tributary to.--Mississippi River.

Type of site.-- Low-flow partial-record station.

Minimum discharge measured.--68.3 ft^3/s, Sept. 12, 1948.

Low-flow frequency.--$Q_{7,2}$ = 73 ft^3/s, $Q_{7,10}$ = 53 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 11 discharge measurements made
          during the period 1945-48.

Accuracy.-- $SE_{7,2}$ = 16 percent, $SE_{7,10}$ = 16 percent.

05331598 Eau Claire River near Gordon, Wis.

Location.--SE¼NE¼ sec. 9, T. 43 N., R. 11 W., at country road, 3.3 mi southeast of Gordon.

Drainage area.--124 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 23, 1946, 81.5 ft^3/s; Sept. 4, 1946, 72.7 ft^3/s; Feb. 26, 1947, 82.3 ft^3/s;
          Aug. 19, 1969, 76.4 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 64 ft^3/s, $Q_{7,10}$ = 50 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 4 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05331603 Eau Claire River at Gordon, Wis.

Location.--SW¼NW¼ sec. 31, T. 44 N., R. 11 W., Douglas County, at mouth, 0.5 mi north of Gordon.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--5/.8 ft^3/s, Oct. 28, 1948.

Low-flow frequency.--$Q_{7,2}$ = 70 ft^3/s, $Q_{7,10}$ = 54 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 8 discharge measurements made during the period 1946-49.

Accuracy.--$SE_{7,2}$ = 7 percent, $SE_{7,10}$ = 15 percent.

05331605 St. Croix River at Gordon, Wis.

Location.--SE¼NE¼ sec. 36, T. 44 N., R. 12 W., Douglas County, at bridge on country road, just downstream from confluence with Eau Claire River, 0.5 mi north of Gordon.

Drainage area.--   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--June 1, 1948, 152 ft^3/s.

05331700 Moose River near Solon Springs, Wis.

Location.--NW¼NE¼ sec. 23, T. 44 N., R. 13 W., Douglas County, at County Trunk M, 7.8 mi southwest of Solon Springs.

Drainage area.--49.9 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.69 ft^3/s, Aug. 18, 1964.

Low-flow frequency.--$Q_{7,2}$ = 1.6 ft^3/s, $Q_{7,10}$ = 0.49 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 11 discharge measurements made during the period 1964-75.

Accuracy.--$SE_{7,2}$ = 27 percent, $SE_{7,10}$ = 46 percent.

05331710 St. Croix River near Gordon, Wis.

Location.--NW¼NW¼ sec. 35, T. 44 N., R. 13 W., Douglas County, at country road, 8.0 mi west of Gordon.

Drainage area.--383 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 163 ft^3/s.

05331795 Castle Creek near Clam Lake, Wis.

Location.--SE¼NW¼ sec. 7, T. 43 N., R. 5 W., Bayfield County, at country road, 7.7 mi southeast of Clam Lake.

Drainage area.--11.7 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 2.38 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.5 ft^3/s, $Q_{7,10}$ = 0.70 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05331801 Namekagon River near Cable, Wis.

Location.--SE¼NW¼ sec. 8, T. 43 N., R. 6 W., Bayfield County, at U.S. Forest Road 211, 7.0 mi east of Cable.

Drainage area.--52.6 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 19.0 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 13 ft^3/s, $Q_{7,10}$ = 8.6 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05331810 Namekagon River near Cable, Wis.

Location.--NW¼SE¼ sec. 15, T. 43 N., R. 7 W., Bayfield County, at bridge on County Highway M, 0.6 mi upstream
          from mouth of Fivemile Creek, 3.2 mi east of Cable.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--July 28, 1975, 26.7 ft^3/s.

05331820 Namekagon River near Cable, Wis.

Location.--SW¼SW¼ sec. 24, T. 43 N., R. 8 W., Bayfield County, at U.S. Highway 63, 1.9 mi southwest of Cable.

Drainage area.--132 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 64.4 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 50 ft^3/s, $Q_{7,10}$ = 40 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05331830 Big Brook near Cable, Wis.

Location.--NW¼NE¼ sec. 26, T. 43 N., R. 8 W., Bayfield County, at country road, 2.3 mi southwest of Cable.

Drainage area.--18.1 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 16.0 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 11 ft^3/s, $Q_{7,10}$ = 7.2 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05331850 Namekagon River near Seeley, Wis.

Location.--SE¼SW¼ sec. 20, T. 42 N., R. 8 W., Sawyer County, at town road, 2.3 mi southwest of Seeley.

Drainage area.--177 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 134 ft^3/s.

27

05331855 Namekagon River near Hayward, Wis.

Location.--NE¼NE¼ sec. 12, T. 41 N., R. 9 W., Sawyer County, at bridge on town road, 3.7 mi northeast of Hayward.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--127 ft^3/s, Oct. 4, 1976.

Low-flow frequency.--$Q_{7,2}$ = 150 ft^3/s, $Q_{7,10}$ = 110 ft^3/s.

Basis of estimate.--Correlated with Namekagon River near Trego using 9 discharge measurements made during the period 1975-78.

Accuracy.--$SE_{7,2}$ = 10 percent, $SE_{7,10}$ = 11 percent.

05331860 Hatchery Creek near Hayward, Wis.

Location.--NE¼NE¼ sec. 26, T 41 N., R. 9 W., Sawyer County, at culverts on country road, 1.6 mi east of Hayward.

Drainage area.--2.53 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurements.--Aug. 12, 1975, 1.53 ft^3/s; June 8, 1976, 1.75 ft^3/s; Aug. 4, 1976, 1.64 ft^3/s; Sept. 30, 1976, 1.64 ft^3/s; Aug. 25, 1977, 1.79 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.6 ft^3/s, $Q_{7,10}$ = 1.3 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05331870 Namekagon River at Hayward, Wis.

Location.--NE¼SE¼ sec. 28, T. 41 N., R. 9 W., Sawyer County, at ranger station, 0.8 mi southwest of U.S. Highway 63 and State Highway 27, in Hayward.

Drainage area.--231 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--107 ft^3/s, July 23, 1974.

Low-flow frequency.--$Q_{7,2}$ = 130 ft^3/s, $Q_{7,10}$ = 100 ft^3/s.

Basis of estimate.--Correlated with Namekagon River near Trego using 7 discharge measurements made during the period 1973-76.

Accuracy.--$SE_{7,2}$ = 14 percent, $SE_{7,10}$ = 22 percent.

05331900 Chippanazie Creek at Stanberry, Wis.

Location.--NW¼NW¼ sec. 33, T. 41 N., R. 10 W., Washburn County, at U.S. Highway 63, 0.8 mi southwest of Stanberry.

Drainage area.--36.2 mi^2.   Tributary to.--Namekagon River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--2.83 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--$Q_{7,2}$ = 5.4 ft^3/s, $Q_{7,10}$ = 2.8 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 14 discharge measurements made during the period 1964-76.

Accuracy.--$SE_{7,2}$ = 11 percent, $SE_{7,10}$ = 18 percent.

05331902 Namekagon River at Stanberry, Wis.

Location.--NE¼NE¼ sec. 32, T. 41 N., R. 10 W., Washburn County, at town road, 0.9 mi southwest of Stanberry.

Drainage area.--304 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 25, 1969, 153 ft^3/s.

05331920 Hay Creek at Spring Brook, Wis.

Location.--NW¼NE¼ sec. 14, T. 40 N., R. 11 W., Washburn County, at town road, 0.8 mi north of Spring Brook.

Drainage area.--13.3 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 3.40 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 2.2 ft^3/s, $Q_{7,10}$ = 1.1 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05331945 Godfrey Creek near Stone Lake, Wis.

Location.--NW¼NW¼ sec. 12, T. 39 N., R. 10 W., Washburn County, at culverts on Lake Road, 2.7 mi northwest of
        Stone Lake.

Drainage area.--2.44 mi^2.   Tributary to.--South Fork Bean Brook.

Type of site.--Miscellaneous site.

Discharge measurements.--Aug. 11, 1975, 0.541 ft^3/s; June 8, 1976, 0.610 ft^3/s; Aug. 5, 1976, 0.66 ft^3/s;
        Sept. 30, 1976, 0.657 ft^3/s; Aug. 25, 1977, 0.567 ft3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.61 ft^3/s, $Q_{7,10}$ = 0.51 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent.

05331950 Bean Brook near Spring Brook, Wis.

Location.--NE¼NE¼ sec. 1, T. 39 N., R. 11 W., Washburn County, at County Trunk M, 3.5 mi southeast of
        Spring Brook.

Drainage area.--39.4 mi^2.   Tributary to.--Namekagon River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--20.7 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--$Q_{7,2}$ = 25 ft^3/s, $Q_{7,10}$ = 20 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 14 discharge measurements made
        during the period 1964-76.

Accuracy.--$SE_{7,2}$ = 6 percent, $SE_{7,10}$ = 9 percent.

05332000 Namekagon River at Trego, Wis.

Location.--NE¼SW¼ sec. 35, T. 40 N., R. 12 W., Washburn County, at Chicago and Northwestern Railroad bridge, at Trego.

Drainage area.--460 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--April 1914 to September 1927.

Average discharge.--13 years, 430 ft^3/s.

Extremes.--Maximum discharge, 1,810 ft^3/s Apr. 10 and 11, 1922; minimum discharge, 180 ft^3/s Mar. 4, 1926.

Period of con- secutive days	Magnitude and frequency of annual low flow		
	Discharge, in cubic feet per second, for indicated recurrence interval, in years		
	2	5	10
7	264	233	216
14	270	240	224
30	286	251	233
60	298	261	241
90	313	276	254

Duration table of daily flow							
Discharge, in cubic feet per second, which was exceeded for indicated percent of time							
Percent	2	5	10	20	30	40	50
ft^3/s	920	740	640	520	450	410	390
Percent	60	70	80	90	95	98	99.9
ft^3/s	367	340	316	289	264	238	160

Accuracy.--$SE_{7,2}$ = 4 percent, $SE_{7,10}$ = 7 percent.

05332100 Potato Creek at Trego, Wis.

Location.--NW¼SW¼ sec. 2, T. 39 N., R. 12 W., Washburn County, at U.S. Highways 53 and 63, 0.9 mi south of Trego.

Drainage area.--27.3 mi^2.   Tributary to.--Namekagon River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--9.03 ft^3/s, Aug. 6, 1964.

Low-flow frequency.--$Q_{7,2}$ = 12 ft^3/s, $Q_{7,10}$ = 8.2 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 13 discharge measurements made during the period 1962-76.

Accuracy.--$SE_{7,2}$ = 9 percent, $SE_{7,10}$ = 17 percent.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

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05332500 Namekagon River near Trego, Wis.

Location.--NW¼SW¼ sec. 17, T. 40 N., R. 12 W., Washburn County, at powerplant of Northern States Power Co., 4.4 mi northwest of Trego.

Drainage area.--503 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--October 1927 to September 1970.

Average discharge.--43 years, 472 ft^3/s.

Extremes.--Maximum daily discharge, 5,200 ft^3/s Sept. 2, 1941; minimum daily discharge, 113 ft^3/s Aug. 17 and Sept. 7, 1930.

Period of consecutive days	Magnitude and frequency of annual low flow Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	300	253	229	209	187	173
14	309	260	235	215	194	180
30	316	267	242	222	201	188
60	330	280	255	235	214	200
90	340	289	264	243	221	207

Duration table of daily flow Discharge, in cubic feet per second, which was exceeded for indicated percent of time							
Percent ft^3/s	2	5	10	20	30	40	50
	1,110	880	720	580	500	450	410
Percent ft^3/s	60	70	80	90	95	98	99.9
	381	352	322	289	260	230	139

Accuracy.--SE$_{7,2}$ = 3 percent, SE$_{7,10}$ = 5 percent.

Remarks.--Slight regulation by powerhouse at station.

05332700 Stuntz Brook near Minong, Wis.

Location.--SE¼SW¼ sec. 23, T. 41 N., R. 13 W., Washburn County, at County Trunk F, 8.8 mi southwest of Minong.

Drainage area.--25.0 mi^2.   Tributary to.--Namekagon River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.71 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--Q$_{7,2}$ = 1.3 ft^3/s, Q$_{7,10}$ = 0.58 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 15 discharge measurements made during the period 1964-76.

Accuracy.--SE$_{7,2}$ = 15 percent, SE$_{7,10}$ = 24 percent.

05333020 Webb Creek near Webb Lake, Wis.

Location.--SW¼SW¼ sec. 2, T. 41 N., R. 14 W., Burnett County, at country road, 0.4 mi upstream from mouth, 4.0 mi northeast of Webb Lake.

Drainage area.--21.4 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 11.4 ft^3/s.

Low-flow frequency.--Q$_{7,2}$ = 7.4 ft^3/s, Q$_{7,10}$ = 4.6 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--SE$_{7,2}$ = 38 percent, SE$_{7,10}$ = 52 percent.

05333055 Totagatic River near Wascott, Wis.

Location.--SE¼NE¼ sec. 6, T. 42 N., R. 10 W., Washburn County, at country road, 6.8 mi southeast of Wascott.

Drainage area.--82.1 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 1.59 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.2 ft^3/s, $Q_{7,10}$ = 0.48 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05333060 Ounce River near Gordon, Wis.

Location.--SE¼SE¼ sec. 25, T. 43 N., R. 11 W., Douglas County, at country road, 7.8 mi southeast of Gordon.

Drainage area.--46.2 mi^2.   Tributary to.--Totagatic River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--8.34 ft^3/s, Aug. 18, 1964.

Low-flow frequency.--$Q_{7,2}$ = 11 ft^3/s, $Q_{7,10}$ = 7.3 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 11 discharge measurements made during
            the period 1964-75.

Accuracy.--$SE_{7,2}$ = 9 percent, $SE_{7,10}$ = 14 percent.

05333080 Frog Creek near Minong, Wis.

Location.--NW¼NW¼ sec. 20, T. 42 N., R. 11 W., Washburn County, at country road, 2.4 mi northeast of Minong.

Drainage area.--31.9 mi^2.   Tributary to.--Totagatic River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--1.19 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--$Q_{7,2}$ = 2.5 ft^3/s, $Q_{7,10}$ = 1.1 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 15 discharge measurements made during
            the period 1964-76.

Accuracy.--$SE_{7,2}$ = 13 percent, $SE_{7,10}$ = 21 percent.

05333100 Little Frog Creek near Minong, Wis.

Location.--NW¼NW¼ sec. 29, T. 42 N., R. 11 W., Washburn County, at country road, 2.4 mi east of Minong.

Drainage area.--13.0 mi^2.   Tributary to.--Frog Creek.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.37 ft^3/s, Aug. 25, 1970.

Low-flow frequency.--$Q_{7,2}$ = 0.58 ft^3/s, $Q_{7,10}$ = 0.21 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 23 discharge measurements made during
            the period 1961-76.

Accuracy.--$SE_{7,2}$ = 13 percent, $SE_{7,10}$ = 21 percent.

05333110 Totagatic River near Minong, Wis.

Location.--SE¼SE¼ sec. 2, T. 42 N., R. 12 W., Washburn County, at country road, 3.2 mi north of Minong.

Drainage area.--219 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 35.6 ft^3/s.

05333300 Totagatic River near Webb Lake, Wis.

Location.--NE¼NE¼ sec. 5, T. 41 N., R. 13 W., Washburn County, at country road, 7.2 mi northeast of Webb Lake.

Drainage area.--339 mi^2.   Tributary to.--Namekagon River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 121 ft^3/s.

05333400 Namekagon River near Webb Lake, Wis.

Location.--NE¼NE¼ sec. 33, T. 42 N., R. 14 W., Burnett County, at forest road, 5.2 mi north of Webb Lake.

Drainage area.--1,030 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 72.1 ft^3/s.

05333500 St. Croix River near Danbury, Wis.

Location.--NW¼SE¼ sec. 33, T. 42 N., R. 15 W., Burnett County, on left bank at downstream side of bridge on
          State Highway 35, 3.5 mi downstream from Namekagon River, 7.5 mi northeast of Danbury.

Drainage area.--1,588 mi^2.   Tributary to.--Mississippi River.

Type of site.--Gaging station.

Period of record.--March 1914 to September 1977.

Average discharge.--63 years, 1,297 ft^3/s.

Extremes.--Maximum discharge, 10,200 ft^3/s May 6, 1950; minimum observed, 393 ft^3/s Aug. 6 and 13, 1934.

Period of con- secutive days	Magnitude and frequency of annual low flow Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	721	599	541	496	449	420
14	739	613	553	506	456	425
30	769	639	576	528	476	443
60	809	681	619	571	520	488
90	844	712	649	599	547	513

Duration table of daily flow Discharge, in cubic feet per second, which was exceeded for indicated percent of time					
Percent ft^3/s	2	5	10	20	30	40
	3,700	2,820	2,200	1,600	1,330	1,180
Percent ft^3/s	50	60	70	80	90	95
	1,050	970	880	800	720	650
Percent ft^3/s	98	99.9				
	580	440				

Accuracy.--SE$_{7,2}$ = 3 percent, SE$_{7,10}$ = 4 percent.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05333510   Chases Brook near Danbury, Wis.

Location.--SW¼NE¼ sec. 32, T. 42 N., R. 15 W., Burnett County, at forest road, 7.0 mi northeast of Danbury.

Drainage area.--38.0 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--1.53 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--$Q_{7,2}$ = 2.8 ft^3/s, $Q_{7,10}$ = 1.2 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 16 discharge measurements made during
        the period 1964-76.

Accuracy.--$SE_{7,2}$ = 15 percent, $SE_{7,10}$ = 23 percent.

05333983   Yellow River near Spooner, Wis.

Location.--NW¼SW¼ sec. 33, T. 39 N., R. 12 W., Washburn County, at State Highway 70, 1.2 mi east of Spooner.

Drainage area.--34.6 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 20, 1965, 38.9 ft^3/s; Aug. 19, 1969, 25.3 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 19 ft^3/s, $Q_{7,10}$ = 14 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05333987   Beaver Brook near Sarona, Wis.

Location.--SE¼SE¼ sec. 22, T. 38 N., R. 12 W., Washburn County, at County Trunk B, 3.1 mi northwest of Sarona.

Drainage area.--9.3 mi^2.   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 0.405 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.23 ft^3/s, $Q_{7,10}$ = 0.08 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05333990   Beaver Brook near Spooner, Wis.

Location.--SW¼NW¼ sec. 15, T. 38 N., R. 12 W., Washburn County, at country road, 4.0 mi southeast of Spooner.

Drainage area.--14.1 mi^2.   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 1.59 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.95 ft^3/s, $Q_{7,10}$ = 0.41 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05333993 Yellow River at Spooner, Wis.

Location.--NE¼SW¼ sec. 31, T. 39 N., R. 12 W., Washburn County, 100 ft downstream from Fish Hatchery dam, at Spooner.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--July 20, 1965, 44.8 ft^3/s.

05333996 Yellow River near Spooner, Wis.

Location.--NE¼SE¼ sec. 35, T. 39 N., R. 13 W., Washburn County, at Tozer Lake Road, 2.0 mi west of Spooner.

Drainage area.--76.8 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--30.9 ft^3/s, June 9, 1976.

Low-flow frequency.--$Q_{7,2}$ = 33 ft^3/s, $Q_{7,10}$ = 27 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 18 percent, $SE_{7,10}$ = 27 percent.

05334100 Sawyer Creek tributary near Shell Lake, Wis.

Location.--SE¼SE¼ sec. 13, T. 38 N., R. 13 W., Washburn County, at U.S. Highway 63, 2.0 mi north of Shell Lake.

Drainage area.--1.04 mi^2.   Tributary to.--Sawyer Creek.

Type of site.--Miscellaneous site.

Discharge measurement.--June 27, 1963, 0.0 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--Not applicable.

05334110 Sawyer Creek near Shell Lake, Wis.

Location.--NW¼NE¼ sec. 14, T. 38 N., R. 13 W., Washburn County, at culvert on country road, 2.8 mi north of Shell Lake.

Drainage area.--33.7 mi^2.   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--4.10 ft^3/s, June 9, 1976.

Low-flow frequency.--$Q_{7,2}$ = 4.3 ft^3/s, $Q_{7,10}$ = 3.2 ft^3/s.

Basis of estimate.--Correlated with Namekagon River near Trego using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 15 percent, $SE_{7,10}$ = 25 percent.

05334130 Yellow River near Shell Lake, Wis.

Location.--NW¼NW¼ sec. 10, T. 38 N., R. 13 W., Washburn County, at country road, 4.1 mi northwest of Shell Lake.

Drainage area.--116 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 72.7 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 60 ft^3/s, $Q_{7,10}$ = 49 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05334300 Yellow River near Hertel, Wis.

Location.--NE¼SW¼ sec. 23, T. 39 N., R. 15 W., Burnett County, at forest road, 2.8 mi north of Hertel.

Drainage area.--198 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 117 ft^3/s.

05334400 Yellow River near Webster, Wis.

Location.--SW¼NE¼ sec. 17, T. 39 N., R. 15 W., Burnett County, at country road, 6.0 mi east of Webster.

Drainage area.--221 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 116 ft^3/s.

05334500 Yellow River at Webster, Wis.

Location.--SE¼NE¼ sec. 5, T. 39 N., R. 16 W., Burnett County, at State Highway 35, 1.3 mi north of Webster.

Drainage area.--244 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--115 ft^3/s, Aug. 7, 1964.

Low-flow frequency.--$Q_{7,2}$ = 140 ft^3/s, $Q_{7,10}$ = 110 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 15 discharge measurements made during the period 1964-76.

Accuracy.--$SE_{7,2}$ = 7 percent, $SE_{7,10}$ = 10 percent.

05335004 Yellow River at Danbury, Wis.

Location.--NE¼SE¼ sec. 28, T. 41 N., R. 16 W., Burnett County, at bridge on State Highway 35, at Danbury.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Oct. 15, 1919, 189 ft^3/s.

05335006 Loon Creek near Danbury, Wis.

Location.--SW¼NW¼ sec. 1, T. 40 N., R. 15 W., Burnett County, 300 ft downstream from dam at outlet of Loon
        Lake, 9.7 mi east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 0.73 ft^3/s.

053350065 Loon Creek near Danbury, Wis.

Location.--SW¼NE¼ sec. 2, T. 40 N., R. 15 W., Burnett County, 0.6 mi downstream from dam at outlet of Loon
        Lake, 9.1 mi east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 1.42 ft^3/s.

05335007 Loon Creek near Danbury, Wis.

Location.--SE¼SE¼ sec. 3, T. 40 N., R. 15 W., Burnett County, at Loon Lake Road, 8.6 mi east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--2.31 ft^3/s, Aug. 10, 1970.

Low-flow frequency.--$Q_{7,2}$ = 2.3 ft^3/s, $Q_{7,10}$ = 1.8 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 6 discharge measurements made during
              1970.

Accuracy.--$SE_{7,2}$ = 18 percent, $SE_{7,10}$ = 25 percent.

053350075 Loon Creek near Danbury, Wis.

Location.--NW¼SE¼ sec. 3, T. 40 N., R. 15 W., Burnett County, 0.6 mi downstream from Loon Lake Road, 8.2 mi
        east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 3.54 ft^3/s.

05335008 Spring Creek near Danbury, Wis.

Location.--SE¼SW¼ sec. 10, T. 40 N., R. 15 W., Burnett County, at Loon Lake Road, 8.4 mi southeast of
        Danbury.

Drainage area.--   Tributary to.--Loon Creek.

Type of site.--Miscellaneous site.

Minimum discharge measured.--1.90 ft^3/s, July 9, 1970.

Low-flow frequency.--$Q_{7,2}$ = 2.1 ft^3/s, $Q_{7,10}$ = 1.7 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 6 discharge measurements made in 1970.

Accuracy.--$SE_{7,2}$ = 24 percent, $SE_{7,10}$ = 34 percent.

053350083 Spring Creek near Danbury, Wis.

Location.--SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 10, T. 40 N., R. 15 W., Burnett County, 125 ft upstream from inlet to Culbertson Lake, 8.3 mi southeast of Danbury.

Drainage area.--   Tributary to.--Loon Creek.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 2.08 ft^3/s.

053350085 Spring Creek near Danbury, Wis.

Location.--NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 10, T. 40 N., R. 15 W., Burnett County, at outlet of Culbertson Lake, 7.9 mi east of Danbury.

Drainage area.--   Tributary to.--Loon Creek.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 9, 1970, 3.11 ft^3/s.

05335009 Spring Creek near Danbury, Wis.

Location.--SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 35, T. 41 N., R. 15 W., Burnett County, 300 ft upstream from mouth, 7.8 mi east of Danbury.

Drainage area.--   Tributary to.--Loon Creek.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 3.92 ft^3/s.

05335010 Loon Creek near Danbury, Wis.

Location.--NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 35, T. 41 N., R. 15 W., Burnett County, 1.8 mi upstream from inlet to Eagle Lake, 7.7 mi east of Danbury.

Drainage area.--16.9 mi^2.   Tributary to.--Yellow River.

Type of site.--Gaging station.

Period of record.--June 1970 to June 1971; during open-water periods.

Extremes.--Maximum discharge, 19 ft^3/s Oct. 9, 1970; minimum daily, 4.4 ft^3/s Mar. 26, 1971.

Low-flow frequency.--$Q_{7,2}$ = 4.9 ft^3/s, $Q_{7,10}$ = 4.0 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 11 discharge measurements and daily mean flows in the period 1970-71.

Accuracy.--$SE_{7,2}$ = 13 percent, $SE_{7,10}$ = 21 percent.

05335013 Loon Creek near Danbury, Wis.

Location.--SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 34, T. 41 N., R. 15 W., Burnett County, 0.3 mi upstream from inlet to Eagle Lake, 7.3 mi east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 9, 1970, 7.02 ft^3/s; Sept. 11, 1970, 7.27 ft^3/s.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05335015 Loon Creek tributary near Danbury, Wis.

Location.--SW¼SW¼ sec. 34, T. 41 N., R. 15 W., Burnett County, at country road culvert, 0.2 mi upstream from inlet to Eagle Lake, 6.8 mi east of Danbury.

Drainage area.--   Tributary to.--Loon Creek.

Type of site.--Miscellaneous site.

Discharge measurement.--July 9, 1970, 0.09 ft^3/s.

05335017 Loon Creek near Danbury, Wis.

Location.--SW¼NW¼ sec. 34, T. 41 N., R. 15 W., Burnett County, at country road bridge, 0.2 mi downstream from outlet of Eagle Lake, 6.5 mi east of Danbury.

Drainage area.--   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 9, 1970, 15.3 ft^3/s; Aug. 10, 1970, 13.1 ft^3/s; Sept. 11, 1970, 9.37 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 11 ft^3/s, $Q_{7,10}$ = 8.0 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 3 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05335020 Loon Creek near Danbury, Wis.

Location.--SE¼SE¼ sec. 30, T. 41 N., R. 15 W., Burnett County, at forest road, 4.3 mi east of Danbury.

Drainage area.--32.4 mi^2.   Tributary to.--Yellow River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 19.3 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 13 ft^3/s, $Q_{7,10}$ = 9.0 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05335300 Clam River near Frederic, Wis.

Location.--NE¼NE¼ sec. 6, T. 36 N., R. 15 W., Polk County, at County Trunk W, 10.2 mi east of Frederic.

Drainage area.--38.4 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.46 ft^3/s, Sept. 28, 1976.

Low-flow frequency.--$Q_{7,2}$ = 0.68 ft^3/s, $Q_{7,10}$ = 0.30 ft^3/s.

Basis of estimate.--Correlated with Namekagon River near Trego using 14 discharge measurements made during the period 1962-76.

Accuracy.--$SE_{7,2}$ = 29 percent, $SE_{7,10}$ = 54 percent.

39

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

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05335330 Clam River near Siren, Wis.

Location.--SW¼SW¼ sec. 24, T. 38 N., R. 16 W., Burnett County, at bridge on County Trunk B, 4.3 mi southeast of Siren.

Drainage area.--96.7 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 40.0 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 30 ft^3/s, $Q_{7,10}$ = 22 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05335360 South Fork Clam River near Barronett, Wis.

Location.--SE¼SE¼ sec. 15, T. 37 N., R. 14 W., Burnett County, at County Trunk J, 5.1 mi southwest of Shell Lake.

Drainage area.--7.6 mi^2.   Tributary to.--North Fork Clam River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 3.15 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.7 ft^3/s, $Q_{7,10}$ = 0.85 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05335370 North Fork Clam River near Barronett, Wis.

Location.--NE¼SE¼ sec. 4, T. 37 N., R. 14 W., Burnett County, at County Trunk H, 7.4 mi northwest of Barronett.

Drainage area.--40.5 mi^2.   Tributary to.--Clam River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 13.8 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 9.2 ft^3/s, $Q_{7,10}$ = 5.8 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05335380 Bashaw Brook near Shell Lake, Wis.

Location.--SW¼SW¼ sec. 8, T. 38 N., R. 14 W., Burnett County, at country road, 10.5 mi northwest of Shell Lake.

Drainage area.--24.9 mi^2.   Tributary to.--North Fork Clam River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--3.92 ft^3/s, Nov. 6, 1967.

Low-flow frequency.--$Q_{7,2}$ = 4.0 ft^3/s, $Q_{7,10}$ = 2.2 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 25 discharge measurements made during the period 1962-70.

Accuracy.--$SE_{7,2}$ = 9 percent, $SE_{7,10}$ = 20 percent.

05335410 Sand Creek near Hertel, Wis.

Location.--SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 6, T. 37 N., R. 14 W., Burnett County, at town road, 6.8 mi south of Hertel.

Drainage area.--35.9 mi^2.   Tributary to.--North Fork Clam River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 21, 1969, 15.2 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 10 ft^3/s, $Q_{7,10}$ = 6.4 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05335450 North Fork Clam River near Siren, Wis.

Location.--NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 19, T. 38 N., R. 15 W., Burnett County, at town road, 5.2 mi southeast of Siren.

Drainage area.--166 mi^2.   Tributary to.--Clam River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 80.1 ft^3/s.

05335490 Clam River tributary near Webster, Wis.

Location.--SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 16, T. 39 N., R. 16 W., Burnett County, at culvert on Bass Lake Road, 1.2 mi southeast of Webster.

Drainage area.--1.54 mi^2.   Tributary to.--Clam River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0 ft^3/s (ponded), July 25, 1974 and July 30, 1975.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 6 discharge measurements made during the period 1972-76.

Accuracy.--Not applicable.

05335500 Clam River near Webster, Wis.

Location.--SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 9, T. 39 N., R. 17 W., Burnett County, at Ice-House Bridge, 2.5 mi downstream from Black Brook, 6 mi west of Webster.

Drainage area.--364 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--October 1940 to September 1942.

Extremes.--Maximum discharge, 1,250 ft^3/s Sept. 20, 1941; minimum observed, 92 ft^3/s Aug. 13, 1941.

Low-flow frequency.--$Q_{7,2}$ = 110 ft^3/s, $Q_{7,10}$ = 79 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 12 daily mean discharges and discharge measurements made during the period 1940-69.

Accuracy.--$SE_{7,2}$ = 11 percent, $SE_{7,10}$ = 17 percent.

05335550 Clam River near Danbury, Wis.

Location.--NE¼SE¼ sec. 14, T. 40 N., R. 18 W., Burnett County, at mouth, 9.5 mi southwest of Danbury.

Drainage area.--385 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Oct. 26, 1940, 137 ft^3/s.

05336000 St. Croix River near Grantsburg, Wis.

Location.--NW¼SE¼ sec. 30, T. 40 N., R. 18 W., Burnett County, at end of town road, on left bank of Norway
          Point, 0.5 mi downstream from Sand Creek, 10.2 mi north of Grantsburg.

Drainage area.--2,820 mi^2.   Tributary to.--Mississippi River.

Type of site.--Gaging station.

Period of record.--April 1923 to September 1970.

Average discharge.--47 years, 2,304 ft^3/s.

Extremes.--Maximum discharge, 26,300 ft^3/s May 7, 1950; minimum, 510 ft^3/s Aug. 14 and 17, 1934.

Period of con- secutive days	Magnitude and frequency of annual low flow Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	1,120	904	801	721	636	584
14	1,140	924	819	738	653	600
30	1,190	967	858	774	684	628
60	1,260	1,040	941	861	777	723
90	1,330	1,110	1,000	920	835	781

Duration table of daily flow Discharge, in cubic feet per second, which was exceeded for indicated percent of time					
Percent ft^3/s	2	5	10	20	30	40
	8,400	5,800	4,200	2,800	2,250	1,920
Percent ft^3/s	50	60	70	80	90	95
	1,710	1,580	1,410	1,290	1,110	1,010
Percent ft^3/s	98	99.9				
	890	570				

Accuracy.--SE$_{7,2}$ = 3 percent, SE$_{7,10}$ = 5 percent.

Remarks.--The frequency analyses for the 7-, 14-, 30-, 60-, and 90-day low flows are based on the extension
          of records with 05333500 St. Croix River near Danbury, Wis. (1915-77 CY). All correlation
          coefficients were greater than 0.96. Diurnal fluctuation caused by powerplants upstream from
          station.

05338900 Wood River near Siren, Wis.

Location.--SE¼NE¼ sec. 28, T. 38 N., R. 17 W., Burnett County, at country road, 4.8 mi southwest of Siren.

Drainage area.--26.8 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.10 ft^3/s, Sept. 28, 1976.

Low-flow frequency.--$Q_{7,2}$ = 0.23 ft^3/s, $Q_{7,10}$ = 0.08 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 15 discharge measurements made during
          the period 1964-76.

Accuracy.--SE$_{7,2}$ = 19 percent, SE$_{7,10}$ = 28 percent.

05338915 Wood River tributary near Frederic, Wis.

Location.--SW¼SE¼ sec. 20, T. 37 N., R. 17 W., Polk County, at culvert on County Trunk W, 1.9 mi northwest
          of Frederic.

Drainage area.--1.78 mi^2.   Tributary to.--Wood River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 23, 1974, 0.725 ft^3/s; Aug. 5, 1976, 0.33 ft^3/s; Sept. 28, 1976, 0.372 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.46 ft^3/s, $Q_{7,10}$ = 0.25 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 3 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05338928 Wood River near Alpha, Wis.

Location.--NE¼NE¼ sec. 28, T. 38 N., R. 18 W., Burnett County, at culvert on country road, 1.2 mi southwest
          of Alpha.

Drainage area.--72.7 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--Aug. 20, 1969, 22.5 ft^3/s; July 23, 1974, 23.1 ft^3/s; Aug. 5, 1976, 16.2 ft^3/s;
                        Sept. 28, 1976, 14.6 ft3/s.

Low-flow frequency.--$Q_{7,2}$ = 18 ft^3/s, $Q_{7,10}$ = 12 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 3 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05338930 Wood River near Alpha, Wis.

Location.--NE¼NW¼ sec. 21, T. 38 N., R. 18 W., Burnett County, at State Highway 70, 1.2 mi west of Alpha.

Drainage area.--79.8 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 22.5 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 18 ft^3/s, $Q_{7,10}$ = 12 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05338950 North Fork Wood River near Grantsburg, Wis.

Location.--NW¼SE¼ sec. 8, T. 38 N., R. 18 W., Burnett County, at country road, 3.5 mi northeast of Grantsburg.

Drainage area.--68.3 mi^2.   Tributary to.--Wood River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--1.96 ft^3/s, Sept. 29, 1976.

Low-flow frequency.--$Q_{7,2}$ = 3.9 ft^3/s, $Q_{7,10}$ = 2.2 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 14 discharge measurements made during
                    the period 1964-76.

Accuracy.--$SE_{7,2}$ = 35 percent, $SE_{7,10}$ = 35 percent.

05338970 Wood River at Grantsburg, Wis.

Location.--SE¼NW¼ sec. 14, T. 38 N., R. 19 W., Burnett County, at bridge on County Trunk F, at Grantsburg.

Drainage area.--   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1939, 40.2 ft^3/s.

05338975 Wood River at Grantsburg, Wis.

Location.--SE¼SW¼ sec. 15, T. 38 N., R. 19 W., Burnett County, at bridge on State Highway 70, 1.3 mi west
    of Grantsburg.

Drainage area.--163 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--37.5 ft^3/s, June 9, 1976.

Low-flow frequency.--$Q_{7,2}$ = 34 ft^3/s, $Q_{7,10}$ = 25 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 6 discharge measurements made during
    the period 1973-76.

Accuracy.--$SE_{7,2}$ = 7 percent, $SE_{7,10}$ = 9 percent.

05339000 Wood River near Grantsburg, Wis.

Location.--NW¼SW¼ sec. 20, T. 38 N., R. 19 W., Burnett County, at end of trail, 3.4 mi southwest of Grantsburg.

Drainage area.--176 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--January 1939 to December 1939.

Extremes.--Maximum discharge, 585 ft^3/s Mar. 27, 1939; minimum, 29 ft^3/s Sept. 30, 1939.

Low-flow frequency.--$Q_{7,2}$ = 35 ft^3/s, $Q_{7,10}$ = 26 ft^3/s.

Basis of estimate.--Correlated with St. Croix River near Danbury using 9 daily mean discharges recorded in
    the period January to December 1939.

Accuracy.--$SE_{7,2}$ = 13 percent, $SE_{7,10}$ = 22 percent.

05339010 Wood River near Grantsburg, Wis.

Location.--NW¼SE¼ sec. 19, T. 38 N., R. 19 W., Burnett County, town road, 1.7 mi upstream from mouth, 4.1 mi
    west of Grantsburg.

Drainage area.--177 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--Aug. 24, 1940, 30.3 ft^3/s; Aug. 20, 1969, 50.9 ft^3/s.

05339500 St. Croix River near Rush City, Minn.

Location.--SE¼SW¼ sec. 8, T. 37 N., R. 20 W., Burnett County (Wis.) and Chisago County (Minn.), on right
      bank, 200 ft upstream from old site of railroad bridge, 4.7 mi east of Rush City.

Drainage area.--5,120 mi^2.   Tributary to.--Mississippi River.

Type of site.--Gaging station.

Period of record.--April 1923 to September 1961.

Average discharge.--38 years, 3,607 ft^3/s.

Extremes.--Maximum discharge, 60,000 ft^3/s May 8, 1950; minimum observed, 630 ft^3/s Aug. 14, 1933.

Period of con- secutive days	Magnitude and frequency of annual low flow					
	Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	1,340	1,070	944	853	761	705
14	1,389	1,100	970	873	806	713
30	1,460	1,160	1,020	913	806	741
60	1,550	1,250	1,110	1,000	900	835
90	1,630	1,310	1,170	1,070	960	901

Duration table of daily flow					
Discharge, in cubic feet per second, which was exceeded for indicated percent of time					
Percent ft^3/s	2	5	10	20	30	40
	16,300	11,100	7,600	4,400	3,200	2,600
Percent ft^3/s	50	60	70	80	90	95
	2,250	1,990	1,750	1,560	1,370	1,190
Percent ft^3/s	98	99.9				
	1,000	660				

Accuracy.--SE$_{7,2}$ = 3 percent, SE$_{7,10}$ = 5 percent.

Remarks.--The frequency analyses for the 7-, 14-, 30-, 60-, and 90-day low flows are based on the extension
      of records with 05340500 St. Croix River at St. Croix Falls, Wis. (1911-77 CY). All correlation
      coefficients were greater than 0.96. Slight regulation from powerplants upstream from station.

05340300 Trade River near Fredric, Wis.

Location.--SW¼SW¼ sec. 4, T. 36 N., R. 17 W., Polk County, at State Highways 35 and 48, 2.5 mi southwest of
      Frederic.

Drainage area.--6.34 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.66 ft^3/s, Aug. 22, 1962.

Low-flow frequency.--Q$_{7,2}$ = 1.3 ft^3/s, Q$_{7,10}$ = 0.70 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 23 discharge measurements made during the
      period 1960-76.

Accuracy.--SE$_{7,2}$ = 11 percent, SE$_{7,10}$ = 24 percent.

05340303 Trade River tributary at Frederic, Wis.

Location.--SW¼NW¼ sec. 34, T. 37 N., R. 17 W., Polk County, at culvert on State Highways 35 and 48, 0.6 mi
      south of Frederic.

Drainage area.--1.56 mi^2.   Tributary to.--Trade River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.002 ft^3/s, July 30, 1975.

Low-flow frequency.--Q$_{7,2}$ = <0.01 ft^3/s, Q$_{7,10}$ = <0.01 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 6 discharge measurements made during the
      period 1972-76.

Accuracy.--Not applicable.

05340309   Trade River tributary near Luck, Wis.

Location.--NW¼NW¼ sec. 21, T. 36 N., R. 17 W., Polk County, at culvert on country road, 1.7 mi north of Luck.

Drainage area.--2.13 mi^2.   Tributary to.--Trade River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.39 ft^3/s, July 23, 1974.

Low-flow frequency.--$Q_{7,2}$ = 0.15 ft^3/s, $Q_{7,10}$ = 0.05 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 17 percent, $SE_{7,10}$ = 28 percent.

05340340   Trade River at Trade River, Wis.

Location.--NE¼SE¼ sec. 35, T. 32 N., R. 19 W., Burnett County, at State Highway 87, at Trade River.

Drainage area.--72.3 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 17.2 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 13 ft^3/s, $Q_{7,10}$ = 7.9 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05340370   Trade River near Trade River, Wis.

Location.--NE¼NW¼ sec. 19, T. 36 N., R. 19 W., Polk County, at country road, 5.9 mi southwest of Trade River.

Drainage area.--129 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 38.2 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 30 ft^3/s, $Q_{7,10}$ = 21 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05340385   Cowan Creek near Trade River, Wis.

Location.--NE¼NW¼ sec. 19, T. 36 N., R. 19 W., Polk County, at country road, 5.9 mi southwest of Trade River.

Drainage area.--17.8 mi^2.   Tributary to.--Trade River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 6.33 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 3.8 ft^3/s, $Q_{7,10}$ = 2.1 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05340400 Wolf Creek near St. Croix Falls, Wis.

Location.--SE¼SE¼ sec. 33, T. 36 N., R. 19 W., Polk County, at County Trunk G, 11.0 mi northwest of St. Croix Falls.

Drainage area.--29.3 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--2.50 ft^3/s, Aug. 17, 1964.

Low-flow frequency.--$Q_{7,2}$ = 3.3 ft^3/s, $Q_{7,10}$ = 1.6 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 16 discharge measurements made during the period 1964-76.

Accuracy.--$SE_{7,2}$ = 20 percent, $SE_{7,10}$ = 37 percent.

05340460 Big Rock Creek near St. Croix Falls, Wis.

Location.--NW¼SE¼ sec. 7, T. 34 N., R. 18 W., Polk County, at State Highway 87, 2.4 mi north of St. Croix Falls.

Drainage area.--12.6 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 0.50 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.28 ft^3/s, $Q_{7,10}$ = 0.10 ft^3/s,

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05340500 St. Croix River at St. Croix Falls, Wis.

Location.--SW¼NW¼ sec. 30, T. 34 N., R. 18 W., Polk County (Wis.) and Chisago County (Minn.), on left bank, 0.3 mi downstream from powerplant, at St. Croix Falls.

Drainage area.--5,930 mi^2.   Tributary to.--Mississippi River.

Type of site.--Gaging station.

Period of record.--January 1902 to September 1977. Prior to January 1910, monthly discharge only.

Average discharge.--75 years, 4,172 ft^3/s.

Extremes.--Maximum discharge, 54,900 ft^3/s May 8, 1950; minimum daily, 75 ft^3/s July 17, 1910.

Period of con- secutive days	Magnitude and frequency of annual low flow Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	1,490	1,210	1,080	991	895	836
14	1,580	1,270	1,130	1,020	912	844
30	1,670	1,340	1,190	1,070	946	870
60	1,780	1,440	1,290	1,170	1,050	980
90	1,860	1,510	1,350	1,240	1,120	1,050

Duration table of daily flow Discharge, in cubic feet per second, which was exceeded for indicated percent of time					
Percent	2	5	10	20	30	40
ft^3/s	19,000	12,800	8,400	5,000	3,650	3,000
Percent	50	60	70	80	90	95
ft^3/s	2,590	2,280	2,000	1,740	1,500	1,280
Percent	98	99.9				
ft^3/s	980	360				

Accuracy.--$SE_{7,2}$ = 3 percent, $SE_{7,10}$ = 4 percent.

Remarks.--Diurnal fluctuation caused by St. Croix Falls powerplant 1,800 ft upstream.

05340524 St. Croix River tributary near Osceola, Wis.

Location.--SW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 14, T. 33 N., R. 19 W., Polk County, at road to fish hatchery, 2.1 mi northeast of Osceola.

Drainage area.--0.38 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--June 9, 1976, 4.33 ft^3/s; Aug. 3, 1976, 3.49 ft^3/s; Sept. 28, 1976, 4.35 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 2.1 ft^3/s, $Q_{7,10}$ = 0.89 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 3 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05340525 Tributary to St. Croix River tributary at Dresser, Wis.

Location.--SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 7, T. 33 N., R. 18 W., Polk County, just upstream from sewage-treatment plant, 0.4 mi west of Dresser.

Drainage area.--4.95 mi^2.   Tributary to.--St. Croix River tributary.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0 ft^3/s (dry), June 9, 1976.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 6 discharge measurements made during the period 1972-76.

Accuracy.--Not applicable.

05340545 Trout Brook near Osceola, Wis.

Location.--SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 36, T. 33 N., R. 19 W., Polk County, at culvert on country road, 3.0 mi southeast of Osceola.

Drainage area.--6.16 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 24, 1974, 0.94 ft^3/s; July 29, 1975, 1.51 ft^3/s; June 9, 1976, 1.61 ft^3/s; Aug. 3, 1976, 0.78 ft^3/s; Sept. 28, 1976, 1.21 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.59 ft^3/s, $Q_{7,10}$ = 0.24 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05340550 Trout Brook at Osceola, Wis.

Location.--NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 27, T. 33 N., R. 19 W., Polk County, at bridge on County Trunk M (Third Street), at Osceola.

Drainage area.--15.7 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 24, 1974, 4.51 ft^3/s; June 9, 1976, 5.26 ft^3/s; Aug. 3, 1976, 3.39 ft^3/s; Sept. 28, 1976, 3.38 ft3/s.

Low-flow frequency.--$Q_{7,2}$ = 2.4 ft^3/s, $Q_{7,10}$ = 1.0 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 4 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05340555 St. Croix River tributary at Osceola, Wis.

Location.--NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 27, T. 33 N., R. 19 W., Polk County, just upstream from sewage-treatment plant, at Osceola.

Drainage area.--0.08 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0 ft^3/s, Aug. 14, 1972.

Low-flow frequency.--$Q_{7,2}$ = 0.03 ft^3/s, $Q_{7,10}$ = <0.01 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 6 discharge measurements made during the period 1972-76.

Accuracy.--Not applicable.

05340970 Apple River near Range, Wis.

Location.--NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 11, T. 34 N., R. 16 W., Polk County, at County Highway E, 3.9 mi northwest of Range.

Drainage area.--90.6 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 14.8 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 11 ft^3/s, $Q_{7,10}$ = 6.5 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341100 Fox Creek near Balsam Lake, Wis.

Location.--NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 33, T. 35 N., R. 16 W., Polk County, at country road, 5.2 mi northeast of Balsam Lake.

Drainage area.--52.6 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 16.4 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 11 ft^3/s, $Q_{7,10}$ = 7.1 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341230 South Branch Beaver Brook tributary near Clayton, Wis.

Location.--NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 11, T. 33 N., R. 15 W., Polk County, at culvert on country road, 2.2 mi northwest of Clayton.

Drainage area.--2.73 mi^2.   Tributary to.--South Branch Beaver Brook.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.ft^3/s (ponded), July 29, 1975.

Low-flow frequency.--$Q_{7,2}$ = 0.07 ft^3/s, $Q_{7,10}$ = 0.01 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05341250 Beaver Brook near Joel, Wis.

Location.--SE¼NE¼ sec. 13, T. 33 N., R. 16 W., Polk County, at County Trunk JJ, 2.6 mi southwest of Joel.

Drainage area.--58.6 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 5.5 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 3.8 ft^3/s, $Q_{7,10}$ = 1.9 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341300 Beaver Brook near Amery, Wis.

Location.--SE¼NW¼ sec. 27, T. 33 N., R. 16 W., Polk County, at country road, 1.4 mi northeast of Amery.

Drainage area.--64.9 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 10.2 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 7.2 ft^3/s, $Q_{7,10}$ = 4.1 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341305 Apple River at Amery, Wis.

Location.--NW¼SW¼ sec. 33, T. 33 N., R. 16 W., Polk County, on town road, just upstream from sewage-treatment plant, 0.1 mi southeast of junction of County Trunk F and State Highway 46, at Amery.

Drainage area.--256 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--60.5 ft^3/s, Aug. 3, 1976.

Low-flow frequency.--$Q_{7,2}$ = 49 ft^3/s, $Q_{7,10}$ = 23 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 7 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 23 percent, $SE_{7,10}$ = 41 percent.

05341370 Balsam Branch near Milltown, Wis.

Location.--SE¼SW¼ sec. 17, T. 35 N., R. 17 W., Polk County, at bridge on country road, 1.0 mi south of Milltown.

Drainage area.--4.40 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.24 ft^3/s, July 30, 1975.

Low-flow frequency.--$Q_{7,2}$ = 0.17 ft^3/s, $Q_{7,10}$ = 0.07 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 46 percent, $SE_{7,10}$ = 86 percent.

05341402 Balsam Branch at Balsam Lake, Wis.

Location.--NE¼SE¼ sec. 10, T. 34 N., R. 17 W., Polk County, just upstream from sewage-treatment plant, at south side of town of Balsam Lake.

Drainage area.--44.6 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--1.78 ft^3/s, June 10, 1976.

Low-flow frequency.--$Q_{7,2}$ = 1.5 ft^3/s, $Q_{7,10}$ = 0.36 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 6 discharge measurements made during the period 1972-76.

Accuracy.--$SE_{7,2}$ = 103 percent, $SE_{7,10}$ = 233 percent.

05341410 Balsam Branch near Wanderoos, Wis.

Location.--NW¼SE¼ sec. 10, T. 33 N., R. 17 W., Polk County, at County Trunk C, 4.2 mi northeast of Wanderoos.

Drainage area.--78.9 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 16.6 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 12 ft^3/s, $Q_{7,10}$ = 7.4 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341418 Friday Creek near Deronda, Wis.

Location.--NW¼NE¼ sec. 24, T. 33 N., R. 17 W., Polk County, at County Trunk C, 2.5 mi northeast of Deronda.

Drainage area.--9.76 mi^2.   Tributary to.--Sucker Branch.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 1.04 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.56 ft^3/s, $Q_{7,10}$ = 0.23 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341426 Sucker Branch near Deronda, Wis.

Location.--NE¼NE¼ sec. 3, T. 32 N., R. 17 W., Polk County, at County Trunk K, 1.4 mi southwest of Deronda.

Drainage area.--102 mi^2.   Tributary to.--Apple River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 17.9 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 13 ft^3/s, $Q_{7,10}$ = 8.3 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341435 Apple River near Star Prairie, Wis.

Location.--SW¼NW¼ sec. 29, T. 32 N., R. 17 W., Polk County, at country road, 2.7 mi north of Star Prairie.

Drainage area.--411 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 130 ft^3/s.

05341437 Apple River at Star Prairie, Wis.

Location.--SE¼SE¼ sec. 1, T. 31 N., R. 18 W., St. Croix County, at bridge on County Trunk HH, at Star Prairie.

Drainage area.--422 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 24, 1974, 169 ft^3/s; July 29, 1975, 210 ft^3/s; June 9, 1976, 194 ft^3/s; Aug. 3, 1976, 119 ft^3/s; Sept. 28, 1976, 151 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 100 ft^3/s, $Q_{7,10}$ = 53 ft^3/s.

Basis of estimate.--Correlated with Apple River near Somerset using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05341450 Horse Creek near Star Prairie, Wis.

Location.--SW¼SW¼ sec. 15, T. 32 N., R. 18 W., Polk County, at County Trunk X, 5.3 mi northwest of Star Prairie.

Drainage area.--32.6 mi^2.   Tributary to.--Apple River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--6.27 ft^3/s, Aug. 6, 1964.

Basis of estimate.--Correlated with Apple River near Somerset using 11 discharge measurements made during the period 1962-69.

Accuracy.--$SE_{7,2}$ = 16 percent, $SE_{7,10}$ = 42 percent.

05341500 Apple River near Somerset, Wis.

Location.--NE¼SE¼ sec. 21, T. 31 N., R. 19 W., St. Croix County, at powerplant of NSP Co., 3.1 mi northwest of Somerset.

Drainage area.--555 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--January 1901 to September 1914 (monthly discharge only), October 1914 to September 1970.

Average discharge.--69 years, 305 ft^3/s.

Extremes.--Maximum daily discharge, 2,510 ft^3/s Apr. 13, 1965; minimum daily, 7 ft^3/s Aug. 21, 1927, Sept. 30, 1929, July 19, 1932, and Aug. 2 and 3, 1933.

Period of consecutive days	Magnitude and frequency of annual low flow Discharge, in cubic feet per second, for indicated recurrence interval, in years					
	2	5	10	20	50	100
7	142	98	77	62	47	39
14	154	110	90	74	58	50
30	168	122	100	83	66	55
60	183	135	111	93	74	64
90	193	144	120	101	82	70

Duration table of daily flow Discharge, in cubic feet per second, which was exceeded for indicated percent of time							
Percent	2	5	10	20	30	40	50
ft^3/s	920	650	490	365	302	262	239
Percent	60	70	80	90	95	98	99.9
ft^3/s	216	194	171	140	120	94	35

Accuracy.--$SE_{7,2}$ = 5 percent, $SE_{7,10}$ = 11 percent.

Remarks.--Flow regulated by many powerplants upstream. Service ponds are small and monthly flows are only slightly affected.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05341555 Willow River tributary at Clear Lake, Wis.

Location.--SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 20, T. 32 N., R. 15 W., Polk County, at bridge on town road, at Clear Lake.

Drainage area.--1.93 mi^2.   Tributary to.--Willow River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0 ft^3/s (dry)--observed 5 times in period 1972-76.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 6 discharge measurements made during the period 1972-76.

Accuracy.--Not applicable.

05341640 Willow River tributary near Forest, Wis.

Location.--SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 30, T. 31 N., R. 15 W., St. Croix County, at bridge on U.S. Highway 63, 1.2 mi northwest of Forest.

Drainage area.--7.42 mi^2.   Tributary to.--Willow River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 24, 1974, 0 ft^3/s; July 28, 1975, 0 ft^3/s (ponded); June 8, 1976, 0 ft^3/s; Aug. 3, 1976, 0 ft^3/s (ponded); Sept. 27, 1976, 0 ft3/s (ponded).

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 5 discharge measurements.

Accuracy.--Not applicable.

05341680 Willow River near Deer Park, Wis.

Location.--SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 16, T. 31 N., R. 16 W., St. Croix County, at bridge on country road, 1.5 mi southeast of Deer Park.

Drainage area.--75.9 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--July 24, 1975, 10.5 ft^3/s; July 29, 1975, 15.6 ft^3/s; June 10, 1976, 17.1 ft^3/s; Aug. 3, 1976, 12.3 ft3/s; Sept. 27, 1976, 17.2 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 6.4 ft^3/s, $Q_{7,10}$ = 2.9 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 5 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05341690 Willow River near New Richmond, Wis.

Location.--SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 25, T. 31 N., R. 17 W., St. Croix County, at State Highway 64, 6.2 mi east of New Richmond.

Drainage area.--85.1 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--4.97 ft^3/s, Aug. 6, 1964.

Low-flow frequency.-- $Q_{7,2}$ = 6.7 ft^3/s, $Q_{7,10}$ = 3.0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 15 discharge measurements made during the period 1962-76.

Accuracy.--$SE_{7,2}$ = 14 percent, $SE_{7,10}$ = 29 percent.

05341692 Hutton Creek tributary at Emerald, Wis.

Location.--NW¼SE¼ sec. 13, T. 30 N., R. 16 W., St. Croix County, at bridge on town road, at Emerald.

Drainage area.--5.83 mi^2.   Tributary to.--Hutton Creek.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0 ft^3/s, 6 observations of no flow during the period 1972-76.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 7 discharge measurements made during the
            period 1972-76.

Accuracy.--Not applicable.

05341694 South Fork Willow River near Cylon, Wis.

Location.--NE¼NE¼ sec. 31, T. 31 N., R. 16 W., St. Croix County, at U.S. Highway 63, 1.7 mi northwest of
            Cylon.

Drainage area.--32.2 mi^2.   Tributary to.--Willow River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 2.61 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.7 ft^3/s, $Q_{7,10}$ = 0.76 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341699 Willow River at New Richmond, Wis.

Location.--SW¼SE¼ sec. 35, T. 31 N., R. 18 W., St. Croix County, downstream from sewage-treatment plant,
            0.9 mi west of New Richmond.

Drainage area.--205 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--42.5 ft^3/s, Aug. 17, 1972.

Low-flow frequency.--$Q_{7,2}$ = 20 ft^3/s, $Q_{7,10}$ = 11 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 6 discharge measurements made during the
            period 1972-76.

Accuracy.--$SE_{7,2}$ = 44 percent, $SE_{7,10}$ = 77 percent.

05341720 Willow River at Boardman, Wis.

Location.--SW¼SW¼ sec. 19, T. 30 N., R. 18 W., St. Croix County, at country road, 0.7 mi west of Boardman.

Drainage area.--218 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Discharge measurements.--June 7, 1968, 31.8 ft^3/s; Aug. 19, 1969, 19.6 ft^3/s.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05341730 Tenmile Creek at Boardman, Wis.

Location.--NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 29, T. 30 N., R. 18 W., St. Croix County, at town road, 0.2 mi southeast of Boardman.

Drainage area.--17.9 mi^2.   Tributary to.--Willow River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 5.20 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 3.1 ft^3/s, $Q_{7,10}$ = 1.7 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341840 Kinnickinnic River tributary near Hammond, Wis.

Location.--NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 32, T. 29 N., R. 17 W., St. Croix County, at bridge on county road, 1.5 mi southwest
        of Hammond.

Drainage area.--1.88 mi^2.   Tributary to.--Kinnickinnic River.

Type of site.--Miscellaneous site.

Discharge measurements.--Aug. 16, 1972, no measurable flow; Oct. 18, 1973, dry; July 29, 1975, dry;
        June 8, 1976, 0 ft3/s.

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 4 discharge measurements.

Accuracy.--Not applicable.

05341850 Kinnickinnic River near Hammond, Wis.

Location.--SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 2, T. 28 N., R. 18 W., St. Croix County, at County Trunk N, 5.5 mi southwest of
        Hammond.

Drainage area.--47.8 mi^2.   Tributary to.--St. Croix River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--6.42 ft^3/s, Aug. 15, 1968.

Low-flow frequency.--$Q_{7,2}$ = 6.5 ft^3/s, $Q_{7,10}$ = 5.4 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 7 discharge measurements.

Accuracy.--$SE_{7,2}$ = 9 percent, $SE_{7,10}$ = 20 percent.

05341860 Kinnickinnic River tributary near Hammond, Wis.

Location.--SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 12, T. 28 N., R. 18 W., St. Croix County, at country road, 5.3 mi southwest of
        Hammond.

Drainage area.--13.5 mi^2.   Tributary to.--Kinnickinnic River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 0.74 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.51 ft^3/s, $Q_{7,10}$ = 0.20 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05341880 Kinnickinnic River near River Falls, Wis.

Location.--NE¼NE¼ sec. 36, T. 28 N., R. 19 W., St. Croix County, at State Highway 35, 1.2 mi north of
         River Falls.

Drainage area.--95.8 mi^2.   Tributary to.--St. Croix River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--32.4 ft^3/s, Aug. 20, 1969.

Low-flow frequency.--$Q_{7,2}$ = 26 ft^3/s, $Q_{7,10}$ = 18 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 7 discharge measurements made during the
         period 1969-76.

Accuracy.--$SE_{7,2}$ = 30 percent, $SE_{7,10}$ = 57 percent.

05341890 South Fork Kinnickinnic River at River Falls, Wis.

Location.--NE¼SW¼ sec. 1, T. 27 N., R. 19 W., Pierce County, at State Highway 29, at River Falls.

Drainage area.--17.1 mi^2.   Tributary to.--Kinnickinnic River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 5.81 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 3.5 ft^3/s, $Q_{7,10}$ = 1.9 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05342000 Kinnickinnic River near River Falls, Wis.

Location.--NE¼NW¼ sec. 18, T. 27 N., R. 19 W., Pierce County, at County Trunk F bridge, 1.9 mi upstream
         from mouth, 5.5 mi west of River Falls.

Drainage area.--167 mi^2.   Tributary to.--St. Croix River.

Type of site.--Gaging station.

Period of record.--October 1916 through September 1921.

Average discharge.--5 years, 95.2 ft^3/s.

Extremes.--Maximum discharge, 4,760 ft^3/s Mar. 15, 1920; minimum, 11 ft^3/s Aug. 30, 1920.

Low-flow frequency.--Unable to determine low-flow characteristics due to upstream regulation.

Remarks.--Daily flow was regulated almost completely by Clifton Falls Power Company's dam just upstream from
         station. Daily flow also was regulated by three dams in River Falls about 7 miles upstream from
         the station, the lower two were operated by the city of River Falls for municipal light and power
         purposes. The storage at these dams was relatively small and the monthly flows were considered
         to be nearly normal flow.

05344600 Big River near Trimbelle, Wis.

Location.--SE¼SW¼ sec. 22, T. 26 N., R. 19 W., Pierce County, at County Trunk Q, 4.6 mi west of Trimbelle.

Drainage area.--17.3 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 2.61 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.6 ft^3/s, $Q_{7,10}$ = 0.73 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05346300 Trimbelle River near Ellsworth, Wis.

Location.--SW¼SE¼ sec. 17, T. 26 N., R. 18 W., Pierce County, at U.S. Highway 10, at Trimbelle, 5.0 mi west of Ellsworth.

Drainage area.--42.8 mi^2.   Tributary to.--Mississippi River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--6.27 ft^3/s, Aug. 18, 1964.

Low-flow frequency.--$Q_{7,2}$ = 6.8 ft^3/s, $Q_{7,10}$ = 4.6 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 7 discharge measurements made during the period 1964-70.

Accuracy.--$SE_{7,2}$ = 13 percent, $SE_{7,10}$ = 26 percent.

05346400 Spring Creek near Ellsworth, Wis.

Location.--SE¼SW¼ sec. 21, T. 26 N., R. 18 W., Pierce County, at County Trunk O, 4.3 mi west of Ellsworth.

Drainage area.--7.8 mi^2.   Tributary to.--Trimbelle River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 0.21 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 0.11 ft^3/s, $Q_{7,10}$ = 0.03 ft^3/s.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05346500 Trimbelle River near Diamond Bluff, Wis.

Location.--NE¼SW¼ sec. 17, T. 25 N., R. 18 W., Pierce County, at country road, 1.8 mi east of Diamond Bluff.

Drainage area.--65.6 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 19.9 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 14 ft^3/s, $Q_{7,10}$ = 9.3 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05346600 Little Trimbelle Creek near Bay City, Wis.

Location.--SE¼SW¼ sec. 21, T. 25 N., R. 18 W., Pierce County, at County Trunk K, 6.7 mi northwest of Bay City.

Drainage area.--19.9 mi^2.   Tributary to.--Trimbelle River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--0.57 ft^3/s, July 24, 1964.

Low-flow frequency.--$Q_{7,2}$ = 0.60 ft^3/s, $Q_{7,10}$ = 0.22 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 20 discharge measurements made during the period 1961-70.

Accuracy.--$SE_{7,2}$ = 16 percent, $SE_{7,10}$ = 35 percent.

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

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<center>05355258 Isabelle Creek at Ellsworth, Wis.</center>

Location.--SW¼SE¼ sec. 17, T. 26 N., R. 17 W., Pierce County, just upstream from creamery outfall, at Ellsworth.

Drainage area.--1.53 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurements.--June 29, 1973, 0.077 ft^3/s; Nov. 14, 1974, 0.423 ft^3/s; Aug. 24, 2976, 0.297 ft^3/s; Aug. 9, 1977, 0 ft3/s (dry).

Low-flow frequency.--$Q_{7,2}$ = 0 ft^3/s, $Q_{7,10}$ = 0 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 4 discharge measurements.

Accuracy.--Not applicable.

<center>05355260 Isabelle Creek near Ellsworth, Wis.</center>

Location.--NE¼NE¼ sec. 20, T. 26 N., R. 17 W., Pierce County, at sewage-treatment plant, 1.2 mi east of Ellsworth.

Drainage area.--2.81 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.40 ft^3/s, Aug 24, 1976.

Low-flow frequency.--No estimate possible, discharge is primarily effluent.

<center>05355300 Isabelle Creek near Bay City, Wis.</center>

Location.--NW¼SE¼ sec. 28, T. 25 N., R. 17 W., Pierce County, at County Trunk EE, 2.4 mi north of Bay City.

Drainage area.--31.2 mi^2.   Tributary to.--Mississippi River.

Type of site.--Low-flow partial-record station.

Minimum discharge measured.--1.40 ft^3/s, Aug. 18, 1964.

Low-flow frequency.--$Q_{7,2}$ = 1.8 ft^3/s, $Q_{7,10}$ = 0.54 ft^3/s.

Basis of estimate.--Correlated with Hay River at Wheeler using 7 discharge measurements made during the period 1964-70.

Accuracy.--$SE_{7,2}$ = 43 percent, $SE_{7,10}$ = 99 percent.

<center>05355304 Rush River tributary at Baldwin, Wis.</center>

Location.--NW¼NW¼ sec. 36, T. 29 N., R. 17 W., St. Croix County, at bridge on country road, 1.1 mi southwest of Baldwin.

Drainage area.--4.30 mi^2.   Tributary to.--Rush River.

Type of site.--Miscellaneous site.

Minimum discharge measured.--0.17 ft^3/s, Aug. 16, 1972.

Low-flow frequency.--No estimate possible, discharge is predominantly effluent.

<center>05355308 Rush River near Martell, Wis.</center>

Location.--NE¼SW¼ sec. 35, T. 28 N., R. 17 W., St. Croix County, at County Trunk Y, 2.8 mi north of Martell.

Drainage area.--46.3 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 1.50 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.0 ft^3/s, $Q_{7,10}$ = 0.40 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

<center>58</center>

Table 1.--Low-flow characteristics for sites in the St. Croix River basin--Continued

05355316 Lost Creek near El Paso, Wis.

Location.--SE¼SW¼ sec. 28, T. 26 N., R. 16 W., Pierce County, at country road, 4.8 mi south of El Paso.

Drainage area.--24.8 mi^2.   Tributary to.--Rush River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 6.50 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 4.1 ft^3/s, $Q_{7,10}$ = 2.3 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

05355318 Rush River near El Paso, Wis.

Location.--SE¼NW¼ sec. 33, T. 26 N., R. 16 W., Pierce County, at country road, 5.3 mi south of El Paso.

Drainage area.--123 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 19, 1969, 56.1 ft^3/s.

Low-flow frequency.--Unable to determine low-flow characteristics, additional discharge measurements are
        required.

05355325 Rush River near Maiden Rock, Wis.

Location.--NE¼NW¼ sec. 16, T. 24 N., R. 16 W., Pierce County, at State Highway 3ɔ, 1.1 mi northwest of
        Maiden Rock.

Drainage area.--176 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurements.--June 22, 1936, 49.9 ft^3/s; June 7, 1968, 60.8 ft^3/s; Aug. 20, 1969, 71.8 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 36 ft^3/s, $Q_{7,10}$ = 25 ft^3/s.

Basis of estimate.--Correlated with Trempealeau River at Dodge using 3 discharge measurements.

Accuracy.--$SE_{7,10}$ = 50 percent (basin average).

05355335 Bogus Creek near Stockholm, Wis.

Location.--SW¼NW¼ sec. 21, T. 23 N., R. 15 W., Pepin County, at State Highway 35, 2.8 mi southeast of
        Stockholm.

Drainage area.--10.7 mi^2.   Tributary to.--Mississippi River.

Type of site.--Miscellaneous site.

Discharge measurement.--Aug. 20, 1969, 2.30 ft^3/s.

Low-flow frequency.--$Q_{7,2}$ = 1.3 ft^3/s, $Q_{7,10}$ = 0.60 ft^3/s.

Basis of estimate.--Used regression equations 3 and 4.

Accuracy.--$SE_{7,2}$ = 38 percent, $SE_{7,10}$ = 52 percent.

Table 2.--Basin characteristics for low-flow partial-record stations
in the St. Croix River basin

Station number	Station name	Drainage area (mi^2) A	Main-channel slope (ft/mi) S	Main-channel length (mi) L	Basin storage (percent) Bs	Forest cover (percent) F
05331590	Lower Ox Creek near Solon Springs	89.1	9.20	11.6	5.37	94.0
05331700	Moose River near Solon Springs	49.9	9.30	15.2	26.8	91.2
05331900	Chippanazie Creek at Stanberry	36.2	6.43	11.6	31.5	85.5
05331950	Bean Brook near Spring Brook	39.4	11.1	11.8	13.2	84.2
05332100	Potato Creek near Trego	27.3	14.2	14.6	12.9	79.5
05332700	Stuntz Brook near Minong	25.0	8.86	12.9	25.4	85.8
05333060	Ounce River near Gordon	46.2	16.4	23.0	17.1	95.2
05333080	Frog Creek near Minong	31.9	12.6	15.4	55.9	83.9
05333100	Little Frog Creek near Minong	13.0	28.5	4.9	27.7	92.3
05333510	Chases Branch near Danbury	38.0	15.3	21.8	33.8	96.5
05334500	Yellow River at Webster	244	3.20	58.3	34.4	64.4
05335300	Clam River near Frederic	38.4	11.3	14.5	17.9	79.0
05335380	Bashaw Brook near Shell Lake	24.9	16.7	8.5	11.2	41.9
05338900	Wood River near Siren	26.8	22.8	14.2	10.4	72.5
05338950	North Fork Wood River near Grantsburg	68.3	5.02	13.8	64.7	40.2
05340300	Trade River near Frederic	6.34	53.8	3.50	11.2	44.2
05340400	Wolf Creek near St. Croix Falls	29.3	7.42	8.80	26.2	86.0
05341450	Horse Creek near Star Prairie	32.6	4.81	11.1	9.8	24.6
05341690	Willow River near New Richmond	85.1	6.16	25.3	7.75	12.4
05341850	Kinnickinnic River near Hammond	47.8	9.88	16.2	.08	4.00
05346300	Trimbelle Creek near Ellsworth	42.8	25.8	13.7	.0	14.4
05346600	Little Trimbelle Creek near Bay City	19.9	34.9	11.1	.0	17.6
05355300	Isabelle Creek near Bay City	31.2	27.0	13.1	.0	20.6

Table 2.--Basin characteristics for low-flow partial-record stations
in the St. Croix River basin

Mean annual precipitation (in.) P	Soil infil- tration rate (in/hr) I	Mean annual snowfall (in.) Sn	Base-flow index {(ft^3/s)/mi^2} Bf	Hydraulic conductivity {(gal/d)/ft^2} K	Drift thickness (ft) H	Transmissivity {(gal/d)/ft} T
31.1	7.50	57.0	0.157	2,500	125	312,000
30.5	1.65	56.0	.020	75.6	61.9	4,680
30.5	3.58	54.0	.195	69.4	76.7	5,320
29.9	1.79	52.0	.703	1,310	155	203,000
29.0	2.08	50.0	.493	724	143	104,000
30.1	3.77	52.0	.090	2,100	88.3	185,000
31.5	3.00	58.0	.243	685	70.2	48,100
30.7	2.75	55.0	.087	609	55.8	33,400
30.3	1.91	55.0	.053	512	54.7	28,000
30.2	2.78	53.0	.062	95.6	65.7	6,280
28.8	3.82	46.0	.454	2,090	153	320,000
28.0	1.65	47.0	.021	1,940	172	334,000
28.0	3.35	46.0	.206	2,100	151	317,010
28.0	1.85	46.0	.017	1,890	84.9	160,000
28.5	.96	47.0	.079	2,500	200	500,000
28.0	1.65	46.0	.186	131	68.5	8,970
28.0	1.74	45.0	.110	742	184	137,000
28.0	3.02	42.0	.240	2,250	109	245,000
28.3	.88	40.0	.096	23.6	77.6	1,830
28.8	.81	39.0	.154	309	62.8	19,400
29.3	.10	39.0	.192	10	50	500
29.5	.21	40.0	.087	10	55	550
29.6	.33	38.0	.176	10	50	500

Table 3.—Comparison of methods available to estimate low-flow characteristics in the St. Croix River basin

Type of site	Type of data	Number of sites with data	Time required to collect data	Analytical method to determine $Q_{7,10}$	Standard error of 10-year low flow ($SE_{7,10}$)
Gaging station	10 years or more recorded stream-flow	7	13-69 years	Frequency analysis	6 percent
Gaging station	10 years recorded streamflow	None[1]	10 years	Frequency analysis	13 percent
Low-flow partial-record stations	8-25 base-flow discharge measurements	26	3-10 years	Correlation analysis	27 percent
Miscellaneous measurement sites	3 base-flow discharge measurements	--	1- 2 years	Correlation analysis	50 percent
Miscellaneous measurement sites	1 base-flow discharge measurement and drainage area	40	1 day	Regression analysis	52 percent
Ungaged sites	Mapped Bf values from plate 2 and drainage area	Limited to sites meeting conditions on page 16	1 hour	Regression analysis	Undefined[2]
Ungaged sites with drainage areas less than 150 mi2	Drainage area	Unlimited	1 hour.	Regression analysis	150 percent

[1]Example was presented to illustrate the accuracy that could be obtained from 10 years of recorded streamflow in the basin. Data from existing gaging stations were adjusted to represent 10 years of recorded streamflow for the analysis.

[2]Limited number of sites were tested. The percent difference between computed and observed values was within the standard error of 52 percent predicted by the equation (see text, p. 17).