# Techniques for Estimating Peak Flow on Small Streams in Minnesota

**U.S. Geological Survey**
**Water-Resources Investigations Report 97-4249**

**Prepared in cooperation with the**
**Minnesota Department of Transportation**

# Techniques for Estimating Peak Flow on Small Streams in Minnesota

**By David L. Lorenz, George H. Carlson, and Chris A. Sanocki**

**U.S. Geological Survey**
**Water-Resources Investigations Report 97-4249**

**Prepared in cooperation with the**
**Minnesota Department of Transportation**

**Mounds View, Minnesota**
**1997**

**U.S. DEPARTMENT OF THE INTERIOR**

**BRUCE BABBITT, Secretary**

**U.S. GEOLOGICAL SURVEY**

**Mark Schaefer, Acting Director**

---

For additional information write to:

District Chief
U.S. Geological Survey
2280 Woodale Drive
Mounds View, MN 55112

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, Colorado 80225-0286

## CONTENTS



## ILLUSTRATIONS



## TABLES

## CONVERSION FACTORS

| Multiply | by | To obtain |
|---|---|---|
| inch (in.) | 25.4 | millimeter |
| square mile (mi2) | 2.590 | square kilometer |
| foot(ft) | .3048 | meter |
| cubic foot per second (ft3/s) | .02832 | cubic meter per second |

Use of trade, product, or firm names in this report are for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

# Techniques for estimating peak flow on small streams in Minnesota

by D.L. Lorenz, G.H. Carlson, and C.A. Sanocki

## ABSTRACT

Two statistically-derived techniques, regional regression equation and region of influence regression, that estimate peak flow on small, ungaged streams in Minnesota were developed. Both techniques relate physical and climatic characteristics to peak flow for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals.

Regional regression equations were developed for each recurrence interval in each of six regions in Minnesota. The region of influence regression technique dynamically selects stations with characteristics similar to a site of interest. Thus, the region of influence regression technique allows use of a potentially unique set of stations for estimating peak flow at each site of interest. Two methods of selecting streamflow gaging stations, similarity and proximity, are recommended for use in the region of influence regression technique.

The regional regression equation technique is recommended as a first estimate of peak flow in regions C, E, and F. The similarity method of the region of influence regression technique should be used as a first estimate in regions A and D. The proximity method should be used as a first estimate in region B.

Tables showing the peak-flow-frequency data and basin characteristics for streamflow gaging stations, and regional peak-flow prediction equations, are documented.

## INTRODUCTION

Knowledge of the peak flow of floods of a given recurrence interval is essential for regulation and planning of water resources and bridge, culvert, and dam design along Minnesota's rivers and streams. Techniques are needed to estimate peak flow at ungaged sites because long-term streamflow records are available at relatively few places.

This report is one of a series of reports prepared in cooperation with the Minnesota Department of Transportation that discuss peak-flow frequency on small streams. This report supersedes previous reports by Prior (1949), Prior and Hess (1961), Wiitala (1965), Patterson and Gamble (1968), Guetzkow (1977), and Jacques and Lorenz (1987); all of which dealt with techniques for estimating peak flow in Minnesota. Analysis of annual peak-flow records for the first of these reports that employed the Log Pearson Type III method of analysis (Guetzkow, 1977) may not have included historical flood information in the analysis, and the period of record for many small streams was very short from the standpoint of flood history. Most of the long-term record stations included the low annual peaks from the 1930's drought and high annual peaks during the 1950's and 1960's. Historical flood information was incorporated in the analysis done by Jacques and Lorenz (1987). Jacques and Lorenz (1987) also used fewer regions than Guetzkow (1977), which resulted in larger standard errors of estimate for the regional equations.

### Background

Continuous daily records for streamflow gaging stations in Minnesota span a relatively short time period. The longest record is for the Mississippi River at St. Paul, which is continuous from 1867 to present, except for 1871. Gaging of several streams to obtain daily streamflow records was started about 1909. The number of streamflow gaging stations decreased between 1912 and 1920. During the late 1920's and early 1930's, the number of streamflow gaging stations increased. Many of those streamflow gaging stations presently are in operation. Over the years, streamflow gaging stations were added where flow information was needed, and other stations were discontinued where additional data were not needed. Streamflow gaging stations operated to obtain daily records generally are located on streams that drain areas greater than 300 $mi^2$ and flow continuously.

In the 1950's, planners for the interstate highway system learned that little information was available about peak flow on small streams. This information was needed for determining the necessary size of bridges and culverts at road crossings. As a result of this need, small-stream flood investigation projects were initiated nationwide. The program in Minnesota began in 1958 and over the next 6 years about 150 streamflow gaging stations were established to determine annual peak flow and stage on streams draining about 60 $mi^2$ or less. Most of those stations were operated through the 1970's. In the 1980's, gaging for annual peak flow and stage for most of the drainage basins of less than 10 $mi^2$ was discontinued. Some new peak-flow gaging stations recently were established on streams draining areas from 10 $mi^2$ to several hundred square miles.

## Purpose and scope

This report (1) documents the analytical techniques used for annual series peak-flow-frequency computations, basin characterization, regionalization, and development of equations for estimating peak flow on small drainage basins; (2) presents peak-flow data and basin characteristics at streamflow gaging stations; and (3) discusses techniques for estimating peak flow at ungaged sites on small, unregulated streams in Minnesota.

Streamflow gaging stations on the Red Lake, Minnesota, Mississippi, Rainy, St. Louis, and Red River of the North Rivers that have drainage areas greater than 5,000 $mi^2$, were not included in this analysis. Other streamflow gaging stations that were not included in this analysis had peak flows that were affected by controlled storage or regulated releases.

## Acknowledgments

The authors thank Steven K. Sando and David Eash, of the U.S. Geological Survey, for providing basin characteristics and peak flow analyses of streamflow gaging stations in South Dakota and Iowa. We thank Gary Tasker, of the U.S. Geological Survey, for his assistance in statistical analysis.

# ANALYTICAL TECHNIQUES

This section describes the analytical techniques and adjustments to analyses that were required to develop the techniques for estimating the peak flow on small streams. It also presents preliminary computations required for regression analysis.

## Frequency analysis of annual peak flow data at streamflow gaging stations

An annual series peak-flow-frequency analysis at each streamflow gaging station (fig. 1) was prepared according to the procedures outlined in Bulletin 17B (U.S. Water Resources Council, 1982).

Many more streamflow gaging stations that have at least 25 years of record are available now than when the skew map of Bulletin 17B (U.S. Water Resources Council, 1982) was developed. Therefore, before computations of peak-flow frequency were begun, stations with 25 or more years of record in and near Minnesota were analyzed to determine the station skew coefficient and an updated generalized skew coefficient map was prepared and published (Lorenz, 1997). The resultant generalized skew coefficients were used in the Log-Pearson Type III peak-flow-frequency analysis used for this report.

Treatment of discontinuous periods of record (also called broken record) and the occurrence of large floods either within or outside the period of record, and considered "historic", are described below.

1. Where the record is not continuous and there is no indication of a historic flood, the record has been treated as though it was a continuous homogeneous record.

2. Where the flow of a large flood that occurred several years before the start of the record of annual peak flows is known, and that flood flow has not been exceeded, a historic period extending from the year of the large flood to 1995, or to the end of annual peak data, was used in the peak-flow frequency computation. For some streams where the record ended prior to 1995, and the large, historic flood flow has not been exceeded since the end of the record, the historic period was extended to 1995, if that extension improved the agreement between the observed peaks and the peak-flow-frequency analysis.

3. Where a large flood occurred before the start of the record of annual peak flows, but the flow is not known, the record was analyzed with a corresponding historic period if the record

contained a high outlier, as defined by U.S. Water Resources Council, 1982. If possible, that result was compared to peak-flow frequency analysis of nearby stations to support the valid use of the historic period.

4. Where the record was continuous for at least 50 years and there was a very large flood flow in the record, and there was evidence of a large regional flood outside of the period of record, the record was analyzed with and without use of a historic period. The results of both analyses were compared to the station data and the peak-flow frequency analysis of nearby stations, if possible. The analysis using the historic period was used if the comparison justified it.

The peak-flow frequency computations for streamflow gaging stations outside of Minnesota were obtained from a U.S. Gelogical Survey (USGS) office of the given state. The peak-flow frequency computations are listed table 1 (in the Supplemental Information at the end of this report).

## Estimating basin characteristics

Fourteen reports published by the USGS describe basin characteristics for gaged streams in the Minnesota and Crow River Basins (southern part of Minnesota). These reports list the drainage area, percent of the drainage area covered by lakes, percent drainage area covered by lakes and wetlands (storage), main-channel length, and main-channel slope.

For other gaged streams in Minnesota, drainage area boundaries were delineated on the basis of topographic contours and anthropogenic alterations to the landscape. Those alterations, such as the installation of storm sewers, the drainage of wetlands, and the diversion of streams can change the drainage area of a stream. Drainage basin delineation was done by the USGS, the Minnesota Department of Natural Resources Division of Waters, and Mankato State University Water Resources Center. Drainage area boundaries were drawn on USGS 1:24,000 topographic maps. The drainage area boundaries were digitized or scanned by the Minnesota Department of Natural Resources, Minnesota State Planning Land Management Information Center, Mankato State University, and the USGS and transferred to a geographic information system (GIS). The Canada Centre For Mapping, Department of Energy, Mines and Resources Canada 1:50,000 topographic maps were used to obtain subbasin boundaries, main-channel length, contour elevation points, area of lakes, and area of wetlands within Canada.

Lake and wetland data were obtained from the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI). NWI data were extracted for each gaging station to identify the percentage of lake and percentage of storage (lake and wetland) area in the basin represented by each streamflow gaging station. The total area of lakes and wetlands in the basin represented by each streamflow gaging station was calculated using the GIS.

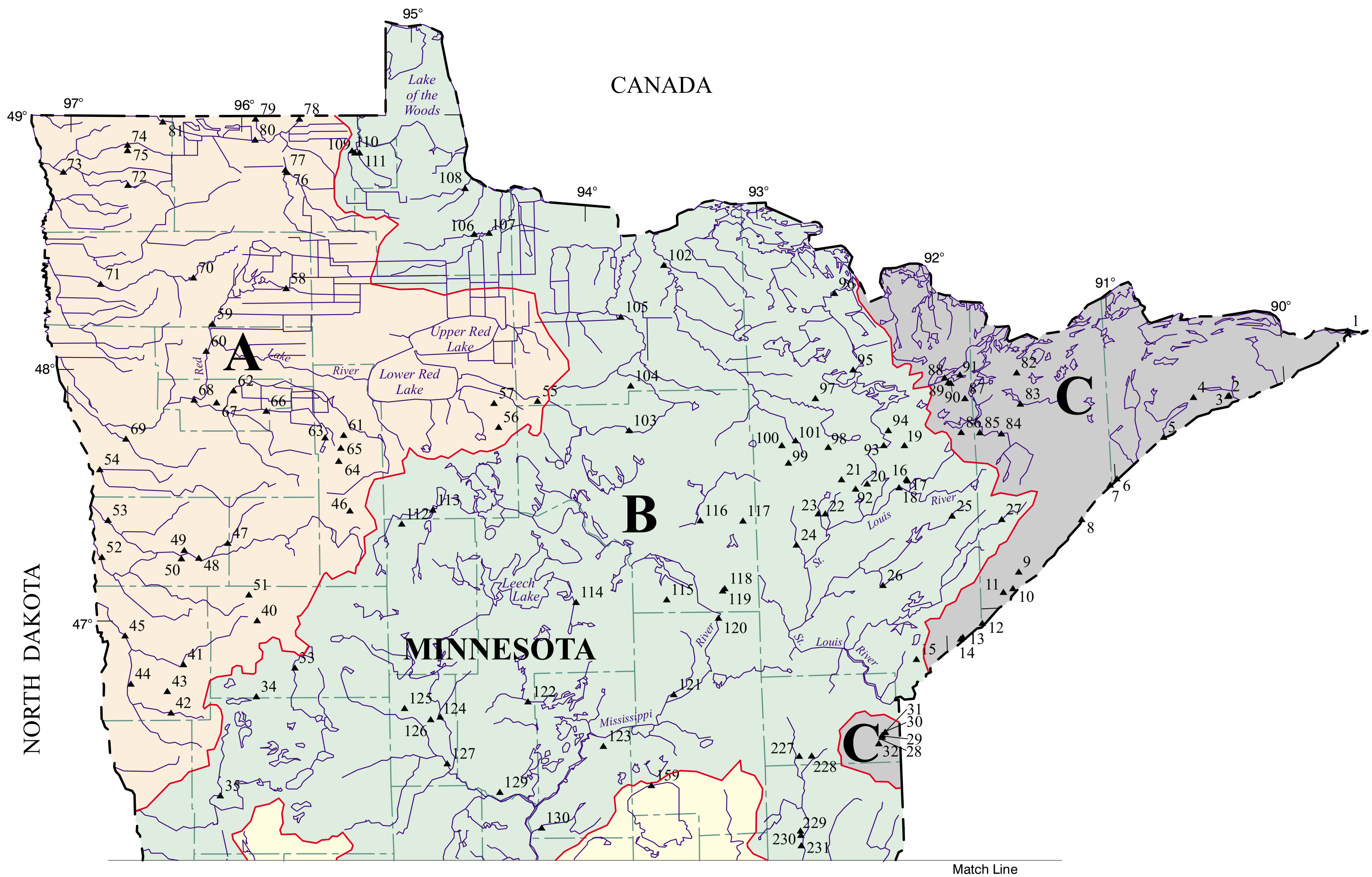
Main channels were defined from Basemap ’97 (Minnesota Department of Transportation, 1997). Basemap ’97 is a basic core of geographic data that cover the state of Minnesota. Extensions to the main channel through lakes and from the end of the mapped stream line to an endpoint within the drainage basin, generally at the divide, were added to the Basemap ’97 data.

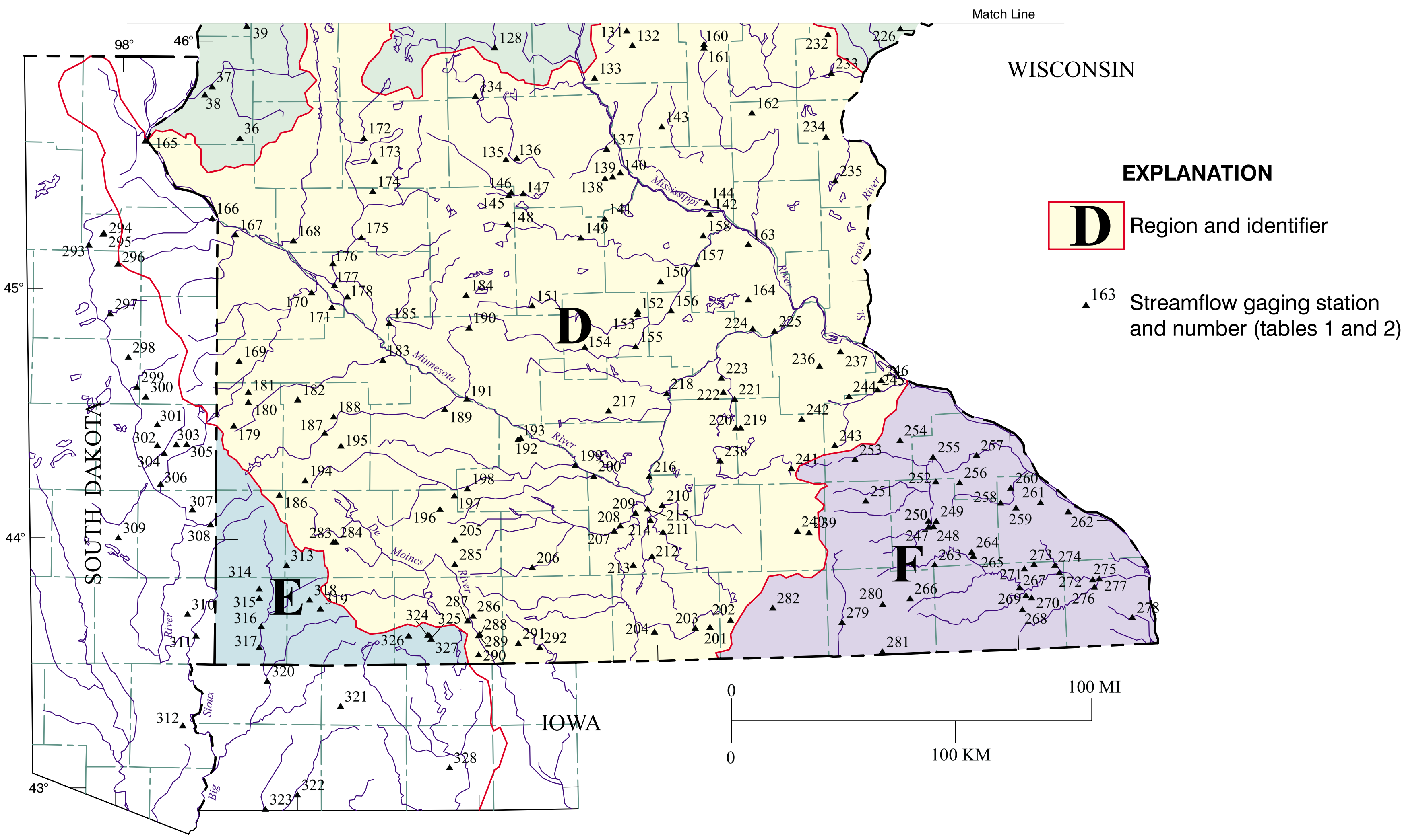
Elevations of intersections of topographic contour lines and main channels were digitized using the GIS. Two points on the main channel, at 10 percent and at 85 percent of the main-channel length from the streamflow gaging station to the endpoint of the extension, were located by the GIS. The elevations of these two points were interpolated from digitized elevation data. Main-channel slope was calculated by dividing the difference in elevation between those points by the distance along the main channel between those points.

The generalized runoff was based on the map of Gebert and others (1985) (fig. 2). The value of the generalized runoff for the basin was determined from the streamflow gaging station location using the surface interpolation function by Akima (1978). The basin characteristics are listed in table 2 (in the Supplemental Information section at the end of this report).

## Regression analysis

Tasker and others (1986) described the use of the generalized least squares (GLS) technique to estimate 100-year peak flow for an area in Arizona. They showed that the technique provided better estimates than the ordinary least squares technique. The GLS technique accounts for cross-correlated peak-flow data between stations having concurrent record. It also accounts for variance in estimated peak flow at each streamflow gaging station


CANADA
NORTH DAKOTA
MINNESOTA
A
B
C
C
Lake of the Woods
Upper Red Lake
Lower Red Lake
Red Lake River
Leech Lake
Mississippi River
St. Louis River
49°
48°
47°
97°
96°
95°
94°
93°
92°
91°
90°
Match Line




Base from U.S. Geological Survey digital data 1:2,000,000, 1972, standard parallels 29°30´ and 45°30´, Central meridian 96°.

**Figure 1. Locations of streamflow gaging stations and regions for estimating peak flow.**

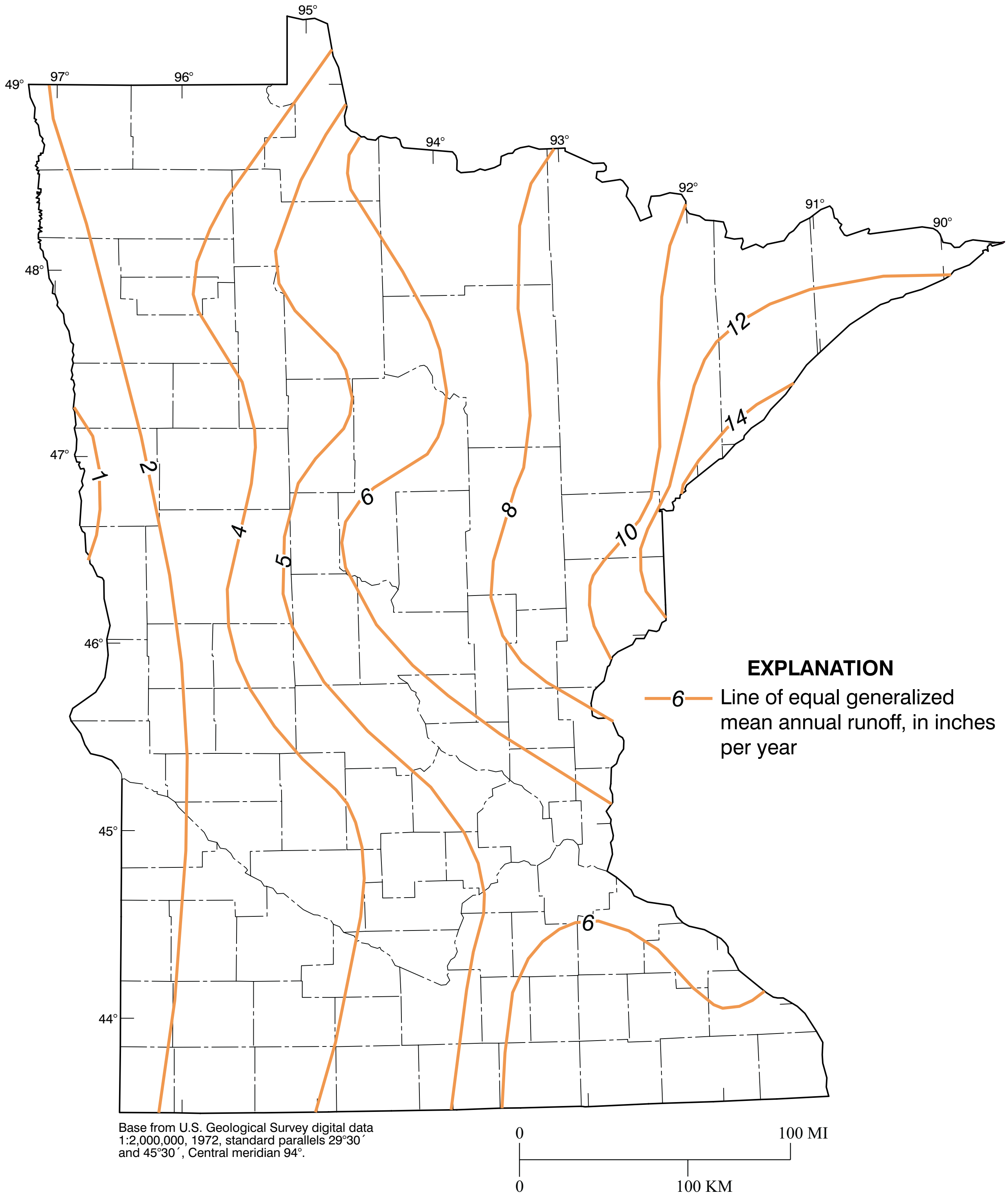



**Figure 2. Generalized mean annual runoff in Minnesota, 1951-85 [modified from Gebert and others, 1985].**

because of the difference in record length. Cross correlation is the correlation between peak flow at two different streamflow gaging stations as a result of similar weather patterns affecting those stations. In ordinary least squares regression, cross-correlated peak-flow data decrease the effective amount of information in an analysis and can contribute to errors in predictive precision (model error) and errors in determination of the coefficients of the independent variables (Stedinger and Tasker, 1985).

The GLS technique requires a reasonable estimate of the cross correlation between flows at every pair of stations (Tasker and Stedinger, 1989). An estimate based on the measured flows is not reliable because of the short concurrent records usually encountered in peak-flow data. Therefore, sample cross correlations are estimated by relating the distance between each pair of stations to the correlation between peak flows. Stations with at least 25 years of record were selected for the analysis of cross correlation and distance. From these stations, there were 9,735 pairs of correlations where there were at least 25 years of concurrent record. These 9,735 data pairs were reduced to 152 using the following two steps. First, the data were sorted by distance. Second, the mean distance and mean correlation, both weighted by concurrent record length, were computed for each sequential group of 64 data points. These 152 pairs of reduced data were used in a nonlinear regression analysis to relate cross correlation to distance. These data are shown in figure 3. These data summarize the trend of the entire data set, but do not represent the true scatter of the original data. The nonlinear regression equation relating cross correlation to distance is as follows:

$$\rho(i,j) = 0.6314 - 0.4062 * \operatorname{atan}(\operatorname{dist}(i,j)/92.27),$$

where

$\rho(i,j)$ = the estimated cross correlation between stations $i$ and $j$,

atan(x) = the arctangent of x, and

dist($i,j$) = the distance, in miles, between stations $i$ and $j$.

The equation is valid for $i$ not equal to $j$; for $i$ equal to $j$, the cross correlation is 1.

Step-backward selection is used for selecting variables in the regression models. The selection process begins by calculating statistics for all independent variables. Then variables are deleted from the model if the coefficient has the incorrect sign or if the T-score is less than 1.7. At each step, the variable having the lowest T-score is deleted.

### Regional analysis

The regions for estimating peak flow shown on figure 1 were modified from those in Jacques and Lorenz (1987). The regions defined in that report formed the basis for formation of new regions described in this report. Regional regression equations were developed for the regions defined by Jacques and Lorenz (1987). The residuals of peak-flow values associated with the regressions were examined in a two-step process. In the first step, the residuals from each regional regression were examined for a subregional pattern. If a subregional pattern was evident, that subregion was removed from the original region. In the second step, the residuals were examined to verify a normal, homoscedastic distribution. If the residuals were approximately normally distributed and homoscedastic, the region was accepted; otherwise, the region was subdivided again and the second step was repeated from this two-step process, two new regions, E and F, were identified and regions B and C were slightly modified. The average standard error of the estimate (SEE), discussed in the Accuracy and Limitations of the Estimating Techniques section, decreased from 51 percent for old region D to an average 47 percent for new regions D, E, and F.

Regional boundaries are shown on figure 1. Table 3 includes the number of streamflow gaging stations in each region. The regional boundaries follow drainage divides so that the drainage basin of a small stream will not overlap two regions, making interpretation easier for all small streams.

## TECHNIQUES FOR ESTIMATING PEAK FLOW ON SMALL STREAMS IN MINNESOTA

This section presents two statistically-derived techniques for estimating peak flows on small, ungaged streams in Minnesota. Both of the techniques relate physical and climatic characteristics to peak flows for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals.

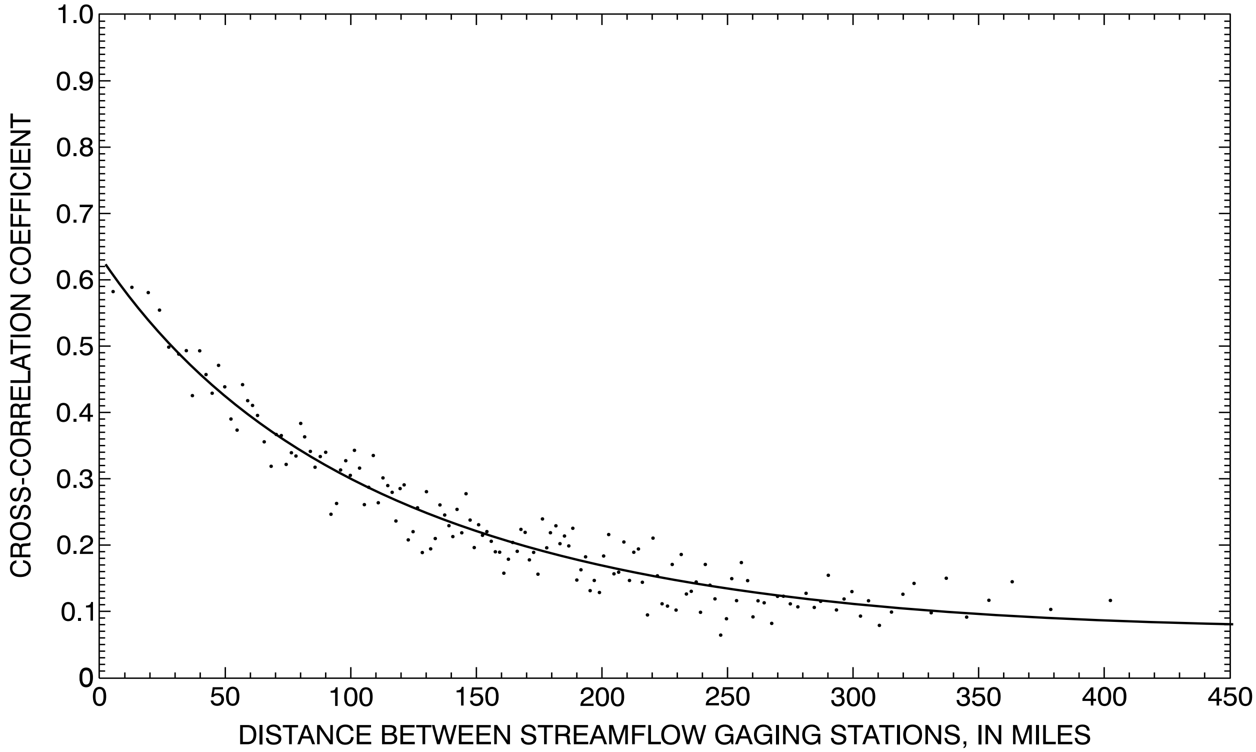



**Figure 3. Distance between streamflow gaging stations and peak-flow cross correlation in Minnesota.**

### Regional regression equation technique

Regression equations were developed for each recurrence interval and for each region shown on figure 1. Table 3 presents those equations, the SEE and the equivalent years of record discussed in the Accuracy and Limitations of the Estimating Techniques section. The SEE is included for comparison to previous regional regression equations.

### Region of influence regression technique

The fundamental premise of the region of influence regression (ROI) technique is that there is no need for distinct boundaries between regions (Burn, 1990). Each region is defined by selecting streamflow gaging stations with characteristics that are similar to the site of interest. Thus, the ROI technique allows use of a potentially unique set of streamflow gaging stations for each site of interest. Two methods are available for this technique. The similarity method selects streamflow gaging stations that have similar characteristics (variables). The proximity method selects streamflow gaging stations that are nearby.

The ROI technique requires the selection of a distance metric defining the similarity of each streamflow gaging station to the site of interest. Similarity is defined in terms of shortest distance. An appropriate metric is the weighted Euclidean distance in M-dimensional space (Burn, 1990). The distance metric is defined:

$$D(i) = \sqrt{\sum_{m=1}^{M} [W(m) \times (X(m,i) - X(m))^2]},$$

where
$D(i)$ = the distance from station $i$ to the site of interest,
$W(m)$ = the weight applied to variable $m$,
$X(m,i)$ = the value of attribute $m$ for station $i$, and
$X(m)$ = the value of the attribute for the site of interest.
In most cases, the weight for each attribute is the reciprocal of the variance of the attribute, computed from the values at all streamflow gaging stations. This technique selects a certain number, 36 for this study, of streamflow gaging stations closest to the site of interest to represent the region.

Table 3.--Regression equations, standard errors of the estimate, and the equivalent years of record.

[SEE, standard error of the estimate; EY, equivalent years of record; DA, drainage area, in square miles; ST, storage, in percent of drainage area; LK, area covered by lakes, in percent of drainage area; RO, generalized runoff, in inches; SL, slope, in feet per mile. Number in parentheses following region is number of streamflow gaging stations used to develop the equation.]

| Regression equation | SEE (percent) | EY |
|---|---|---|
| REGION A (42) | | |
| $Q2 = 22.2\ DA^{0.667}\ (ST+1)^{-0.076}\ (LK+1)^{-0.121}$ | 40 | 4.7 |
| $Q5 = 49.7\ DA^{0.680}\ (ST+1)^{-0.136}\ (LK+1)^{-0.186}$ | 36 | 7.5 |
| $Q10 = 75.2\ DA^{0.682}\ (ST+1)^{-0.168}\ (LK+1)^{-0.208}$ | 37 | 9.9 |
| $Q25 = 116.\ DA^{0.681}\ (ST+1)^{-0.205}\ (LK+1)^{-0.223}$ | 39 | 12.4 |
| $Q50 = 154.\ DA^{0.678}\ (ST+1)^{-0.230}\ (LK+1)^{-0.228}$ | 41 | 13.6 |
| $Q100 = 197.\ DA^{0.675}\ (ST+1)^{-0.252}\ (LK+1)^{-0.231}$ | 44 | 14.5 |
| REGION B (59) | | |
| $Q2 = 5.16\ DA^{0.820}\ (ST+1)^{-0.136}\ (LK+1)^{-0.400}\ RO^{0.859}$ | 38 | 2.8 |
| $Q5 = 15.2\ DA^{0.818}\ (ST+1)^{-0.170}\ (LK+1)^{-0.479}\ RO^{0.667}$ | 41 | 3.4 |
| $Q10 = 26.0\ DA^{0.818}\ (ST+1)^{-0.195}\ (LK+1)^{-0.515}\ RO^{0.590}$ | 43 | 4.1 |
| $Q25 = 44.9\ DA^{0.818}\ (ST+1)^{-0.228}\ (LK+1)^{-0.550}\ RO^{0.523}$ | 45 | 5.2 |
| $Q50 = 63.2\ DA^{0.818}\ (ST+1)^{-0.252}\ (LK+1)^{-0.570}\ RO^{0.489}$ | 47 | 6.0 |
| $Q100 = 85.4\ DA^{0.818}\ (ST+1)^{-0.276}\ (LK+1)^{-0.587}\ RO^{0.464}$ | 49 | 6.7 |
| REGION C (29) | | |
| $Q2 = 34.6\ DA^{0.961}\ SL^{0.359}\ (ST+1)^{-0.532}\ (LK+1)^{-0.280}$ | 33 | 3.2 |
| $Q5 = 64.5\ DA^{0.928}\ SL^{0.387}\ (ST+1)^{-0.561}\ (LK+1)^{-0.314}$ | 37 | 3.6 |
| $Q10 = 81.4\ DA^{0.913}\ SL^{0.425}\ (ST+1)^{-0.567}\ (LK+1)^{-0.328}$ | 39 | 4.4 |
| $Q25 = 97.6\ DA^{0.898}\ SL^{0.481}\ (ST+1)^{-0.569}\ (LK+1)^{-0.342}$ | 42 | 5.4 |
| $Q50 = 106.\ DA^{0.890}\ SL^{0.527}\ (ST+1)^{-0.569}\ (LK+1)^{-0.350}$ | 44 | 6.0 |
| $Q100 = 112.\ DA^{0.883}\ SL^{0.574}\ (ST+1)^{-0.567}\ (LK+1)^{-0.356}$ | 47 | 6.5 |
| REGION D (126) | | |
| $Q2 = 7.15\ DA^{0.796}\ SL^{0.449}\ (LK+1)^{-0.401}$ | 49 | 3.4 |
| $Q5 = 14.1\ DA^{0.796}\ SL^{0.475}\ (LK+1)^{-0.411}$ | 44 | 5.7 |
| $Q10 = 19.8\ DA^{0.794}\ SL^{0.488}\ (LK+1)^{-0.414}$ | 45 | 7.5 |
| $Q25 = 28.2\ DA^{0.792}\ SL^{0.503}\ (LK+1)^{-0.416}$ | 47 | 9.3 |
| $Q50 = 35.1\ DA^{0.791}\ SL^{0.513}\ (LK+1)^{-0.416}$ | 50 | 10.3 |
| $Q100 = 42.5\ DA^{0.790}\ SL^{0.522}\ (LK+1)^{-0.416}$ | 54 | 10.9 |
| REGION E (36) | | |
| $Q2 = 1.84\ DA^{0.848}\ SL^{0.758}\ RO^{0.690}$ | 62 | 5.0 |
| $Q5 = 6.12\ DA^{0.826}\ SL^{0.721}\ RO^{0.647}$ | 48 | 10.8 |
| $Q10 = 10.8\ DA^{0.821}\ SL^{0.706}\ RO^{0.644}$ | 42 | 18.4 |
| $Q25 = 18.4\ DA^{0.823}\ SL^{0.698}\ RO^{0.655}$ | 36 | 33.7 |
| $Q50 = 25.0\ DA^{0.828}\ SL^{0.697}\ RO^{0.670}$ | 32 | 50.4 |
| $Q100 = 32.2\ DA^{0.834}\ SL^{0.699}\ RO^{0.686}$ | 30 | 71.8 |
| REGION F (36) | | |
| $Q2 = 37.6\ DA^{0.712}\ SL^{0.223}$ | 38 | 5.3 |
| $Q5 = 55.3\ DA^{0.718}\ SL^{0.317}$ | 32 | 10.1 |
| $Q10 = 66.7\ DA^{0.721}\ SL^{0.367}$ | 30 | 15.2 |
| $Q25 = 79.7\ DA^{0.723}\ SL^{0.425}$ | 30 | 21.4 |
| $Q50 = 87.9\ DA^{0.724}\ SL^{0.466}$ | 31 | 24.6 |
| $Q100 = 94.9\ DA^{0.725}\ SL^{0.505}$ | 33 | 26.3 |

For this study, slope, percent storage, percent lake area, and generalized runoff were used to define the region of influence for the similarity method. These variables vary regionally across Minnesota to a certain extent. Drainage area is not included in the selection variables because the correlation between drainage area, slope, percent storage and percent lakes does restrict the range of drainage basin areas when the other variables are included.

An alternative to the similarity method is the proximity method, in which the distance metric is defined as the actual distance, in miles for example, between the site of interest and streamflow gaging stations. In the proximity method, the weight of variables is not considered. This method assumes that the region of influence is determined from a gradient of climatic and physiographic factors that are best represented by location and that those factors are not necessarily limited to the independent variables selected for this analysis.

The trade-off between the similarity method and the proximity method is in the cross correlation between the streamflow gaging stations selected in the region of influence. Stations selected using the proximity method probably will have a higher cross correlation than stations selected using the similarity method. The higher cross correlation reduces the effective amount of information for the region and can make the regression equations appear more accurate than they are when comparing predicted and measured peak flows. The average cross-correlation coefficient was 0.09 for the similarity method and 0.13 for the proximity method in Minnesota. These average cross-correlation coefficient values for the two methods were not substantially different.

## Comparison of regional regression equation and region of influence regression techniques

One method for comparing the regional regression equation technique and the region of influence regression technique is to use the PRESS/n statistic, which is the mean Prediction Error Sum of Squares. The PRESS/n statistic is determined by removing each site (of n sites) from the analysis, re-developing the prediction equations, and comparing the predicted peak-flow value to the measured value for that site in a region. The differences between the predicted and measured values are squared and the mean for all sites is computed. That way, n analyses are made without the predicted site being included. It is a reasonably unbiased comparison if the sites are not highly cross correlated.

Table 4 is a listing of the PRESS/n statistics for each region and recurrence interval. The minimum mean PRESS/n statistic indicates the preferred technique for each region. However, for region C, because the difference between the PRESS/n for the regional regression equation and the proximity method of ROI is only 0.0001 and the individual PRESS/n statistics for each recurrence interval greater than 5 years is less for the regional regression equation; that technique is preferred for that region. For the other regions, the proximity method is preferred for region B, the similarity method for regions A and D, the regional regression equations for regions E and F.

Regional regression appears strongly preferable for region E because the mean PRESS/n statistics for the ROI methods are so much higher than those for the regional regression equation. For the other regions, all methods might be given some consideration in evaluating the peak flow for a given recurrence interval.

## Software

A software packet is included with this report. It is a 3.5-inch floppy disk that contains the program and data files to run the regional regression equations and the region of influence regression techniques. The program is for use on an MSDOS operating system (version 3.0 or higher) and requires a math co-processor.

The software can be installed on any computer system using the MSDOS operating system. The steps for installing the software are as follows.

1. Open a MSDOS window if using any window system.

2. Insert the floppy disk into drive a:.

3. Type "a:install c:\peakflow", where c:\peakflow is the desired directory to install the software.

4. Two versions of the executable are included. The version called pf16.exe will run on any MSDOS computer. The version called pf32.exe will only run on a computer that supports a 32-bit operating system (Windows 95 or newer).

5. To run the program, change directory to c:\peakflow and type pf32 or pf16,whichever is appropriate for the system.

The program requires the user to enter an output file name; select a technique, either RRE for regional regression equations or ROI for region of influence regression; enter a site identifier; and enter the necessary basin characteristics. For the RRE technique, only those basin characteristics necessary for the equation are entered. For the ROI technique, drainage area, main-channel slope, area of storage, area of lakes, and generalized runoff must be entered. For the ROI technique, the user must specify a selection method, usually P for proximity or S for similarity. Multiple analyses for any number of stations or techniques can be performed during a single session.

An example of the dialogue from the program is shown in the Supplemental Information section, with informative messages in normal font, program prompts in italics, and user input in bold. The dialogue includes an example of both the RRE and ROI techniques, and the similarity and proximity method for the ROI technique. The method of selecting stations by list is not shown in the dialogue because it is a specialized method and should be used only when the user does not get a satisfactory result from the ROI technique (see discussion of output) and the user elects not to use the regional regression equation. The list method is used by selecting G as the option for selecting stations, then entering the number of stations to use and the eight-digit station number for each station, one to a line.

The example site is Judicial Ditch 11 in Sibley County, at the crossing of County Road 51, 3 miles south of Buffalo Lake. The relevant basin characteristics are:

Drainage area: 15.0 mi$^2$,
Main-channel slope: 2.6 ft/mi,
Storage: 0.0 percent,
Lake area: 0.0 percent,
Generalized runoff: 4.0 in./yr,
Latitude: 44$^o$ 41’22", and
Longitude: 94$^o$ 37’10".

The example site is in region D, where the recommended technique is ROI using the similarity method. RRE and ROI using the proximity method are also shown as an example.

Table 4.--PRESS/n statistics for each region and recurrence interval.
[ROI, region of influence regression]

| Region identifier | Recurrence interval (years) | PRESS/n | | |
|---|---|---|---|---|
| | | Proximity method ROI | Similarity method ROI | Regional regression |
| A | 2 | 0.0431 | 0.0425 | 0.0358 |
| A | 5 | .0411 | .0369 | .0411 |
| A | 10 | .0402 | .0350 | .0401 |
| A | 25 | .0439 | .0392 | .0442 |
| A | 50 | .0458 | .0436 | .0534 |
| A | 100 | .0498 | .0493 | .0628 |
| A(mean) | | .0440 | .0411 | .0462 |
| B | 2 | .0362 | .0360 | .0337 |
| B | 5 | .0413 | .0423 | .0430 |
| B | 10 | .0447 | .0507 | .0445 |
| B | 25 | .0488 | .0603 | .0510 |
| B | 50 | .0516 | .0682 | .0546 |
| B | 100 | .0543 | .0770 | .0598 |
| B (mean) | | .0462 | .0558 | .0478 |
| C | 2 | .0232 | .0344 | .0318 |
| C | 5 | .0314 | .0404 | .0339 |
| C | 10 | .0385 | .0429 | .0383 |
| C | 25 | .0466 | .0561 | .0445 |
| C | 50 | .0532 | .0630 | .0496 |
| C | 100 | .0599 | .0685 | .0549 |
| C (mean) | | .0421 | .0509 | .0422 |
| D | 2 | .0453 | .0449 | .0498 |
| D | 5 | .0442 | .0421 | .0435 |
| D | 10 | .0528 | .0466 | .0473 |
| D | 25 | .0705 | .0560 | .0566 |
| D | 50 | .0828 | .0649 | .0654 |
| D | 100 | .0957 | .0747 | .0752 |
| D (mean) | | .0652 | .0549 | .0563 |
| E | 2 | .0856 | .0594 | .0809 |
| E | 5 | .0734 | .0538 | .0578 |
| E | 10 | .0778 | .0591 | .0550 |
| E | 25 | .0903 | .0729 | .0582 |
| E | 50 | .1074 | .0838 | .0638 |
| E | 100 | .1204 | .1004 | .0713 |
| E (mean) | | .0925 | .0716 | .0645 |
| F | 2 | .0423 | .0485 | .0348 |
| F | 5 | .0315 | .0428 | .0301 |
| F | 10 | .0297 | .0457 | .0312 |
| F | 25 | .0332 | .0527 | .0350 |
| F | 50 | .0384 | .0545 | .0392 |
| F | 100 | .0432 | .0605 | .0443 |
| F | mean | .0364 | .0508 | .0358 |

The dialogue lists the peak flow, standard error of prediction (SEP) (discussed in the Accuracy and Limitations of Estimating Techniques section), equivalent years of record, and the lower and upper flow values of the 90-percent prediction interval. The SEP for the RRE will always be equal to or larger than the value of the SEE in table 3.

The output file from the regional regression equation technique reiterates the screen output and is not shown in this report. The output from the region of influence regression technique contains additional diagnostics about the regressions. A section of the output file is shown in the Supplemental Information section. The basic form of the output is repeated for each recurrence interval.

The output file presents information about the regression analysis. First, the results of the step-backward selection of independent variables are shown. Second, the residuals and influence statistics are listed. Third, the estimated peak flow and statistics are shown.

The output from the step-backward selection process shows the coefficients and their statistics, the variable to be deleted, and the reason for deletion for each of the steps. If the variable is forced out of the analysis, the coefficients and statistics are not shown.

The residuals and influence list includes the stations used in the analysis, the base-10 logarithm of the observed peak, the base-10 logarithm of the predicted peak, the studentized residual, the leverage, and Cook's D for each station. The studentized residual is the computed residual divided by the estimated standard deviation of that residual. Leverage is a measure of the distance from the observation to the mean of all observations. The leverage statistic can identify stations that are potentially influential because of their location in independent-variable space. Cook's D is a measure of influence that uses the studentized residual and leverage. Cook's D reveals which observations are influential in affecting the coefficients of the regression equation. Stations with values of the studentized residual, leverage, and Cook's D that are substantially larger than any other of the respective values could be considered for deletion. If basin characteristics of a particular station are substantially different from the remaining stations and the site in question, it could be deleted from the analysis and the remaining stations used in the ROI technique, using the list method.

Two statistics are printed at the bottom of the list. They are the mean sampling error variance and the mean model error variance. The mean sampling error variance is the portion of the average prediction error that is caused by estimation errors in the regression coefficients as opposed to the model error. The mean model error variance is the error caused by an imperfect model (lack of fit). The sum of these numbers is the mean prediction error variance. Hodge and Tasker (1995) describe the development of these statistics.

The predicted peak flow and statistics reiterate the information shown on the screen. The statistics include the percent standard error of prediction, the equivalent years of record, and the upper and lower 90-percent prediction interval. These statistics are explained in the Accuracy and Limitations of the Estimating Techniques section. The output on the screen will include a caution statement if the predicted value for a peak is smaller than the predicted value for a shorter recurrence interval.

The program will make a second pass through all regressions to construct a set of equations for estimating peak-flow that are based on a consistent set of independent variables. Independent variables that are used in at least three of the peak-flow estimates are included in that consistent set. Predicted peak flows based on a consistent set of independent variables may be desirable in all cases and should eliminate the occurrence of smaller predicted values at longer recurrence intervals.

## ACCURACY AND LIMITATIONS OF THE ESTIMATING TECHNIQUES

The accuracy of a statistically derived equation is measured by the closeness of the estimated value to the true value. Regression analyses give an unbiased estimate of the true value and statistics to assess the accuracy of the estimate.

The standard error of the estimate (SEE) is a measure of the fit of the observed data about the regression surface. The SEE is expressed as a percentage of the estimated value. It has traditionally been used for comparing the relative accuracy of the equations, although it is less useful for GLS regressions.

The standard error of prediction (SEP) is an estimate of the accuracy of the result of applying a regression equation to a set of independent variables. It accounts for the regression error and the uncertainty of the coefficients of the independent variables. It varies from site to site because it is a function of the basin characteristics at a site.

Hardison (1971) presented an equation that defines the equivalent years of record (EY) represented by the regression equation. The EY is the ratio of the mean variance of the logarithms of the annual peak to the mean square error of prediction, multiplied by a factor dependent on the recurrence interval. It is an estimate of the number of years of record that would be needed at a site to compute a peak flow at that recurrence interval with the same confidence interval.

The 90 percent confidence interval is another measure of the uncertainty of the predicted value. It is the estimated value multiplied or divided by a factor that is dependent on the mean SEP and the critical value of the t-distribution for a particular model. The information necessary to compute prediction intervals are in the file predict.dat on the disk included with this report.

The accuracy of the estimating equation is limited by the variance and bias of the input data. Variance is a measure of the random variation about the true value, and bias is the consistent deviation of the value from the true value.

The accuracy of the regression estimate is affected by errors in the independent variables. Errors in quantifying the drainage-basin characteristics result from an inability to completely describe the effect of those characteristics. For example, the effects of wetlands and lakes depend on their size and location in the basin and in the stream channels, but the independent variable storage is simply expressed as a percentage of total drainage area without regard to size or location.

Bias of an estimate can result from systematic errors in the computation of the dependent variable. Bias in the computation of the dependent variable is probably the result of collecting peak-flow data over a period of time that does not reflect the long-term population of peak flows. Most short-term records at streamflow gaging stations used in this analysis were from the 1960-85 and current (through 1995) periods. The derived peak-flow statistics reflect those periods, which may not be representative of the long-term conditions.

The accuracy of an estimate made using the techniques presented in this report can also be affected by the user. Each user will make certain decisions based on his or her best judgement about the actual outline of the drainage basin, the path of the main channel, interpolation of generalized runoff, and the source of lake and wetland data. These individual sources of error can be reduced by use of shared computer data sets that are updated as improved information becomes available and the use of geographic information systems that provide consistent results.

The accuracy of peak-flow estimates made at sites immediately downstream of a lake or ponding area where the storage capacity could substantially alter peak-flow characteristics can be improved by a routing adjustment. In such places, the frequency relations could be used as an aid in developing a hydrograph of the inflow and then a simulation of that flow can be routed through the lake to determine the peak of the outflow.

The values of the independent variables used in this analysis were all computed from consistent data sets using a GIS or spatial interpolation software. It is expected that careful analysis using 7 1/2-minute USGS topographic maps should provide accurate estimates of drainage area, main-channel slope, percent storage, and percent lake. Interpolation of generalized runoff from figure 2 can be improved by using runoff data from table 2 in conjunction with data for nearby streamflow gaging stations.

Multi-collinearity among the independent variables can have adverse effects on the accuracy of coefficients of those variables in the regression equation (Helsel and Hirsch, 1992). Freund and Minton (1979) indicated that predictions from regressions where the independent variables exhibit multi-collinearity are reliable where the correlation structure of the predicted site is similar to that of the data used to construct the regression equation. This condition likely is true for any site in Minnesota using any of the techniques for predicting peak flow described herein.

Collinearity can be intrinsic in the data, such as the relation between main-channel slope and drainage area, or introduced in the computation of variables, such as percent storage and percent lake. The correlation (a measure of collinearity) between slope and drainage area is about -.85 for regions in Minnesota. The correlation between percent storage and percent lake is less than 0.6 for regions in Minnesota. A measure of multi-collinearity is the variance inflation factor (VIF). Helsel and

Hirsch (1992) stated that VIFs of less than 10 were not a concern in multiple linear regression analyses. The VIF for each independent variable in each regional regression equation in this study was less than 8.

Peak-flow-frequency equations presented in this report can be used to estimate the peak flows of several recurrence intervals on most small streams in Minnesota. The applicability and accuracy of these relations depend partly on whether the basin characteristics of the site are within the range of the characteristics used to define the peak-flow equations. The range in sampled basin characteristics is large enough to allow the application of the equations at most sites where streamflow is not affected by regulation, diversion, or urbanization. The upper and lower value and geometric mean for each basin characteristic for each region are listed in table 5.

Table 5.--Upper and lower values and geometric mean of the independent variables used in the regional regression analysis for each region.

[$mi^2$, square miles; ft/mi, feet per mile]

| | Drainage area ($mi^2$) | Main-channel slope (ft/mi) | Storage (percent) | Lake (percent) |
|---|---|---|---|---|
| | | REGION A | | |
| Upper | 1560 | 36.7 | 72 | 10 |
| Mean | 82 | 6.2 | 17 | .7 |
| Lower | 1.2 | 1.3 | 0.1 | .0 |
| | | REGION B | | |
| Upper | 1680 | 251 | 95 | 26 |
| Mean | 66 | 5.9 | 26 | 2.2 |
| Lower | .4 | .4 | 1.7 | .0 |
| | | REGION C | | |
| Upper | 609 | 214 | 46 | 21 |
| Mean | 19 | 33 | 18 | 1.4 |
| Lower | .5 | 4.5 | 0.8 | .0 |
| | | REGION D | | |
| Upper | 2640 | 219 | 44 | 23 |
| Mean | 26 | 9.6 | 4.8 | .9 |
| Lower | .1 | .9 | .0 | .0 |
| | | REGION E | | |
| Upper | 790 | 122 | 5.7 | 2.4 |
| Mean | 14 | 16 | .8 | .1 |
| Lower | .2 | 4.0 | .0 | .0 |
| | | REGION F | | |
| Upper | 1540 | 237 | 4.1 | .7 |
| Mean | 25 | 20 | 1.1 | .1 |
| Lower | .1 | 3.1 | .0 | .0 |

The geometric mean is included because it best represents the mean of the data. Where runoff is included as an independent variable, the range of those data is sufficient to ensure that any value in that region is within the range. The program will issue a warning message if the predicted peak flow is an extrapolation beyond the data on which the prediction is based

## SUMMARY

This report (1) documents the analytical techniques used for annual series peak-flow-frequency computations, basin characterization, regionalization, and development of equations for estimating peak flows on small drainage basins; (2) presents peak-flow data and basin characteristics at streamflow gaging stations; and (3) discusses techniques for estimating peak flow at ungaged sites on small, unregulated streams in Minnesota.

Two statistically derived techniques, regional regression equation and region of influence regression, for estimating peak flow on small, ungaged streams in Minnesota were developed. Both of the techniques relate physical and climatic characteristics to peak flows for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals. Regional regression equations were developed for each recurrence interval in each of the six regions in Minnesota. The region of influence regression technique dynamically selects stations with characteristics similar to site of interest. Two methods of selecting streamflow gaging stations, similarity and proximity, can be used in the region of influence regression technique. Thus, the region of influence regression technique allows use of a potentially unique set of stations for estimating peak flow at each site of interest.

The regional regression equation technique is preferable as a first estimate of peak flow in regions C, E, and F. The similarity method of the region of influence regression technique is preferable as a first estimate in regions A and D. The proximity method should be used as a first estimate in region B.

Tables showing the peak-flow-frequency data and basin characteristics for streamflow gaging stations, and regional peak-flow prediction equations are documented in the report and in the Supplemental Information section.

## SELECTED REFERENCES

Akima, H., 1978, Bivariate interpolation and smooth surface fitting for irregularly distributed data points: Association for Computing Machinery, Transactions on Mathematical Software, v. 4, no. 2, p. 160-164.

Burn, D.H., 1990, Evaluation of regional flood frequency analysis with a region of influence approach: Water Resources Research, v. 26, no. 10, p. 149-165.

Freund, R.J. and Minton, P.D., 1979, Regression methods, a tool for data analysis: Marcel Dekker, Inc. New York, 261 p.

Gebert, W.A., Graczyk, K.J., and Krug, W.R., 1985, Average annual runoff in the United States, 1951-80: U.S. Geological Survey Open-File Report 85-627, 1 sheet, scale 1:2,000,000.

Guetzkow, L.C., 1977, Techniques for estimating magnitude and frequency of floods in Minnesota: U.S. Geological Survey Water-Resources Investigations 77-31, 33 p.

Hardison, C.H., 1971, Predicion of error of regressioin estimates of streamflow characteristics at gaged sites: U.S. Geolgical Survey Professional Paper 750-C, p. C228-C236.

Helsel, D.R. and Hirsch, R.M., 1992, Statistical methods in water resources: Elsevier, Amsterdam, The Netherlands, 522 p.

Hodge, S.A. and Tasker, G.D., 1995, Magnitude and frequency of floods in Arkansas: U.S. Geological Survey Water-Resources Investigations Report 95-4224, 275 p.

Jacques, J.E. and Lorenz, D.L., 1987, Techniques for estimating the magnitude and frequency of floods in Minnesota: U.S. Geological Survey Water-Resources Investigations Report 87-4170, 48 p.

Lorenz, D.L., 1997, Generalized skew coefficients for flood-frequency analysis in Minnesota: U.S. Geological Survey Open-File Report 97-4089, 15 p.

Lorenz, D.L., and Payne, G.A., 1989, Selected data describing stream subbasins in the Redwood River Basin, southwestern Minnesota: U.S. Geological Survey Open-File Report 89-405, 5 p., 1 plate, scale 1:100,000.

____1991a, Selected data for stream subbasins in the Le Sueur River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report 91-62, 8 p., 1 plate, scale 1:100,000.

____1991b, Selected data for stream subbasins in the Watonwan River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report 91-61, 7 p., 1 plate, scale 1:100,000.

____1992, Physical characteristics of stream subbasins in the Blue Earth River Basin, south-central Minnesota and north-central Iowa: U.S. Geological Survey Open-File Report 91-512, 10 p., 1 plate, scale 1:100,000.

____1994, Physical characteristics of stream subbasins in the Pomme de Terre River Basin, west-central Minnesota: U.S. Geological Survey Open-File Report 93-47, 8 p., 1 plate, scale 1:100,000.

Lorenz, D.L., Sanocki, C.A., and Winterstein, T.A., 1994, Physical characteristics of stream subbasins in the Lac qui Parle River Basin, southwestern Minnesota and eastern South Dakota: U.S. Geological Survey Open-File Report 93-46, 12 p., 1 plate, scale 1:100,000.

Minnesota Department of Transportation, 1997, Basemap '97: Office of Land Management, Surveying and Mapping Section, 1 compact disk.

Patterson, J.L., and Gambel, G.R., 1968, Magnitude and frequency of floods in the United States, Part 5: U.S. Geological Survey Water-Supply Paper 1678, 546 p.

Prior, C.H., 1949, Magnitude and frequency of floods in Minnesota: Minnesota Department of Conservation, Division of Waters Bulletin 1, 128 p.

Prior, C.H. and Hess, J.H., 1961, Floods in Minnesota--Magnitude and frequency: Minnesota Department of Conservation, Division of Waters Bulletin 12, 142 p.

Sanocki, C.A., 1995a, Physical characteristics of stream subbasins in the Cottonwood River Basin, southwestern Minnesota: U.S. Geological Survey

Open-File Report 95-333, 14 p., 1 plate, scale 1:100,000.

Sanocki, C.A., 1995b, Physical characteristics of stream subbasins in the Upper Minnesota River Basin, west-central Minnesota, northeastern South Dakota, and southeastern North Dakota: U.S. Geological Survey Open-File Report 95-162, 16 p., 1 plate, scale 1:100,000.

Sanocki, C.A., 1996a, Physical characteristics of stream subbasins in the Middle Minnesota-Little Cottonwood River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report 96-631, 13 p., 1 plate, scale 1:100,000.

Sanocki, C.A., 1996b, Physical characteristics of stream subbasins in the Hawk Creek-Yellow Medicine River Basin, southwestern Minnesota and Eastern South Dakota: U.S. Geological Survey Open-File Report 96-632, 21 p., 1 plate, scale 1:100,000.

Sanocki, C.A., 1997a, Physical characteristics of stream subbasins in the Lower Minnesota River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report 97-205, 16 p., 1 plate, scale 1:100,000.

Sanocki, C.A., in press, Physical characteristics of stream subbasins in the North Fork Crow River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report.

Sanocki, C.A., in press, Physical characteristics of stream subbasins in the South Fork Crow River Basin, south-central Minnesota: U.S. Geological Survey Open-File Report.

Sanocki, C.A., and Krumrie, J.R., 1994, Physical characteristics of stream subbasins in the Chippewa River Basin, west-central Minnesota: U.S. Geological Survey Open-File Report 94-488, 16 p., 1 plate, scale 1:100,000.

Stedinger, J.D., and Tasker, G.D., 1985, Regional hydrologic analysis 1--Ordinary, weighted, and generalized least squares compared: Water Resources Research, v. 21, no. 9, p. 1421-1432.

Tasker, G.D., Eychaner, J.H., and Stedinger, J.R., 1986, Application of generalized least squares in hydrologic regression analysis, *in* Selected Papers in the Hydrologic Sciences: U.S. Geological Survey Water-Supply Paper 2310, p. 107-115.

Tasker, G.D., and Stedinger, J.D., 1989, An operational GLS model for hydrologic regression: Journal of Hydrology, v. 111, no. xx, p 361-375.

U.S. Water Resources Council, 1982, Guidelines for determining flood flow frequency, revised September 1981, Editorial corrections March 1982: Hydrology Committee Bulletin 17B, Washington, D.C., 190 p., 1 plate.

Wiitala, S.W., 1965, Magnitude and frequency of floods in the United States, Part 4: U.S. Geological Survey Water-Supply Paper 1677, 357 p.

## Supplemental Information

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 1 | C | 04010500 | Pigeon River at Middle Falls near Grand Portage, Minnesota | 4360 | 6130 | 7390 | 9090 | 10400 | 11900 |
| 2 | C | 04011370 | Little Devil Track River near Grand Marais, Minnesota | 146 | 246 | 327 | 447 | 549 | 664 |
| 3 | C | 04011390 | Little Devil Track River Tributary near Grand Marais, Minnesota | 12.8 | 26.8 | 40.9 | 66.4 | 92.3 | 126 |
| 4 | C | 04011990 | Cascade River near Grand Marais, Minnesota | 712 | 948 | 1110 | 1340 | 1510 | 1690 |
| 5 | C | 04012500 | Poplar River at Lutsen, Minnesota | 865 | 1340 | 1710 | 2260 | 2740 | 3260 |
| 6 | C | 04013100 | Lake Superior Tributary near Taconite Harbor, Minnesota | 74.9 | 167 | 267 | 461 | 672 | 959 |
| 7 | C | 04013200 | Caribou River near Little Marais, Minnesota | 541 | 1000 | 1450 | 2220 | 2990 | 3960 |
| 8 | C | 04014500 | Baptism River near Beaver Bay, Minnesota | 2380 | 3850 | 5080 | 6980 | 8670 | 10600 |
| 9 | C | 04015150 | Crow Creek near Silver Creek, Minnesota | 40.1 | 75.0 | 109 | 169 | 228 | 304 |
| 10 | C | 04015250 | Silver Creek Tributary near Two Harbors, Minnesota | 300 | 579 | 846 | 1300 | 1750 | 2310 |
| 11 | C | 04015300 | Little Stewart River near Two Harbors, Minnesota | 169 | 256 | 326 | 430 | 520 | 621 |
| 12 | C | 04015330 | Knife River near Two Harbors, Minnesota | 2850 | 4090 | 5020 | 6330 | 7390 | 8540 |
| 13 | C | 04015360 | Lake Superior Tributary #2 at French River, Minnesota | 143 | 315 | 497 | 833 | 1190 | 1650 |
| 14 | C | 04015370 | Talmadge River at Duluth, Minnesota | 247 | 432 | 598 | 864 | 1110 | 1410 |
| 15 | B | 04015400 | Miller Creek at Duluth, Minnesota | 231 | 357 | 447 | 567 | 660 | 757 |
| 16 | B | 04015500 | Second Creek near Aurora, Minnesota | 122 | 1659 | 196 | 237 | 270 | 305 |
| 17 | B | 04016000 | Partridge River near Aurora, Minnesota | 939 | 1610 | 2110 | 2810 | 3370 | 3960 |
| 18 | B | 04016500 | St. Louis River near Aurora, Minnesota | 1430 | 2160 | 2700 | 3470 | 4090 | 4760 |
| 19 | B | 04017000 | Embarrass River at Embarrass, Minnesota | 570 | 994 | 1330 | 1820 | 2220 | 2660 |
| 20 | B | 04017700 | Mckinley Lake Tributary at Mckinley, Minnesota | 12.5 | 24.4 | 34.1 | 48.2 | 59.9 | 72.5 |
| 21 | B | 04018800 | East Two River Tributary at Virginia, Minnesota | 53.8 | 73.0 | 85.7 | 102 | 114 | 126 |
| 22 | B | 04018900 | East Two River near Iron Junction, Minnesota | 334 | 502 | 617 | 763 | 873 | 984 |
| 23 | B | 04019000 | West Two River near Iron Junction, Minnesota | 543 | 799 | 966 | 1170 | 1320 | 1470 |
| 24 | B | 04019500 | East Swan River near Toivola, Minnesota | 1180 | 1530 | 1750 | 2010 | 2200 | 2380 |
| 25 | B | 04020480 | North Branch Whiteface River near Fairbanks, Minnesota | 167 | 291 | 392 | 543 | 672 | 817 |
| 26 | B | 04020700 | Bug Creek at Shaw, Minnesota | 287 | 397 | 469 | 560 | 628 | 695 |
| 27 | B | 04021690 | Cloquet River near Toimi, Minnesota | 525 | 755 | 930 | 1180 | 1380 | 1600 |
| 28 | C | 04024095 | Nemadji River near Holyoke, Minnesota | 1730 | 2500 | 3050 | 3790 | 4380 | 5000 |
| 29 | C | 04024098 | Deer Creek near Holyoke, Minnesota | 360 | 764 | 1150 | 1800 | 2430 | 3190 |
| 30 | C | 04024100 | Rock Creek near Blackhoof, Minnesota | 445 | 831 | 1150 | 1610 | 2010 | 2440 |
| 31 | C | 04024110 | Rock Creek Tributary near Blackhoof, Minnesota | 18.4 | 35.9 | 51.0 | 74.4 | 95.1 | 119 |
| 32 | C | 04024200 | South Fork Nemadji River near Holyoke, Minnesota | 740 | 1260 | 1650 | 2200 | 2630 | 3090 |
| 33 | B | 05030000 | Otter Tail River near Detroit Lakes, Minnesota | 169 | 255 | 309 | 374 | 419 | 461 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[ft$^3$/s, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in ft$^3$/s | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 34 | B | 05040000 | Pelican River near Detroit Lakes, Minnesota | 139 | 186 | 214 | 249 | 274 | 298 |
| 35 | B | 05040500 | Pelican River near Fergus Falls, Minnesota | 299 | 475 | 607 | 789 | 936 | 1090 |
| 36 | B | 05047700 | West Branch Mustinka River Tributary near Graceville, Minnesota | 31.6 | 75.4 | 119 | 192 | 261 | 344 |
| 37 | B | 05049000 | Mustinka River above Wheaton, Minnesota | 841 | 2400 | 3980 | 6630 | 9060 | 11900 |
| 38 | B | 05049200 | Eighteen Mile Creek near Wheaton, Minnesota | 179 | 644 | 1210 | 2300 | 3440 | 4880 |
| 39 | B | 05050700 | Rabbit River near Nashua, Minnesota | 477 | 950 | 1310 | 1800 | 2190 | 2570 |
| 40 | A | 05060800 | Buffalo River near Callaway, Minnesota | 235 | 445 | 604 | 820 | 989 | 1160 |
| 41 | A | 05061000 | Buffalo River near Hawley, Minnesota | 660 | 1230 | 1650 | 2220 | 2660 | 3100 |
| 42 | A | 05061200 | Whisky Creek at Barnesville, Minnesota | 145 | 271 | 374 | 527 | 657 | 799 |
| 43 | A | 05061400 | Spring Creek Above Downer, Minnesota | 47.0 | 142 | 261 | 510 | 796 | 1200 |
| 44 | A | 05061500 | South Branch Buffalo River at Sabin, Minnesota | 1070 | 2400 | 3580 | 5400 | 6980 | 8740 |
| 45 | A | 05062000 | Buffalo River near Dilworth, Minnesota | 1370 | 3080 | 4660 | 7170 | 9430 | 12000 |
| 46 | A | 05062280 | Mosquito Creek near Bagley, Minnesota | 31.8 | 59.8 | 80.2 | 107 | 127 | 146 |
| 47 | A | 05062470 | Marsh Creek Tributary near Mahnomen, Minnesota | 118 | 244 | 344 | 481 | 589 | 700 |
| 48 | A | 05062500 | Wild Rice River at Twin Valley, Minnesota | 1330 | 2700 | 3810 | 5380 | 6640 | 7980 |
| 49 | A | 05062700 | Wild Rice River Tributary near Twin Valley, Minnesota | 90.5 | 175 | 237 | 318 | 379 | 440 |
| 50 | A | 05062800 | Coon Creek near Twin Valley, Minnesota | 472 | 1240 | 1930 | 2960 | 3800 | 4690 |
| 51 | A | 05063200 | Spring Creek Tributary near Ogema, Minnesota | 54.7 | 81.1 | 97.5 | 117 | 130 | 143 |
| 52 | A | 05064000 | Wild Rice River at Hendrum, Minnesota | 2520 | 4460 | 5910 | 7900 | 9460 | 11100 |
| 53 | A | 05067500 | Marsh River near Shelly, Minnesota | 953 | 2190 | 3190 | 4560 | 5610 | 6670 |
| 54 | A | 05069000 | Sand Hill River at Climax, Minnesota | 1030 | 2070 | 2910 | 4090 | 5040 | 6040 |
| 55 | A | 05073600 | South Branch Battle River at Northome, Minnesota | 53.3 | 80.7 | 99.4 | 123 | 141 | 158 |
| 56 | A | 05073750 | Spring Creek near Blackduck, Minnesota | 80.9 | 171 | 256 | 395 | 525 | 679 |
| 57 | A | 05073800 | Perry Creek near Shooks, Minnesota | 35.3 | 60.9 | 79.6 | 105 | 124 | 145 |
| 58 | A | 05075700 | Mud River near Grygla, Minnesota | 753 | 1060 | 1250 | 1480 | 1650 | 1810 |
| 59 | A | 05076000 | Thief River near Thief River Falls, Minnesota | 1420 | 2630 | 3420 | 4350 | 4970 | 5520 |
| 60 | A | 05076600 | Red Lake River Tributary near Thief River Falls, Minnesota | 74.9 | 121 | 153 | 196 | 229 | 262 |
| 61 | A | 05077700 | Ruffy Brook near Gonvick, Minnesota | 193 | 299 | 365 | 443 | 496 | 546 |
| 62 | A | 05078000 | Clearwater River at Plummer, Minnesota | 1370 | 2260 | 2900 | 3750 | 4420 | 5100 |
| 63 | A | 05078100 | Lost River at Gonvick, Minnesota | 150 | 244 | 304 | 376 | 426 | 474 |
| 64 | A | 05078180 | Silver Creek near Clearbrook, Minnesota | 55.1 | 98.6 | 128 | 163 | 187 | 210 |
| 65 | A | 05078200 | Silver Creek Tributary at Clearbrook, Minnesota | 54.5 | 93.6 | 121 | 158 | 185 | 212 |
| 66 | A | 05078230 | Lost River at Oklee, Minnesota | 1110 | 2010 | 2640 | 3440 | 4030 | 4600 |

Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 67 | A | 05078400 | Clearwater River Tributary near Plummer, Minnesota | 51.5 | 101 | 141 | 201 | 252 | 307 |
| 68 | A | 05078500 | Clearwater River at Red Lake Falls, Minnesota | 3020 | 5300 | 6980 | 9210 | 10900 | 12700 |
| 69 | A | 05079901 | Burnham Creek near Crookston, Minnesota | 421 | 1080 | 1700 | 2670 | 3510 | 4450 |
| 70 | A | 05086900 | Middle River near Newfolden, Minnesota | 222 | 470 | 673 | 961 | 1190 | 1440 |
| 71 | A | 05087500 | Middle River at Argyle, Minnesota | 783 | 1700 | 2400 | 3310 | 3990 | 4640 |
| 72 | A | 05094000 | South Branch Two Rivers at Lake Bronson, Minnesota | 1310 | 2350 | 3090 | 4070 | 4800 | 5530 |
| 73 | A | 05095500 | Two Rivers Below Hallock, Minnesota | 942 | 1850 | 2530 | 3450 | 4150 | 4860 |
| 74 | A | 05096000 | North Branch Two Rivers near Lancaster, Minnesota | 84.9 | 253 | 419 | 685 | 919 | 1180 |
| 75 | A | 05096500 | State Ditch #85 near Lancaster, Minnesota | 136 | 275 | 394 | 573 | 727 | 898 |
| 76 | A | 05104000 | South Fork Roseau River near Malung, Minnesota | 453 | 997 | 1420 | 1980 | 2410 | 2830 |
| 77 | A | 05104500 | Roseau River Below South Fork near Malung, Minnesota | 1590 | 3170 | 4310 | 5760 | 6810 | 7820 |
| 78 | A | 05106000 | Sprague Creek near Sprague, Manitoba, Canada | 549 | 1130 | 1550 | 2090 | 2490 | 2860 |
| 79 | A | 05107000 | Pine Creek near Pine Creek, Minnesota | 293 | 533 | 697 | 899 | 1040 | 1180 |
| 80 | A | 05107500 | Roseau River at Ross, Minnesota | 1620 | 2830 | 3680 | 4760 | 5560 | 6340 |
| 81 | A | 05112000 | Roseau River Below State Ditch 51 near Caribou, Minnesota | 1600 | 2280 | 2660 | 3090 | 3360 | 3610 |
| 82 | B | 05124480 | Kawishiwi River near Ely, Minnesota | 981 | 1330 | 1550 | 1820 | 2010 | 2200 |
| 83 | B | 05124500 | Isabella River near Isabella, Minnesota | 1880 | 2990 | 3820 | 4970 | 5910 | 6900 |
| 84 | B | 05125500 | Stony River near Isabella, Minnesota | 807 | 1310 | 1710 | 2280 | 2760 | 3280 |
| 85 | B | 05125550 | Stony River near Babbitt, Minnesota | 1020 | 1470 | 1780 | 2200 | 2530 | 2870 |
| 86 | B | 05126000 | Dunka River near Babbitt, Minnesota | 326 | 510 | 650 | 848 | 1010 | 1190 |
| 87 | B | 05126500 | Bear Island River near Ely, Minnesota | 235 | 332 | 395 | 475 | 533 | 591 |
| 88 | B | 05127205 | Burntside River near Ely, Minnesota | 244 | 322 | 373 | 438 | 486 | 535 |
| 89 | B | 05127210 | Armstrong Creek near Ely, Minnesota | 53.8 | 78.5 | 97.0 | 123 | 144 | 167 |
| 90 | B | 05127215 | Longstorff Creek near Ely, Minnesota | 98.4 | 141 | 172 | 214 | 249 | 286 |
| 91 | B | 05127220 | Burgo Creek near Ely, Minnesota | 82.5 | 181 | 281 | 462 | 645 | 880 |
| 92 | B | 05128300 | Pike River near Gilbert, Minnesota | 22.7 | 38.0 | 50.5 | 69.1 | 85.1 | 103 |
| 93 | B | 05128500 | Pike River near Embarrass, Minnesota | 724 | 1180 | 1540 | 2070 | 2520 | 3030 |
| 94 | B | 05128700 | Pike River Tributary near Wahlsten, Minnesota | 47.2 | 72.8 | 91.2 | 116 | 136 | 156 |
| 95 | B | 05129000 | Vermilion River below Vermilion Lk near Tower, Minnesota | 1080 | 1540 | 1840 | 2230 | 2510 | 2800 |
| 96 | B | 05129115 | Vermilion River near Crane Lake, Minnesota | 2340 | 3230 | 3800 | 4510 | 5030 | 5540 |
| 97 | B | 05129650 | Little Fork River at Cook, Minnesota | 527 | 858 | 1130 | 1530 | 1870 | 2260 |
| 98 | B | 05129710 | Johnson Creek near Britt, Minnesota | 25.8 | 31.7 | 35.1 | 39.2 | 42.0 | 44.7 |
| 99 | B | 05130300 | Boriin Creek near Chisholm, Minnesota | 173 | 298 | 397 | 539 | 657 | 785 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 100 | B | 05130500 | Sturgeon River near Chisholm, Minnesota | 1010 | 1530 | 1910 | 2440 | 2860 | 3310 |
| 101 | B | 05131000 | Dark River near Chisholm, Minnesota | 307 | 503 | 661 | 891 | 1090 | 1300 |
| 102 | B | 05131500 | Little Fork River at Littlefork, Minnesota | 9020 | 13700 | 16900 | 21100 | 24300 | 27500 |
| 103 | B | 05131750 | Big Fork River near Bigfork, Minnesota | 1270 | 1780 | 2100 | 2490 | 2770 | 3040 |
| 104 | B | 05131878 | Bowerman Brook near Craigville, Minnesota | 244 | 431 | 577 | 783 | 951 | 1130 |
| 105 | B | 05132000 | Big Fork River at Big Falls, Minnesota | 5340 | 8580 | 10800 | 13700 | 15900 | 18100 |
| 106 | B | 05134100 | North Branch Rapid River near Baudette, Minnesota | 417 | 700 | 895 | 1140 | 1320 | 1500 |
| 107 | B | 05134200 | Rapid River near Baudette, Minnesota | 2930 | 4800 | 6050 | 7580 | 8680 | 9750 |
| 108 | B | 05137000 | Winter Road River near Baudette, Minnesota | 439 | 863 | 1190 | 1630 | 1970 | 2320 |
| 109 | B | 05139500 | Warroad River near Warroad, Minnesota | 601 | 1180 | 1620 | 2210 | 2660 | 3110 |
| 110 | B | 05140000 | Bulldog Run near Warroad, Minnesota | 142 | 336 | 490 | 693 | 845 | 993 |
| 111 | B | 05140500 | East Branch Warroad River near Warroad, Minnesota | 336 | 662 | 908 | 1240 | 1490 | 1740 |
| 112 | B | 05200200 | Hennepin Creek near Becida, Minnesota | 79.2 | 135 | 179 | 243 | 297 | 356 |
| 113 | B | 05200445 | Mississippi River at Bemidji, Minnesota | 540 | 865 | 1110 | 1430 | 1690 | 1970 |
| 114 | B | 05205200 | Boy River near Remer, Minnesota | 350 | 539 | 670 | 842 | 972 | 1110 |
| 115 | B | 05210200 | Smith Creek near Hill City, Minnesota | 79.7 | 171 | 253 | 379 | 491 | 618 |
| 116 | B | 05212700 | Prairie River near Taconite, Minnesota | 1320 | 2230 | 2920 | 3870 | 4630 | 5440 |
| 117 | B | 05216700 | O'Brien Creek near Nashwauk, Minnesota | 76.7 | 97.2 | 109 | 124 | 133 | 142 |
| 118 | B | 05216980 | Swan River Tributary at Warba, Minnesota | 37.4 | 55.7 | 67.5 | 81.9 | 92.2 | 102 |
| 119 | B | 05217000 | Swan River near Warba, Minnesota | 753 | 1140 | 1430 | 1830 | 2160 | 2520 |
| 120 | B | 05217700 | Bluff Creek near Jacobson, Minnesota | 34.3 | 63.9 | 87.6 | 122 | 150 | 180 |
| 121 | B | 05221020 | Willow River Below Palisade, Minnesota | 1600 | 2450 | 3030 | 3770 | 4320 | 4880 |
| 122 | B | 05229450 | Pine River near Pine River, Minnesota | 598 | 857 | 1030 | 1260 | 1440 | 1610 |
| 123 | B | 05241500 | Rabbit River near Crosby, Minnesota | 22.0 | 39.8 | 53.7 | 73.3 | 89.3 | 106 |
| 124 | B | 05244000 | Crow Wing River at Nimrod, Minnesota | 1270 | 1940 | 2410 | 3030 | 3520 | 4010 |
| 125 | B | 05244100 | Kitten Creek near Sebeka, Minnesota | 104 | 204 | 287 | 411 | 517 | 633 |
| 126 | B | 05244200 | Cat River near Nimrod, Minnesota | 176 | 304 | 403 | 541 | 654 | 774 |
| 127 | B | 05244440 | Leaf River near Aldrich, Minnesota | 1700 | 3020 | 4040 | 5470 | 6630 | 7850 |
| 128 | B | 05245100 | Long Prairie River at Long Prairie, Minnesota | 762 | 1250 | 1630 | 2170 | 2610 | 3100 |
| 129 | B | 05245800 | Sevenmile Creek near Pillager, Minnesota | 95.5 | 172 | 233 | 321 | 394 | 474 |
| 130 | B | 05261520 | Nokasippi River Below Fort Ripley, Minnesota | 405 | 684 | 886 | 1150 | 1360 | 1570 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 131 | D | 05267800 | Big Mink Creek Tributary near Lastrup, Minnesota | 11.8 | 27.9 | 43.0 | 67.4 | 89.4 | 115 |
| 132 | D | 05267900 | Hillman Creek near Pierz, Minnesota | 438 | 998 | 1480 | 2200 | 2800 | 3450 |
| 133 | D | 05268000 | Platte River at Royalton, Minnesota | 1250 | 2300 | 3040 | 3980 | 4670 | 5350 |
| 134 | D | 05270150 | Ashley Creek near Sauk Centre, Minnesota | 289 | 471 | 597 | 758 | 878 | 997 |
| 135 | D | 05270300 | Sauk River Tributary at Spring Hill, Minnesota | 175 | 353 | 525 | 818 | 1100 | 1460 |
| 136 | D | 05270310 | Sauk River Tributary #2 near St. Martin, Minnesota | 25.0 | 68.0 | 118 | 219 | 330 | 483 |
| 137 | D | 05270500 | Sauk River near St. Cloud, Minnesota | 1490 | 2640 | 3530 | 4780 | 5790 | 6870 |
| 138 | D | 05271800 | Johnson Creek Tributary at Luxemburg, Minnesota | 33.2 | 62.6 | 88.0 | 127 | 162 | 201 |
| 139 | D | 05272000 | Johnson Creek Tributary #2 near St. Augusta, Minnesota | 84.1 | 144 | 188 | 250 | 299 | 351 |
| 140 | D | 05272300 | Johnson Creek near St. Augusta, Minnesota | 295 | 580 | 819 | 1180 | 1480 | 1820 |
| 141 | D | 05272950 | Clearwater River near South Haven, Minnesota | 296 | 669 | 992 | 1480 | 1880 | 2330 |
| 142 | D | 05273700 | Otsego Creek near Otsego, Minnesota | 91.3 | 164 | 219 | 295 | 355 | 418 |
| 143 | D | 05274200 | Stony Brook Tributary near Foley, Minnesota | 44.5 | 96.6 | 142 | 210 | 269 | 334 |
| 144 | D | 05275000 | Elk River near Big Lake, Minnesota | 1580 | 2980 | 3990 | 5310 | 6290 | 7260 |
| 145 | D | 05276000 | North Fork Crow River near Regal, Minnesota | 816 | 1250 | 1560 | 1970 | 2290 | 2610 |
| 146 | D | 05276100 | North Fork Crow River Tributary near Paynesville, Minnesota | 19.1 | 35.5 | 48.7 | 67.9 | 84.0 | 101 |
| 147 | D | 05276200 | North Fork Crow River at Paynesville, Minnesota | 791 | 1390 | 1850 | 2490 | 3000 | 3550 |
| 148 | D | 05278000 | Middle Fork Crow River near Spicer, Minnesota | 203 | 347 | 447 | 572 | 664 | 753 |
| 149 | D | 05278120 | North Fork Crow River near Kingston, Minnesota | 1710 | 3570 | 5100 | 7300 | 9090 | 11000 |
| 150 | D | 05278350 | Fountain Creek near Montrose, Minnesota | 50.7 | 78.5 | 99.9 | 131 | 156 | 184 |
| 151 | D | 05278500 | South Fork Crow River at Cosmos, Minnesota | 339 | 682 | 986 | 1460 | 1890 | 2390 |
| 152 | D | 05278700 | Otter Creek near Lester Prairie, Minnesota | 113 | 222 | 315 | 453 | 572 | 704 |
| 153 | D | 05278750 | Otter Creek Tributary near Lester Prairie, Minnesota | 28.7 | 46.4 | 58.7 | 74.5 | 86.4 | 98.2 |
| 154 | D | 05278850 | Buffalo Creek Tributary near Brownton, Minnesota | 34.2 | 63.2 | 86.0 | 118 | 145 | 173 |
| 155 | D | 05278930 | Buffalo Creek near Glencoe, Minnesota | 1210 | 2210 | 3020 | 4170 | 5120 | 6160 |
| 156 | D | 05279000 | South Fork Crow River near Mayer, Minnesota | 2140 | 4460 | 6400 | 9290 | 11700 | 14400 |
| 157 | D | 05280000 | Crow River at Rockford, Minnesota | 3540 | 6990 | 9680 | 13400 | 16300 | 19400 |
| 158 | D | 05280300 | School Lake Creek Tributary near St. Michael, Minnesota | 30.8 | 70 | 110 | 179 | 248 | 333 |
| 159 | D | 05284100 | Mille Lacs Lake Tributary near Wealthwood, Minnesota | 13.8 | 29.7 | 43.5 | 64.4 | 82.3 | 102 |
| 160 | D | 05284600 | Robinson Brook near Onamia, Minnesota | 88.8 | 176 | 241 | 327 | 393 | 458 |
| 161 | D | 05284620 | Rum River Tributary near Onamia, Minnesota | 56.2 | 111 | 160 | 237 | 306 | 387 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 162 | D | 05284920 | Stanchfield Creek Tributary near Day, Minnesota | 36.0 | 68.7 | 94.4 | 130 | 159 | 190 |
| 163 | D | 05287890 | Elm Creek near Champlin, Minnesota | 281 | 480 | 615 | 784 | 906 | 1020 |
| 164 | D | 05289500 | Minnehaha Creek at Minnetonka Mills, Minnesota | 65.7 | 174 | 279 | 450 | 604 | 780 |
| 165 | D | 05290000 | Little Minnesota River Near Peever, SD | 770 | 1840 | 2880 | 4600 | 6200 | 8080 |
| 166 | D | 05291000 | Whetstone River Near Big Stone City, SD | 1290 | 3470 | 5500 | 8640 | 11300 | 14200 |
| 167 | D | 05293000 | Yellow Bank River near Odessa, Minnesota | 1270 | 2970 | 4410 | 6490 | 8170 | 9940 |
| 168 | D | 05294000 | Pomme De Terre River at Appleton, Minnesota | 729 | 1530 | 2230 | 3280 | 4200 | 5220 |
| 169 | D | 05299100 | Lazarus Creek Tributary near Canby, Minnesota | 111 | 301 | 478 | 748 | 975 | 1220 |
| 170 | D | 05300000 | Lac Qui Parle River near Lac Qui Parle, Minnesota | 1620 | 3750 | 5720 | 8880 | 11700 | 15000 |
| 171 | D | 05301200 | Minnesota River Tributary near Montevideo, Minnesota | 6.9 | 25.4 | 48.7 | 95.6 | 146 | 213 |
| 172 | D | 05302500 | Little Chippewa River near Starbuck, Minnesota | 114 | 181 | 226 | 282 | 323 | 363 |
| 173 | D | 05302970 | Outlet Creek Tributary near Starbuck, Minnesota | 10 | 20.7 | 29.8 | 43.1 | 54.3 | 66.3 |
| 174 | D | 05303450 | Hassel Creek near Clontarf, Minnesota | 53.5 | 93.8 | 128 | 179 | 224 | 275 |
| 175 | D | 05304000 | Shakopee Creek near Benson, Minnesota | 765 | 2120 | 3490 | 5810 | 7980 | 10500 |
| 176 | D | 05304500 | Chippewa River near Milan, Minnesota | 1960 | 4090 | 5880 | 8560 | 10800 | 13300 |
| 177 | D | 05305000 | Chippewa River near Watson, Minnesota | 512 | 2200 | 4620 | 10100 | 16500 | 25500 |
| 178 | D | 05305200 | Spring Creek near Montevideo, Minnesota | 113 | 267 | 405 | 620 | 806 | 1010 |
| 179 | D | 05311200 | North Branch Yellow Medicine River near Ivanhoe, Minnesota | 89.0 | 268 | 454 | 772 | 1070 | 1410 |
| 180 | D | 05311250 | North Branch Yellow Medicine River Tributary near Wilno, Minnesota | 16.9 | 32.8 | 44.9 | 61.3 | 74.0 | 86.9 |
| 181 | D | 05311300 | North Branch Yellow Medicine Tributary #2 near Porter, Minnesota | 93.0 | 137 | 168 | 210 | 242 | 276 |
| 182 | D | 05311400 | South Branch Yellow Medicine River at Minneota, Minnesota | 637 | 1470 | 2210 | 3340 | 4310 | 5380 |
| 183 | D | 05313500 | Yellow Medicine River near Granite Falls, Minnesota | 1430 | 3880 | 6250 | 10000 | 13400 | 17100 |
| 184 | D | 05313800 | Kandiyohi County Ditch #16 near Blomkest, Minnesota | 32.2 | 61.6 | 83.9 | 114 | 138 | 162 |
| 185 | D | 05314500 | Hawk Creek near Maynard, Minnesota | 1520 | 2500 | 3210 | 4150 | 4880 | 5620 |
| 186 | D | 05314900 | Redwood River at Ruthton, Minnesota | 117 | 279 | 421 | 632 | 808 | 996 |
| 187 | D | 05315000 | Redwood River near Marshall, Minnesota | 722 | 1720 | 2640 | 4080 | 5360 | 6790 |
| 188 | D | 05315200 | Prairie Ravine near Marshall, Minnesota | 38.5 | 77.9 | 110 | 156 | 194 | 234 |
| 189 | D | 05316500 | Redwood River near Redwood Falls, Minnesota | 1180 | 3350 | 5550 | 9230 | 12600 | 16500 |
| 190 | D | 05316550 | West Fork Beaver Creek near Olivia, Minnesota | 73.7 | 149 | 211 | 303 | 380 | 464 |
| 191 | D | 05316570 | Beaver Creek near Beaver Falls, Minnesota | 718 | 1120 | 1400 | 1770 | 2040 | 2320 |
| 192 | D | 05316690 | Spring Creek Tributary near Sleepy Eye, Minnesota | 39.0 | 78.3 | 110 | 154 | 190 | 228 |

Table 1.--Peak-flow frequency data for streamflow gaging stations.

[ft³/s, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 193 | D | 05316700 | Spring Creek near Sleepy Eye, Minnesota | 206 | 423 | 606 | 879 | 1110 | 1360 |
| 194 | D | 05316800 | Cottonwood River Tributary near Balaton, Minnesota | 36.8 | 117 | 204 | 359 | 508 | 687 |
| 195 | D | 05316850 | Meadow Creek Tributary near Marshall, Minnesota | 17.2 | 54.1 | 95.1 | 169 | 241 | 329 |
| 196 | D | 05316900 | Dry Creek near Jeffers, Minnesota | 133 | 298 | 448 | 683 | 892 | 1130 |
| 197 | D | 05316920 | Cottonwood River Tributary near Sanborn, Minnesota | 28.1 | 65.4 | 99.6 | 153 | 201 | 255 |
| 198 | D | 05316950 | Cottonwood River near Springfield, Minnesota | 2870 | 5730 | 8130 | 11700 | 14700 | 18000 |
| 199 | D | 05317000 | Cottonwood River near New Ulm, Minnesota | 3230 | 6880 | 10200 | 15600 | 20500 | 26300 |
| 200 | D | 05317200 | Little Cottonwood River near Courtland, Minnesota | 508 | 1000 | 1430 | 2090 | 2670 | 3340 |
| 201 | D | 05317845 | East Branch Blue Earth River near Walters, Minnesota | 369 | 468 | 527 | 594 | 641 | 685 |
| 202 | D | 05317850 | Foster Creek near Alden, Minnesota | 90.3 | 166 | 219 | 288 | 338 | 388 |
| 203 | D | 05318000 | East Branch Blue Earth River near Bricelyn, Minnesota | 373 | 761 | 1070 | 1510 | 1860 | 2220 |
| 204 | D | 05318100 | East Branch Blue Earth River Tributary near Blue Earth, Minnesota | 151 | 288 | 398 | 555 | 685 | 824 |
| 205 | D | 05318300 | Watonwan River near Delft, Minnesota | 104 | 329 | 606 | 1170 | 1790 | 2630 |
| 206 | D | 05318897 | South Fork Watonwan River near Ormsby, Minnesota | 450 | 1020 | 1520 | 2270 | 2910 | 3620 |
| 207 | D | 05319490 | Watonwan River Above Garden City, Minnesota | 3280 | 5340 | 6820 | 8780 | 10300 | 11800 |
| 208 | D | 05319500 | Watonwan River near Garden City, Minnesota | 2750 | 5160 | 7230 | 10400 | 13200 | 16400 |
| 209 | D | 05320000 | Blue Earth River near Rapidan, Minnesota | 6200 | 11800 | 16200 | 22300 | 27300 | 32500 |
| 210 | D | 05320200 | Le Sueur River Tributary near Mankato, Minnesota | 19.3 | 47.3 | 77.8 | 135 | 196 | 276 |
| 211 | D | 05320300 | Cobb River Tributary near Mapleton, Minnesota | 133 | 222 | 291 | 390 | 471 | 560 |
| 212 | D | 05320400 | Maple River Tributary near Mapleton, Minnesota | 140 | 348 | 567 | 963 | 1360 | 1870 |
| 213 | D | 05320440 | Judicial Ditch #49 near Amboy, Minnesota | 183 | 317 | 423 | 577 | 706 | 847 |
| 214 | D | 05320480 | Maple River near Rapidan, Minnesota | 2080 | 3080 | 3710 | 4470 | 5000 | 5510 |
| 215 | D | 05320500 | Le Sueur River near Rapidan, Minnesota | 4190 | 8010 | 11200 | 15800 | 19700 | 24100 |
| 216 | D | 05325100 | Minnesota River Tributary near North Mankato, Minnesota | 67.0 | 195 | 347 | 646 | 972 | 1410 |
| 217 | D | 05326100 | Middle Branch Rush River near Gaylord, Minnesota | 546 | 906 | 1150 | 1470 | 1700 | 1930 |
| 218 | D | 05327000 | High Island Creek near Henderson, Minnesota | 936 | 1670 | 2200 | 2880 | 3390 | 3890 |
| 219 | D | 05330150 | Sand Creek Tributary near Montogomery, Minnesota | 20.6 | 32.3 | 41.2 | 53.7 | 63.8 | 74.7 |
| 220 | D | 05330200 | Rice Lake Tributary near Montgomery, Minnesota | 49.9 | 88.4 | 118 | 158 | 189 | 223 |
| 221 | D | 05330300 | Sand Creek near New Prague, Minnesota | 259 | 474 | 646 | 896 | 1100 | 1330 |
| 222 | D | 05330550 | East Branch Raven Stream near New Prague, Minnesota | 164 | 272 | 359 | 489 | 601 | 726 |
| 223 | D | 05330600 | Sand Creek Tributary #2 near Jordan, Minnesota | 47.0 | 97.4 | 145 | 224 | 299 | 389 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 224 | D | 05330800 | Purgatory Creek at Eden Prairie, Minnesoa | 106 | 144 | 167 | 196 | 216 | 235 |
| 225 | D | 05330900 | Nine Mile Creek at Bloomington, Minnesota | 198 | 314 | 395 | 501 | 582 | 664 |
| 226 | D | 05335170 | Crooked Creek near Hinckley, Minnesota | 598 | 1160 | 1600 | 2220 | 2730 | 3260 |
| 227 | D | 05336200 | Glaisby Brook near Kettle River, Minnesota | 415 | 694 | 900 | 1180 | 1400 | 1630 |
| 228 | D | 05336300 | Moose River Tributary at Moose Lake, Minnesota | 72.5 | 146 | 210 | 310 | 398 | 498 |
| 229 | D | 05336550 | Wolf Creek Tributary near Sandstone, Minnesota | 53.6 | 124 | 186 | 278 | 356 | 441 |
| 230 | D | 05336600 | Kettle River Tributary at Sandstone, Minnesota | 16.4 | 34.4 | 49.2 | 70.6 | 88.1 | 107 |
| 231 | D | 05336700 | Kettle River Below Sandstone, Minnesota | 6520 | 10100 | 12600 | 15700 | 18000 | 20300 |
| 232 | D | 05338200 | Mission Creek near Hinckley, Minnesota | 73.0 | 121 | 155 | 200 | 235 | 271 |
| 233 | D | 05338500 | Snake River near Pine City, Minnesota | 4820 | 7670 | 9570 | 11900 | 13600 | 15300 |
| 234 | D | 05339747 | Goose Creek at Harris, Minnesota | 157 | 288 | 383 | 506 | 598 | 689 |
| 235 | D | 05340000 | Sunearise River near Stacy, Minnesota | 308 | 465 | 572 | 711 | 816 | 922 |
| 236 | D | 05345000 | Vermillion River near Empire, Minnesota | 767 | 1700 | 2610 | 4160 | 5650 | 7470 |
| 237 | D | 05345900 | Vermillion River Tributary near Hastings, Minnesota | 25.7 | 112 | 240 | 535 | 893 | 1410 |
| 238 | D | 05348550 | Cannon River Below Sabre Lake near Kilkenny, Minnesota | 240 | 401 | 518 | 677 | 801 | 929 |
| 239 | D | 05352700 | Turtle Creek Tributary #2 near Pratt, Minnesota | 56.8 | 120 | 174 | 251 | 316 | 385 |
| 240 | D | 05352800 | Turtle Creek Tributary near Steele Center, Minnesota | 97.2 | 186 | 257 | 358 | 440 | 528 |
| 241 | D | 05353800 | Straight River near Faribault, Minnesota | 2840 | 4370 | 5380 | 6630 | 7530 | 8410 |
| 242 | D | 05355024 | Cannon River at Northfield, Minnesota | 4060 | 6430 | 7980 | 9870 | 11200 | 12500 |
| 243 | D | 05355100 | Little Cannon River Tributary near Kenyon, Minnesota | 176 | 386 | 572 | 861 | 1110 | 1400 |
| 244 | D | 05355150 | Pine Creek near Cannon Falls, Minnesota | 154 | 349 | 518 | 774 | 990 | 1230 |
| 245 | D | 05355200 | Cannon River at Welch, Minnesota | 5920 | 10600 | 14500 | 20300 | 25300 | 30800 |
| 246 | D | 05355230 | Cannon River Tributary near Welch, Minnesota | 20.3 | 43.2 | 62.3 | 90.2 | 113 | 138 |
| 247 | F | 05372800 | South Fork Zumbro River On Belt Line at Rochester, Minnesota | 2140 | 4050 | 5680 | 8190 | 10400 | 12900 |
| 248 | F | 05372930 | Bear Creek at Rochester, Minnesota | 1120 | 2360 | 3600 | 5750 | 7880 | 10500 |
| 249 | F | 05372950 | Silver Creek at Rochester, Minnesota | 513 | 1200 | 1960 | 3460 | 5090 | 7320 |
| 250 | F | 05372990 | Cascade Creek at Rochester, Minnesota | 578 | 1060 | 1440 | 1980 | 2430 | 2920 |
| 251 | F | 05373080 | Milliken Creek near Concord, Minnesota | 323 | 480 | 583 | 710 | 803 | 894 |
| 252 | F | 05373350 | Zumbro River Tributary near South Troy, Minnesota | 30.1 | 64.4 | 94.6 | 141 | 182 | 229 |
| 253 | F | 05373700 | Spring Creek near Wanamingo, Minnesota | 431 | 951 | 1420 | 2140 | 2780 | 3510 |
| 254 | F | 05373900 | Trout Brook Tributary near Goodhue, Minnesota | 90.4 | 184 | 270 | 413 | 547 | 708 |

Table 1.--Peak-flow frequency data for streamflow gaging stations.

[ft$^3$/s, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in ft$^3$/s 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
|---|---|---|---|---|---|---|---|---|---|
| 255 | F | 05374000 | Zumbro River at Zumbro Falls, Minnesota | 10400 | 17100 | 21700 | 27200 | 31200 | 35000 |
| 256 | F | 05374400 | Long Creek near Potsdam, Minnesota | 196 | 370 | 513 | 724 | 902 | 1100 |
| 257 | F | 05374500 | Zumbro River at Theilman, Minnesota | 12200 | 18000 | 21900 | 26600 | 30000 | 33400 |
| 258 | F | 05376000 | North Fork Whitewater River near Elba, Minnesota | 1480 | 3640 | 5760 | 9340 | 12700 | 16700 |
| 259 | F | 05376500 | South Fork Whitewater River near Altura, Minnesota | 1540 | 3100 | 4280 | 5830 | 7010 | 8180 |
| 260 | F | 05376800 | Whitewater River near Beaver, Minnesota | 3260 | 6690 | 9510 | 13600 | 16900 | 20500 |
| 261 | F | 05378300 | Straight Valley Creek near Rollingstone, Minnesota | 268 | 674 | 1050 | 1630 | 2140 | 2710 |
| 262 | F | 05379000 | Gilmore Creek at Winona, Minnesota | 354 | 992 | 1680 | 2950 | 4210 | 5800 |
| 263 | F | 05383600 | North Branch Root River Tributary near Stewartville, Minnesota | 68.2 | 153 | 232 | 358 | 472 | 604 |
| 264 | F | 05383700 | Mill Creek Tributary near Chatfield, Minnesota | 405 | 595 | 723 | 885 | 1010 | 1130 |
| 265 | F | 05383720 | Mill Creek near Chatfield, Minnesota | 1360 | 2650 | 3810 | 5700 | 7450 | 9520 |
| 266 | F | 05383850 | South Fork Bear Creek near Grand Meadow, Minnesota | 683 | 1380 | 1980 | 2910 | 3730 | 4660 |
| 267 | F | 05384000 | Root River near Lanesboro, Minnesota | 7800 | 13000 | 16700 | 21400 | 24900 | 28400 |
| 268 | F | 05384100 | Duschee Creek near Lanesboro, Minnesota | 214 | 569 | 925 | 1530 | 2090 | 2750 |
| 269 | F | 05384150 | Root River Tributary near Whalan, Minnesota | 27.6 | 67.4 | 107 | 173 | 236 | 311 |
| 270 | F | 05384200 | Gribben Creek near Whalen, Minnesota | 610 | 1610 | 2680 | 4600 | 6530 | 8940 |
| 271 | F | 05384300 | Big Springs Creek near Arendahl, Minnesota | 17.8 | 45.8 | 74.3 | 124 | 171 | 229 |
| 272 | F | 05384350 | Root River at Rushford, Minnesota | 6270 | 10100 | 12900 | 16700 | 19700 | 22800 |
| 273 | F | 05384400 | Pine Creek near Arendahl, Minnesota | 823 | 1890 | 2780 | 4060 | 5080 | 6160 |
| 274 | F | 05384500 | Rush Creek near Rushford, Minnesota | 2060 | 4460 | 6550 | 9720 | 12400 | 15500 |
| 275 | F | 05385000 | Root River near Houston, Minnesota | 9910 | 17000 | 22000 | 28600 | 33500 | 38500 |
| 276 | F | 05385500 | South Fork Root River near Houston, Minnesota | 2420 | 5100 | 7470 | 11200 | 14400 | 18100 |
| 277 | F | 05386000 | Root River Below South Fork near Houston, Minnesota | 13400 | 22200 | 28700 | 37700 | 44800 | 52200 |
| 278 | F | 05387030 | Crooked Creek at Freeburg, Minnesota | 425 | 1050 | 1640 | 2590 | 3440 | 4410 |
| 279 | F | 05457000 | Cedar River near Austin, Minnesota | 4030 | 6930 | 8860 | 11200 | 12800 | 14400 |
| 280 | F | 05457080 | Rose Creek Tributary near Dexter, Minnesota | 99.8 | 196 | 280 | 411 | 527 | 660 |
| 281 | F | 05457778 | Little Cedar River near Johnsburg, Minnesota | 1440 | 2420 | 3100 | 3980 | 4640 | 5300 |
| 282 | F | 05458960 | Bancroft Creek at Bancroft, Minnesota | 237 | 395 | 513 | 674 | 802 | 936 |
| 283 | D | 05474750 | Beaver Creek Tributary #2 near Slayton, Minnesota | 79.0 | 135 | 177 | 238 | 288 | 341 |
| 284 | D | 05474760 | Beaver Creek Tributary Above Slayton, Minnesota | 52.9 | 94.2 | 125 | 166 | 197 | 230 |
| 285 | D | 05475400 | Warren Lake Tributary near Windom, Minnesota | 42.5 | 103 | 166 | 280 | 396 | 543 |

## Table 1.--Peak-flow frequency data for streamflow gaging stations.

[ft$^3$/s, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in ft$^3$/s | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 286 | D | 05475800 | Des Moines River Tributary near Jackson, Minnesota | 24.1 | 49.5 | 70.4 | 101 | 126 | 153 |
| 287 | D | 05475900 | Des Moines River Tributary #2 near Lakefield, Minnesota | 73.7 | 120 | 153 | 194 | 226 | 258 |
| 288 | D | 05476000 | Des Moines River at Jackson, Minnesota | 1710 | 3630 | 5290 | 7850 | 10100 | 12600 |
| 289 | D | 05476010 | Nelson Creek at Jackson, Minnesota | 359 | 807 | 1240 | 1960 | 2640 | 3460 |
| 290 | D | 05476100 | Story Brook near Petersburg, Minnesota | 646 | 1390 | 2040 | 3010 | 3840 | 4760 |
| 291 | D | 05476900 | Fourmile Creek near Dunnell, Minnesota | 223 | 531 | 830 | 1330 | 1800 | 2350 |
| 292 | D | 05476989 | East Fork Des Moines River near Ceylon, Minnesota | 517 | 960 | 1300 | 1770 | 2150 | 2540 |
| 293 | E | 06479215 | Big SIOUX RIVER near Florence, South Dakota | 292 | 956 | 1650 | 2790 | 3820 | 4960 |
| 294 | E | 06479240 | Big Sioux River Tributary No 2 near Summit, South Dakota | 8.9 | 24.5 | 40.4 | 67.5 | 93.1 | 123 |
| 295 | E | 06479260 | Big Sioux River Tributary No 3 near Summit, South Dakota | 93.8 | 331 | 591 | 1040 | 1440 | 1910 |
| 296 | E | 06479350 | Soo Creek Tributary near South Shore, South Dakota | 44.3 | 129 | 222 | 388 | 552 | 754 |
| 297 | E | 06479515 | Willow Creek near Watertown, South Dakota | 698 | 1770 | 2830 | 4590 | 6240 | 8190 |
| 298 | E | 06479529 | Stray Horse Creek near Castlewood, South Dakota | 832 | 2310 | 3910 | 6790 | 9660 | 13200 |
| 299 | E | 06479640 | Hidewood Creek near Estelline, South Dakota | 905 | 2340 | 3830 | 6480 | 9100 | 12300 |
| 300 | E | 06479750 | Peg Munky Run near Estelline, South Dakota | 259 | 793 | 1340 | 2240 | 3060 | 3980 |
| 301 | E | 06479800 | North Deer Creek near Estelline, South Dakota | 171 | 711 | 1500 | 3330 | 5580 | 8870 |
| 302 | E | 06479810 | North Deer Creek Tributary near Brookings, South Dakota | 24.3 | 79.4 | 144 | 268 | 396 | 559 |
| 303 | E | 06479900 | Sixmile Creek Tributary near Brookings, South Dakota | 114 | 447 | 865 | 1680 | 2520 | 3590 |
| 304 | E | 06479910 | Sixmile Creek near Brookings, South Dakota | 330 | 652 | 902 | 1250 | 1520 | 1800 |
| 305 | E | 06479950 | Deer Creek near Brookings, South Dakota | 55.5 | 250 | 505 | 1010 | 1520 | 2160 |
| 306 | E | 06479980 | Medary Creek near Brookings, South Dakota | 802 | 1790 | 2660 | 3990 | 5130 | 6390 |
| 307 | E | 06480400 | Spring Creek near Flandreau, South Dakota | 598 | 1570 | 2520 | 4080 | 5500 | 7140 |
| 308 | E | 06480650 | Flandreau Creek above Flandreau, South Dakota | 1020 | 1890 | 2510 | 3290 | 3850 | 4400 |
| 309 | E | 06480720 | Bachelor Creek Tributary near Wentworth, South Dakota | 12.1 | 34.1 | 56.0 | 92.1 | 125 | 162 |
| 310 | E | 06482600 | West Pipestone Creek Tributary near Garretson, South Dakota | 134 | 433 | 745 | 1260 | 1720 | 2230 |
| 311 | E | 06482610 | Split Rock Creek at Corson, South Dakota | 2390 | 5660 | 8910 | 14500 | 19900 | 26400 |
| 312 | E | 06482870 | Little Beaver Creek Tributary near Canton, South Dakota | 25.0 | 43.7 | 58.6 | 80.3 | 98.5 | 119 |
| 313 | E | 06482933 | Chanarambi Creek near Edgerton, Minnesota | 233 | 538 | 796 | 1170 | 1480 | 1800 |
| 314 | E | 06482950 | Mound Creek near Hardwick, Minnesota | 39.1 | 109 | 184 | 321 | 458 | 629 |
| 315 | E | 06482960 | Mound Creek Tributary at Hardwick, Minnesota | 37.4 | 112 | 188 | 312 | 422 | 547 |
| 316 | E | 06483000 | Rock River at Luverne, Minnesota | 1960 | 4370 | 6700 | 10600 | 14400 | 19000 |

Table 1.--Peak-flow frequency data for streamflow gaging stations.

[$ft^3/s$, cubic feet per second]

| Site number (figure 1) | Region identifier | Station number | Station name | Peak flow at specified recurrence intervals, in $ft^3/s$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 317 | E | 06483050 | Rock River Tributary near Luverne, Minnesota | 34.4 | 104 | 179 | 312 | 443 | 601 |
| 318 | E | 06483200 | Kanaranzi Creek Tributary near Lismore, Minnesota | 96.7 | 177 | 241 | 334 | 411 | 495 |
| 319 | E | 06483210 | Kanaranzi Creek Tributary #2 near Wilmont, Minnesota | 128 | 328 | 510 | 787 | 1020 | 1280 |
| 320 | E | 06483270 | Rock River at Rock Rapids, Iowa | 3850 | 8750 | 13200 | 20200 | 26400 | 33500 |
| 321 | E | 06483460 | Otter Creek near Ashton, Iowa | 840 | 2360 | 4110 | 7470 | 11100 | 15800 |
| 322 | E | 06600100 | Floyd River at Alton, Iowa | 1810 | 5100 | 8560 | 14600 | 20400 | 27500 |
| 323 | E | 06600300 | West Branch Floyd River near Struble, Iowa | 2160 | 4810 | 6950 | 9930 | 12300 | 14600 |
| 324 | E | 06603000 | Little Sioux River near Lakefield, Minnesota | 73.5 | 276 | 551 | 1150 | 1860 | 2860 |
| 325 | E | 06603500 | Jackson County Ditch #11 near Lakefield, Minnesota | 43.7 | 203 | 444 | 1010 | 1710 | 2720 |
| 326 | E | 06603520 | Judicial Ditch #28 Tributary near Spafford, Minnesota | 46.1 | 110 | 174 | 284 | 391 | 521 |
| 327 | E | 06603530 | Little Sioux River near Spafford, Minnesota | 276 | 790 | 1370 | 2480 | 3630 | 5130 |
| 328 | E | 06605340 | Prairie Creek near Spencer, Iowa | 328 | 817 | 1250 | 1900 | 2440 | 3010 |

## Table 2.--Basin characteristics for streamflow gaging stations.

[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 1 | 609 | 11.2 | 19.3 | 11.6 | 11.7 |
| 2 | 6.97 | 55.2 | 21.8 | 3.0 | 12.2 |
| 3 | 0.47 | 127 | 17.0 | .0 | 12.2 |
| 4 | 87.6 | 26.5 | 27.2 | 5.5 | 12.2 |
| 5 | 114 | 20.9 | 27.4 | 7.3 | 12.7 |
| 6 | 1.58 | 214 | 16.6 | .0 | 13.2 |
| 7 | 22.6 | 56.4 | 15.1 | .0 | 13.4 |
| 8 | 137 | 44.7 | 29.4 | 0.7 | 13.9 |
| 9 | 1.04 | 111 | 25.8 | 0.0 | 14.2 |
| 10 | 3.62 | 145 | 0.8 | 0.0 | 14.6 |
| 11 | 4.96 | 56.2 | 13.0 | 0.0 | 14.6 |
| 12 | 83.6 | 39.1 | 17.6 | 0.0 | 14.2 |
| 13 | 1.44 | 144 | 3.1 | 0.0 | 14.4 |
| 14 | 5.86 | 85.1 | 12.9 | 0.0 | 14.4 |
| 15 | 4.91 | 25.9 | 18.3 | 0.0 | 12.5 |
| 16 | 23.4 | 7.9 | 17.7 | 1.6 | 10.2 |
| 17 | 159 | 7.8 | 33.4 | 2.7 | 10.2 |
| 18 | 293 | 7.2 | 43.1 | 3.2 | 10.0 |
| 19 | 95.4 | 3.6 | 37.7 | 2.8 | 10.1 |
| 20 | 0.37 | 251 | 4.7 | 0.0 | 9.0 |
| 21 | 4.46 | 23.7 | 8.9 | 1.2 | 8.6 |
| 22 | 40.9 | 6.4 | 17.8 | 2.6 | 8.3 |
| 23 | 67.3 | 8.7 | 18.7 | 3.4 | 8.3 |
| 24 | 131 | 6.7 | 31.4 | 1.6 | 8.4 |
| 25 | 17.1 | 7.3 | 47.9 | 0.3 | 12.2 |
| 26 | 24.8 | 12.0 | 30.5 | 0.0 | 9.3 |
| 27 | 40.8 | 16.7 | 54.8 | 1.1 | 13.2 |
| 28 | 127 | 13.2 | 27.3 | 1.3 | 12.4 |
| 29 | 7.7 | 45.5 | 15.9 | 0.0 | 12.4 |
| 30 | 4.85 | 40.5 | 1.9 | 0.0 | 12.5 |
| 31 | 0.49 | 36.9 | 14.2 | 0.0 | 12.5 |
| 32 | 19.9 | 43.9 | 15.8 | 0.3 | 12.4 |
| 33 | 218 | 4.6 | 33.9 | 15.2 | 3.4 |
| 34 | 125 | 4.7 | 30.1 | 14.9 | 2.8 |
| 35 | 486 | 2.2 | 27.4 | 15.2 | 1.9 |
| 36 | 9.22 | 11.5 | 1.9 | 0.0 | 1.6 |
| 37 | 810 | 2.1 | 6.9 | 1.5 | 1.6 |
| 38 | 47.1 | 5.5 | 1.7 | 0.0 | 1.5 |
| 39 | 99.2 | 4.8 | 5.6 | 1.6 | 1.5 |
| 40 | 76.4 | 9.5 | 29.9 | 10.1 | 2.9 |
| 41 | 325 | 6.2 | 17.0 | 4.9 | 1.7 |
| 42 | 76.3 | 17.8 | 12.8 | 3.1 | 1.5 |
| 43 | 7.93 | 14.7 | 5.5 | 0.0 | 1.4 |
| 44 | 305 | 5.6 | 7.9 | 1.0 | 1.0 |
| 45 | 975 | 2.6 | 10.9 | 2.3 | 1.0 |

Table 2.--Basin characteristics for streamflow gaging stations.

[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 46 | 4.0 | 11.2 | 5.6 | 0.0 | 4.2 |
| 47 | 13.0 | 4.1 | 5.7 | 0.0 | 2.9 |
| 48 | 934 | 4.2 | 18.8 | 4.2 | 2.3 |
| 49 | 4.75 | 17.7 | 7.7 | 0.0 | 2.1 |
| 50 | 50.1 | 12.7 | 7.4 | 0.0 | 2.1 |
| 51 | 4.99 | 3.0 | 21.7 | 0.0 | 2.9 |
| 52 | 1560 | 4.4 | 13.5 | 2.6 | 0.9 |
| 53 | 220 | 7.3 | 4.3 | 0.1 | 1.2 |
| 54 | 420 | 4.8 | 8.4 | 1.5 | 1.3 |
| 55 | 2.8 | 8.8 | 28.8 | 2.2 | 5.7 |
| 56 | 8.23 | 14.3 | 32.5 | 0.4 | 5.5 |
| 57 | 1.16 | 10.3 | 72.2 | 0.0 | 5.6 |
| 58 | 150 | 3.1 | 48.1 | 0.0 | 3.9 |
| 59 | 985 | 1.9 | 55.2 | 1.3 | 3.2 |
| 60 | 2.35 | 5.5 | 0.1 | 0.0 | 3.4 |
| 61 | 46.2 | 11.1 | 18.3 | 2.3 | 4.6 |
| 62 | 555 | 3.4 | 23.2 | 1.3 | 3.7 |
| 63 | 51.3 | 6.0 | 21.5 | 5.4 | 4.6 |
| 64 | 5.05 | 36.7 | 20.4 | 0.0 | 4.5 |
| 65 | 6.18 | 34.2 | 16.2 | 1.1 | 4.6 |
| 66 | 254 | 4.9 | 17.2 | 1.2 | 4.1 |
| 67 | 6.61 | 13.2 | 5.2 | 0.0 | 3.5 |
| 68 | 1380 | 5.3 | 18.9 | 2.0 | 3.1 |
| 69 | 134 | 11.1 | 13.3 | 0.1 | 1.7 |
| 70 | 88.8 | 9.3 | 14.6 | 0.0 | 2.9 |
| 71 | 255 | 4.3 | 11.3 | 0.0 | 1.9 |
| 72 | 422 | 4.0 | 13.4 | 0.2 | 2.4 |
| 73 | 637 | 4.3 | 12.7 | 0.1 | 2.0 |
| 74 | 38.3 | 3.9 | 17.9 | 0.0 | 2.4 |
| 75 | 92.8 | 1.7 | 43.7 | 0.0 | 2.4 |
| 76 | 219 | 3.3 | 36.8 | 0.0 | 3.4 |
| 77 | 424 | 3.3 | 48.6 | 0.2 | 3.3 |
| 78 | 176 | 5.1 | 15.8 | 0.0 | 3.2 |
| 79 | 83.0 | 13.2 | 7.2 | 0.0 | 3.1 |
| 80 | 1090 | 2.0 | 35.9 | 0.1 | 3.1 |
| 81 | 1420 | 1.3 | 36.7 | 0.2 | 2.6 |
| 82 | 254 | 7.3 | 27.0 | 11.4 | 11.3 |
| 83 | 339 | 7.3 | 29.9 | 4.7 | 11.6 |
| 84 | 214 | 7.8 | 46.4 | 3.5 | 11.8 |
| 85 | 215 | 9.8 | 46.3 | 3.5 | 11.6 |
| 86 | 55.1 | 13.0 | 36.7 | 0.3 | 11.3 |
| 87 | 65.6 | 4.5 | 37.9 | 9.0 | 10.9 |
| 88 | 68.9 | 13.3 | 31.9 | 21.4 | 10.5 |
| 89 | 5.99 | 45.1 | 29.4 | 0.0 | 10.5 |
| 90 | 8.6 | 28.2 | 30.3 | 9.0 | 10.6 |

Table 2.--Basin characteristics for streamflow gaging stations.

[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 91 | 2.84 | 48.4 | 18.1 | 1.1 | 10.7 |
| 92 | 0.7 | 109 | 3.3 | 0.0 | 8.8 |
| 93 | 118 | 4.2 | 35.2 | 1.8 | 9.7 |
| 94 | 2.71 | 17.9 | 41.1 | 3.5 | 9.8 |
| 95 | 490 | 1.8 | 39.2 | 17.4 | 9.5 |
| 96 | 905 | 3.0 | 34.4 | 12.8 | 9.1 |
| 97 | 68.2 | 3.3 | 56.0 | 1.7 | 9.1 |
| 98 | 7.95 | 4.5 | 45.4 | 15.4 | 8.9 |
| 99 | 13.7 | 13.6 | 26.8 | 0.3 | 8.7 |
| 100 | 180 | 7.3 | 32.5 | 4.1 | 8.8 |
| 101 | 50.6 | 10.7 | 29.4 | 8.9 | 8.8 |
| 102 | 1680 | 1.7 | 40.0 | 2.0 | 7.7 |
| 103 | 606 | 0.4 | 45.0 | 9.0 | 6.7 |
| 104 | 25.7 | 11.0 | 38.7 | 0.0 | 6.9 |
| 105 | 1480 | 1.0 | 46.1 | 5.3 | 7.4 |
| 106 | 174 | 2.4 | 94.7 | 0.0 | 6.1 |
| 107 | 542 | 2.8 | 95.1 | 0.0 | 6.3 |
| 108 | 140 | 4.3 | 86.7 | 0.2 | 5.5 |
| 109 | 170 | 5.8 | 77.6 | 0.1 | 3.5 |
| 110 | 11.8 | 7.0 | 17.3 | 0.0 | 3.6 |
| 111 | 54.1 | 5.4 | 61.0 | 0.0 | 3.6 |
| 112 | 36.0 | 6.3 | 15.3 | 2.5 | 4.5 |
| 113 | 358 | 2.4 | 18.5 | 2.6 | 4.8 |
| 114 | 289 | 1.8 | 35.4 | 18.1 | 5.9 |
| 115 | 8.01 | 39.0 | 22.4 | 0.8 | 7.2 |
| 116 | 371 | 2.7 | 35.5 | 5.9 | 7.8 |
| 117 | 10.1 | 43.4 | 16.1 | 1.0 | 8.4 |
| 118 | 3.87 | 12.9 | 30.1 | 2.1 | 8.1 |
| 119 | 239 | 2.8 | 29.8 | 7.5 | 8.1 |
| 120 | 1.46 | 11.8 | 27.7 | 0.0 | 8.1 |
| 121 | 523 | 2.1 | 44.9 | 2.6 | 7.8 |
| 122 | 261 | 3.3 | 27.3 | 7.5 | 6.1 |
| 123 | 8.28 | 5.5 | 36.0 | 25.6 | 6.6 |
| 124 | 1030 | 2.9 | 21.1 | 6.1 | 5.7 |
| 125 | 18.9 | 14.1 | 20.2 | 0.5 | 5.2 |
| 126 | 57.1 | 6.3 | 29.4 | 0.2 | 5.6 |
| 127 | 870 | 1.5 | 23.3 | 1.1 | 5.9 |
| 128 | 434 | 1.2 | 25.4 | 10.7 | 5.4 |
| 129 | 20.1 | 14.8 | 15.0 | 0.1 | 6.0 |
| 130 | 193 | 2.1 | 28.2 | 4.6 | 6.2 |
| 131 | 1.31 | 23.2 | 19.1 | 0.0 | 6.6 |
| 132 | 45.0 | 8.2 | 29.7 | 0.0 | 6.5 |
| 133 | 432 | 4.0 | 27.4 | 2.0 | 5.8 |
| 134 | 119 | 4.0 | 14.1 | 1.9 | 4.9 |
| 135 | 7.11 | 16.1 | 4.8 | 0.0 | 4.7 |

Table 2.--Basin characteristics for streamflow gaging stations.
[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 136 | 0.26 | 77.5 | 1.0 | 0.0 | 4.8 |
| 137 | 1030 | 2.5 | 16.9 | 4.2 | 5.4 |
| 138 | 3.89 | 7.4 | 24.3 | 0.0 | 5.2 |
| 139 | 14.5 | 16.1 | 23.0 | 1.4 | 5.2 |
| 140 | 45.6 | 13.0 | 21.9 | 0.6 | 5.3 |
| 141 | 78.8 | 10.4 | 17.3 | 2.5 | 4.9 |
| 142 | 3.09 | 23.4 | 10.1 | 0.0 | 5.5 |
| 143 | 2.63 | 9.6 | 20.7 | 0.0 | 6.0 |
| 144 | 559 | 3.1 | 20.7 | 1.3 | 5.5 |
| 145 | 213 | 4.2 | 16.8 | 0.9 | 4.4 |
| 146 | 0.49 | 44.4 | 8.4 | 0.0 | 4.4 |
| 147 | 243 | 4.5 | 16.9 | 0.8 | 4.5 |
| 148 | 163 | 3.6 | 30.7 | 10.6 | 4.1 |
| 149 | 779 | 3.4 | 20.5 | 4.7 | 4.6 |
| 150 | 8.83 | 4.8 | 28.6 | 7.7 | 5.0 |
| 151 | 240 | 2.4 | 14.2 | 6.2 | 4.0 |
| 152 | 31.3 | 3.2 | 14.4 | 1.7 | 4.7 |
| 153 | 1.09 | 17.5 | 2.4 | 0.0 | 4.7 |
| 154 | 9.24 | 3.5 | 16.2 | 8.8 | 4.2 |
| 155 | 373 | 2.1 | 7.7 | 1.5 | 4.5 |
| 156 | 1160 | 1.8 | 11.7 | 3.2 | 4.9 |
| 157 | 2640 | 2.7 | 17.4 | 4.6 | 5.2 |
| 158 | 8.83 | 11.0 | 24.8 | 12.8 | 5.3 |
| 159 | 0.54 | 36.3 | 21.0 | 0.0 | 7.8 |
| 160 | 4.73 | 9.8 | 33.1 | 0.0 | 7.6 |
| 161 | 2.33 | 13.1 | 29.4 | 0.0 | 7.6 |
| 162 | 1.34 | 34.5 | 14.9 | 0.0 | 7.2 |
| 163 | 86.0 | 8.2 | 22.9 | 1.9 | 5.3 |
| 164 | 128 | 0.9 | 36.6 | 22.8 | 5.5 |
| 165 | 438 | 5.0 | 3.8 | 1.0 | 1.3 |
| 166 | 398 | 7.3 | 2.4 | 1.4 | 1.1 |
| 167 | 459 | 15.0 | 3.3 | 1.7 | 1.2 |
| 168 | 864 | 2.1 | 12.0 | 7.6 | 1.9 |
| 169 | 2.95 | 55.2 | 2.7 | 0.0 | 1.3 |
| 170 | 960 | 4.9 | 3.7 | 1.1 | 2.1 |
| 171 | 0.4 | 7.9 | 5.8 | 0.0 | 2.4 |
| 172 | 96.2 | 6.5 | 17.7 | 11.1 | 3.3 |
| 173 | 0.57 | 53.5 | 0.5 | 0.0 | 3.3 |
| 174 | 7.24 | 38.1 | 3.6 | 0.3 | 3.1 |
| 175 | 308 | 4.0 | 9.9 | 4.1 | 2.8 |
| 176 | 1880 | 3.0 | 12.5 | 5.5 | 2.4 |
| 177 | 2050 | 2.9 | 11.6 | 5.1 | 2.4 |
| 178 | 15.8 | 5.7 | 1.7 | 0.0 | 2.6 |
| 179 | 14.7 | 8.5 | 2.4 | 0.8 | 1.3 |
| 180 | 0.33 | 84.6 | 0.0 | 0.0 | 1.4 |

Table 2.--Basin characteristics for streamflow gaging stations.

[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 181 | 3.72 | 29.9 | 0.6 | 0.0 | 1.4 |
| 182 | 115 | 12.3 | 2.7 | 0.9 | 2.0 |
| 183 | 664 | 8.4 | 2.3 | 0.9 | 3.0 |
| 184 | 0.83 | 15.6 | 0.0 | 0.0 | 3.6 |
| 185 | 315 | 2.5 | 6.6 | 3.6 | 3.1 |
| 186 | 6.43 | 23.3 | 0.1 | 0.0 | 1.9 |
| 187 | 259 | 9.4 | 4.4 | 2.9 | 2.4 |
| 188 | 5.56 | 11.6 | 0.9 | 0.0 | 2.5 |
| 189 | 629 | 7.0 | 2.7 | 1.6 | 3.5 |
| 190 | 8.75 | 4.3 | 6.8 | 1.0 | 3.7 |
| 191 | 191 | 3.6 | 0.9 | 0.1 | 3.7 |
| 192 | 4.13 | 7.7 | 0.0 | 0.0 | 3.9 |
| 193 | 32.8 | 2.7 | 0.0 | 0.0 | 3.9 |
| 194 | 0.9 | 34.8 | 0.0 | 0.0 | 2.2 |
| 195 | 0.47 | 54.9 | 0.0 | 0.0 | 2.7 |
| 196 | 3.16 | 47.2 | 0.0 | 0.0 | 3.6 |
| 197 | 0.38 | 44.2 | 0.1 | 0.1 | 3.7 |
| 198 | 777 | 6.0 | 1.5 | 0.7 | 3.7 |
| 199 | 1300 | 4.8 | 1.6 | 0.6 | 4.2 |
| 200 | 170 | 6.9 | 2.7 | 0.5 | 4.2 |
| 201 | 30.2 | 12.9 | 0.2 | 0.0 | 5.8 |
| 202 | 2.34 | 26.3 | 0.0 | 0.0 | 6.1 |
| 203 | 120 | 5.8 | 4.6 | 2.6 | 5.6 |
| 204 | 9.66 | 9.1 | 0.0 | 0.0 | 4.9 |
| 205 | 13.5 | 14.6 | 2.0 | 0.6 | 3.7 |
| 206 | 107 | 6.3 | 2.5 | 1.9 | 4.2 |
| 207 | 843 | 5.1 | 2.5 | 1.4 | 4.4 |
| 208 | 851 | 4.9 | 2.5 | 1.4 | 4.4 |
| 209 | 2410 | 2.2 | 2.0 | 1.3 | 4.5 |
| 210 | 0.06 | 103 | 0.0 | 0.0 | 4.8 |
| 211 | 8.21 | 7.9 | 0.0 | 0.0 | 4.9 |
| 212 | 5.74 | 10.0 | 0.1 | 0.0 | 4.8 |
| 213 | 19.0 | 9.6 | 0.7 | 0.2 | 4.6 |
| 214 | 338 | 2.7 | 3.0 | 2.2 | 4.7 |
| 215 | 1110 | 4.1 | 4.2 | 2.3 | 4.6 |
| 216 | 0.23 | 219 | 0.0 | 0.0 | 4.6 |
| 217 | 67.3 | 3.5 | 0.3 | 0.0 | 4.3 |
| 218 | 238 | 3.5 | 3.9 | 2.3 | 4.6 |
| 219 | 0.35 | 75.3 | 0.0 | 0.0 | 5.6 |
| 220 | 3.18 | 13.8 | 17.4 | 0.1 | 5.5 |
| 221 | 62.2 | 2.3 | 12.5 | 4.7 | 5.4 |
| 222 | 22.2 | 10.5 | 5.7 | 1.0 | 5.3 |
| 223 | 2.76 | 17.1 | 0.7 | 0.0 | 5.2 |
| 224 | 27.2 | 8.3 | 13.2 | 5.0 | 5.5 |
| 225 | 45.4 | 7.7 | 9.9 | 5.3 | 5.7 |

Table 2.--Basin characteristics for streamflow gaging stations.
[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 226 | 94.4 | 12.1 | 31.6 | 1.0 | 11.0 |
| 227 | 27.0 | 12.2 | 43.5 | 0.0 | 9.6 |
| 228 | 1.45 | 25.5 | 20.6 | 0.0 | 9.6 |
| 229 | 4.02 | 8.6 | 16.0 | 0.0 | 10.0 |
| 230 | 0.55 | 24.2 | 18.7 | 0.0 | 10.0 |
| 231 | 868 | 5.9 | 35.7 | 1.6 | 10.0 |
| 232 | 4.12 | 22.9 | 26.7 | 0.0 | 9.6 |
| 233 | 974 | 4.4 | 30.6 | 1.2 | 9.2 |
| 234 | 47.3 | 2.8 | 33.7 | 5.2 | 7.5 |
| 235 | 163 | 2.2 | 38.9 | 7.1 | 6.7 |
| 236 | 129 | 8.2 | 11.6 | 1.3 | 5.9 |
| 237 | 15.5 | 6.8 | 0.5 | 0.0 | 5.9 |
| 238 | 87.9 | 1.9 | 20.7 | 6.5 | 5.5 |
| 239 | 1.26 | 35.6 | 1.3 | 0.0 | 6.5 |
| 240 | 5.0 | 15.3 | 0.2 | 0.0 | 6.5 |
| 241 | 435 | 3.4 | 4.0 | 0.6 | 6.3 |
| 242 | 929 | 4.2 | 9.6 | 3.4 | 6.0 |
| 243 | 2.12 | 49.2 | 2.2 | 0.0 | 6.1 |
| 244 | 20.5 | 12.6 | 0.8 | 0.0 | 6.0 |
| 245 | 1340 | 4.9 | 8.1 | 2.6 | 5.9 |
| 246 | 0.07 | 193 | 0.0 | 0.0 | 5.9 |
| 247 | 155 | 7.4 | 4.1 | 0.1 | 6.6 |
| 248 | 78.8 | 17.6 | 2.9 | 0.0 | 6.6 |
| 249 | 17.7 | 26.1 | 2.6 | 0.0 | 6.5 |
| 250 | 38.2 | 14.3 | 1.7 | 0.1 | 6.6 |
| 251 | 22.1 | 5.2 | 0.7 | 0.0 | 6.5 |
| 252 | 0.11 | 152 | 0.0 | 0.0 | 6.2 |
| 253 | 10.0 | 18.9 | 1.5 | 0.0 | 6.2 |
| 254 | 0.37 | 88.3 | 1.3 | 0.0 | 6.0 |
| 255 | 1150 | 6.8 | 2.4 | 0.2 | 6.0 |
| 256 | 4.44 | 44.0 | 0.0 | 0.0 | 5.9 |
| 257 | 1340 | 5.7 | 2.2 | 0.2 | 5.5 |
| 258 | 101 | 11.3 | 1.2 | 0.0 | 5.8 |
| 259 | 77.4 | 15.9 | 1.2 | 0.0 | 5.7 |
| 260 | 271 | 12.1 | 1.8 | 0.0 | 5.5 |
| 261 | 5.02 | 91.7 | 0.4 | 0.0 | 5.5 |
| 262 | 9.04 | 84.7 | 0.3 | 0.0 | 6.1 |
| 263 | 0.74 | 50.1 | 2.3 | 0.0 | 7.1 |
| 264 | 2.39 | 71.3 | 0.3 | 0.0 | 6.9 |
| 265 | 22.6 | 49.8 | 0.8 | 0.0 | 7.0 |
| 266 | 14.1 | 13.1 | 2.9 | 0.0 | 7.0 |
| 267 | 615 | 5.8 | 1.5 | 0.0 | 7.4 |
| 268 | 3.86 | 18.6 | 0.3 | 0.0 | 7.6 |
| 269 | 0.09 | 237 | 0.0 | 0.0 | 7.5 |
| 270 | 7.78 | 73.7 | 0.2 | 0.0 | 7.6 |

Table 2.--Basin characteristics for streamflow gaging stations.
[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 271 | 0.15 | 82.9 | 0.0 | 0.0 | 7.1 |
| 272 | 992 | 5.6 | 1.4 | 0.0 | 7.5 |
| 273 | 28.2 | 16.1 | 0.2 | 0.0 | 7.0 |
| 274 | 132 | 20.1 | 0.4 | 0.0 | 7.2 |
| 275 | 1250 | 6.2 | 1.3 | 0.0 | 8.4 |
| 276 | 275 | 10.6 | 0.4 | 0.0 | 8.5 |
| 277 | 1540 | 6.2 | 1.2 | 0.0 | 8.6 |
| 278 | 44.8 | 44.4 | 0.7 | 0.1 | 8.8 |
| 279 | 399 | 3.1 | 2.3 | 0.7 | 6.9 |
| 280 | 1.13 | 38.0 | 2.3 | 0.0 | 7.0 |
| 281 | 45.8 | 10.4 | 2.7 | 0.0 | 6.9 |
| 282 | 28.7 | 6.5 | 0.5 | 0.0 | 6.5 |
| 283 | 5.01 | 25.9 | 3.7 | 2.3 | 2.7 |
| 284 | 2.22 | 35.4 | 0.6 | 0.0 | 2.7 |
| 285 | 3.29 | 24.0 | 0.1 | 0.0 | 3.8 |
| 286 | 1.45 | 20.3 | 3.8 | 0.0 | 3.9 |
| 287 | 5.1 | 13.5 | 0.3 | 0.0 | 3.9 |
| 288 | 1250 | 2.6 | 5.3 | 2.3 | 4.0 |
| 289 | 6.15 | 42.6 | 0.5 | 0.0 | 4.0 |
| 290 | 25.8 | 9.2 | 0.7 | 0.0 | 4.0 |
| 291 | 15.4 | 14.0 | 0.1 | 0.0 | 4.2 |
| 292 | 128 | 4.7 | 1.7 | 0.8 | 4.2 |
| 293 | 65.8 | 6.8 | 1.9 | 0.2 | 1.0 |
| 294 | 0.26 | 53.2 | 0.0 | 0.0 | 1.0 |
| 295 | 6.61 | 26.6 | 0.3 | 0.0 | 1.0 |
| 296 | 1.56 | 55.6 | 0.1 | 0.0 | 1.0 |
| 297 | 110 | 5.6 | 5.7 | 2.4 | 1.0 |
| 298 | 74.5 | 27.7 | 1.2 | 0.0 | 1.0 |
| 299 | 164 | 4.8 | 5.0 | 1.2 | 1.0 |
| 300 | 25.2 | 24.8 | 1.1 | 0.0 | 1.0 |
| 301 | 48.3 | 18.1 | 0.8 | 0.0 | 1.0 |
| 302 | 0.33 | 54.2 | 0.0 | 0.0 | 1.1 |
| 303 | 9.78 | 23.4 | 0.4 | 0.0 | 1.1 |
| 304 | 54.0 | 14.6 | 1.0 | 0.0 | 1.1 |
| 305 | 4.04 | 47.4 | 0.5 | 0.0 | 1.1 |
| 306 | 200 | 6.3 | 1.8 | 0.0 | 1.1 |
| 307 | 63.2 | 15.9 | 0.8 | 0.0 | 1.3 |
| 308 | 100 | 6.1 | 2.0 | 0.0 | 1.4 |
| 309 | 1.03 | 31.6 | 0.0 | 0.0 | 1.0 |
| 310 | 2.16 | 49.5 | 0.9 | 0.0 | 1.2 |
| 311 | 475 | 5.5 | 1.3 | 0.0 | 1.3 |
| 312 | 0.31 | 122 | 0.0 | 0.0 | 1.2 |
| 313 | 57.3 | 6.5 | 2.6 | 0.0 | 2.1 |
| 314 | 2.52 | 24.1 | 1.0 | 0.0 | 1.7 |
| 315 | 0.2 | 105 | 0.0 | 0.0 | 1.7 |

Table 2.--Basin characteristics for streamflow gaging stations.

[$mi^2$, square miles; ft/mi, feet per mile; in., inches; in./yr, inches per year]

| Site number (figure 1) | Drainage area | Main-channel slope | Storage (percentage of drainage area) | Lake (percentage of drainage area) | Mean annual runoff (in./yr) |
|---|---|---|---|---|---|
| 316 | 419 | 4.1 | 1.7 | 0.0 | 1.8 |
| 317 | 0.22 | 94.3 | 0.0 | 0.0 | 1.8 |
| 318 | 0.15 | 65.2 | 0.0 | 0.0 | 2.5 |
| 319 | 2.13 | 30.8 | 1.5 | 0.0 | 2.7 |
| 320 | 790 | 4.0 | 1.5 | 0.0 | 2.0 |
| 321 | 89.2 | 6.9 | 0.7 | 0.1 | 3.3 |
| 322 | 267 | 4.8 | 0.4 | 0.0 | 2.8 |
| 323 | 180 | 4.4 | 0.4 | 0.0 | 2.3 |
| 324 | 15.6 | 6.5 | 2.6 | 0.0 | 3.7 |
| 325 | 7.63 | 5.4 | 0.1 | 0.0 | 3.8 |
| 326 | 2.67 | 13.9 | 0.8 | 0.0 | 3.7 |
| 327 | 40.5 | 5.8 | 1.3 | 0.0 | 3.8 |
| 328 | 22.4 | 8.2 | 0.0 | 0.0 | 4.0 |

```
This program computes estimates of 2-, 5-, 10-, 25-, 50-, and 100-year peak
flows for ungaged sites in Minnesota based on either a Regional Regression
Equation (RRE) method or a Region Of Influence (ROI) method. (see the report
"Techniques for Estimating Peak Flow on Small Streams in Minnesota" by Loren
Carlson, and Sanocki, USGS Water Resources Investigations Report 97-___).
             * No warranty, expressed or implied, is made by the
             * USGS as to the accuracy and functioning of this
             * program and related program material.

  ENTER name of output file
output
  Use regional regression equations (RRE)
  or region of influence method? (ROI)
rre
  ENTER site id
Judicial Ditch 11
  ENTER region where site is located:
A    B    C    D    E    F
d
  ENTER basin characteristics for site
 Drainage area (sq. mi.)
15.0
 Main-channel slope (ft./mi.)
2.6
 Lakes percent area  + 1
1.0

 Flood frequency estimates for
 Judicial Ditch 11
 Region D
 RECURR.  PEAK FLOW       SEP(%)    EQ. YRS.       90% PRED. INTERVAL
 INTERVAL     (cfs)
     2         95.          52.        3.16          42.        212.
     5        191.          46.        5.18          92.        397.
    10        271.          47.        6.78         129.        570.
    25        389.          50.        8.38         177.        855.
    50        487.          54.        9.20         212.       1120.
   100        593.          57.        9.75         245.       1430.
  Do you want to perform another analysis (y or n)?
y
  Use regional regression equations (RRE)
  or region of influence method? (ROI)
roi
  ENTER indentifer for ungaged site
Judicial Ditch 11
  ENTER basin characteristics for site
 Drainage area (sq. mi.)
15.0
 Main-channel slope (ft./mi.)
2.6
 Storage percent + 1
1.0
 Lakes percent area  + 1
1.0
 Generalized runoff
```

```
4.0
 Enter option for selecting stations
 List of gaging stations (G)
 Proximity criterion (P)
 Similarity criterion (S)
P
 Enter the latitude of the site (ddmmss)
444122
 Enter the longitude of the site (dddmmss)
0943710


 Flood frequency estimates for
 Judicial Ditch 11
 RECURR.  PEAK FLOW      SEP(%)      EQ. YRS.     90% PRED. INTERVAL
 INTERVAL   (cfs)
  2-year       128.          46.        3.42          60.         270.
  5-year       230.          43.        5.28         114.         464.
 10-year       311.          44.        6.99         153.         630.
 25-year       424.          45.        9.05         204.         884.
 50-year       516.          47.       10.33         241.        1100.
100-year       612.          49.       11.35         277.        1350.
  Do you want to perform another analysis (y or n)?
y
  Use regional regression equations (RRE)
  or region of influence method? (ROI)
roi
  ENTER indentifer for ungaged site
Judicial Ditch 11
  ENTER basin characteristics for site
 Drainage area (sq. mi.)
15.0
 Main-channel slope (ft./mi.)
2.6
 Storage percent + 1
1.0
 Lakes percent area  + 1
1.0
 Generalized runoff
1.0
 Enter option for selecting stations
 List of gaging stations (G)
 Proximity criterion (P)
 Similarity criterion (S)
s

 Flood frequency estimates for
 Judicial Ditch 11
 RECURR.  PEAK FLOW      SEP(%)      EQ. YRS.     90% PRED. INTERVAL
 INTERVAL   (cfs)
  2-year       118.          68.        2.15          41.         335.
  5-year       362.          46.        5.89         174.         756.
 10-year       544.          43.        8.87         272.        1090.
 25-year       824.          45.       11.29         399.        1700.
 50-year      1070.          49.       11.81         487.        2350.
```

```
100-year       1340.          54.       11.70         567.       3180.
     The results above are based on an inconsistent
     set of independent variables.  The estimates
     will be redone using the same independent
     variables for each regression.


 Flood frequency estimates for
 Judicial Ditch 11
 RECURR.  PEAK FLOW       SEP(%)      EQ. YRS.     90% PRED. INTERVAL
 INTERVAL   (cfs)
  2-year        161.          61.        2.58          62.        419.
  5-year        362.          46.        5.89         174.        756.
 10-year        544.          43.        8.87         272.       1090.
 25-year        824.          45.       11.29         399.       1700.
 50-year       1070.          49.       11.81         487.       2350.
100-year       1340.          54.       11.70         567.       3180.
```
*Do you want to perform another analysis (y or n)?*

**n**

REGION OF INFLUENCE ANALYSIS OF PEAK FLOW DATA FOR SITE Judicial Ditch 11

Basin characteristic data:

| | |
|---|---|
| Drainage area (sq. mi.) | 15.00000 |
| Main channel slope (ft./mi.) | 2.600000 |
| Storage percent + 1 | 1.000000 |
| Lakes percent area + 1 | 1.000000 |
| Generalized runoff(in./yr) | 4.000000 |

STEP 1 regression coefficients:

| Variable | Coefficient | Standard error | T for H0:beta=0 | Prob>\|T\| |
|---|---|---|---|---|
| Constant | 0.61422 | 0.38234 | 1.60648 | |
| log(DA) | 0.75374 | 0.04108 | 18.34867 | 0.0001 |
| log(SL) | 0.42451 | 0.11144 | 3.80943 | 0.0006 |
| log(ST) | -0.26657 | 0.11679 | -2.28255 | 0.0297 |
| log(LK) | -0.04523 | 0.17081 | -0.26482 | 0.7930 |
| log(RO) | 0.73404 | 0.56706 | 1.29446 | 0.2054 |

Deleting variable: log(LK) , T-score less than 1.7.

STEP 2 regression coefficients:

| Variable | Coefficient | Standard error | T for H0:beta=0 | Prob>\|T\| |
|---|---|---|---|---|
| Constant | 0.59563 | 0.37027 | 1.60865 | |
| log(DA) | 0.75285 | 0.04045 | 18.61240 | 0.0001 |
| log(SL) | 0.42856 | 0.10836 | 3.95498 | 0.0004 |
| log(ST) | -0.28958 | 0.07753 | -3.73509 | 0.0008 |
| log(RO) | 0.76109 | 0.55065 | 1.38217 | 0.1768 |

Deleting variable: log(RO) , T-score less than 1.7.

Final regression statistics for Judicial Ditch 11

2-year peak

Regression coefficients:

| Variable | Coefficient | Standard error | T for H0:beta=0 | Prob>\|T\| |
|---|---|---|---|---|
| Constant | 1.04533 | 0.17730 | 5.89592 | |
| log(DA) | 0.74722 | 0.04074 | 18.33976 | 0.0001 |
| log(SL) | 0.43872 | 0.10960 | 4.00301 | 0.0003 |
| log(ST) | -0.25140 | 0.07342 | -3.42397 | 0.0017 |

Residuals and influence statistics for the log10 transformed data:

| Station ID | Observed peak | Predicted peak | Studentized residual | Leverage | Cook’sD |
|---|---|---|---|---|---|
| 05278850 | 1.53403 | 1.69661 | -1.03862 | 0.15572 | 0.06969 |
| 05278500 | 2.52994 | 2.69222 | -0.94780 | 0.08219 | 0.02545 |
| 05316700 | 2.31366 | 2.36756 | -0.37244 | 0.25178 | 0.01454 |
| 05316690 | 1.59107 | 1.89450 | -1.91156 | 0.14998 | 0.23161 |
| 05326100 | 2.73679 | 2.62171 | 0.68460 | 0.12760 | 0.02276 |
| 05316570 | 2.85588 | 2.92385 | -0.40408 | 0.07536 | 0.00545 |
| 05316550 | 1.86747 | 1.80286 | 0.39272 | 0.10462 | 0.00676 |
| 05278930 | 3.08167 | 2.87110 | 1.17193 | 0.04970 | 0.03252 |

| | | | | | |
|---|---|---|---|---|---|
| 05317000 | 3.50949 | 3.56785 | -0.37756 | 0.12369 | 0.00635 |
| 05313800 | 1.50786 | 1.50831 | -0.00263 | 0.13656 | 0.00000 |
| 05316500 | 3.07159 | 3.36391 | -1.86984 | 0.10661 | 0.13194 |
| 05278750 | 1.45788 | 1.48492 | -0.16629 | 0.08584 | 0.00111 |
| 05278700 | 2.05231 | 2.08270 | -0.18783 | 0.09886 | 0.00152 |
| 05317200 | 2.70552 | 2.93639 | -1.33240 | 0.03139 | 0.03419 |
| 05327000 | 2.97123 | 2.88720 | 0.48727 | 0.03127 | 0.00464 |
| 05278120 | 3.23216 | 3.10417 | 0.69726 | 0.07755 | 0.01482 |
| 05279000 | 3.33116 | 3.17161 | 1.00557 | 0.09114 | 0.03377 |
| 05316950 | 3.45797 | 3.44627 | 0.07015 | 0.08889 | 0.00018 |
| 05278350 | 1.70501 | 1.68274 | 0.14215 | 0.17099 | 0.00141 |
| 05278000 | 2.30685 | 2.56704 | -1.65283 | 0.12732 | 0.13179 |
| 05325100 | 1.82607 | 1.59528 | 1.22965 | 0.23058 | 0.13022 |
| 05316920 | 1.44871 | 1.44281 | 0.03694 | 0.14487 | 0.00008 |
| 05314500 | 3.18301 | 2.86495 | 1.84783 | 0.05440 | 0.07802 |
| 05313500 | 3.15616 | 3.42916 | -1.76749 | 0.13407 | 0.14438 |
| 05272950 | 2.47129 | 2.59120 | -0.66121 | 0.10833 | 0.01632 |
| 05320000 | 3.79260 | 3.59834 | 1.26334 | 0.13533 | 0.07568 |
| 05276200 | 2.89840 | 2.80096 | 0.57833 | 0.07145 | 0.01011 |
| 05276000 | 2.91180 | 2.74267 | 0.91056 | 0.07334 | 0.01983 |
| 05316900 | 2.12385 | 2.15309 | -0.18230 | 0.13674 | 0.00182 |
| 05319500 | 3.43889 | 3.39870 | 0.24245 | 0.07650 | 0.00180 |
| 05276100 | 1.28103 | 1.29184 | -0.07052 | 0.20479 | 0.00041 |
| 05320500 | 3.62262 | 3.40783 | 1.34446 | 0.08127 | 0.05638 |
| 05319490 | 3.51574 | 3.40371 | 0.43945 | 0.03766 | 0.00253 |
| 05330600 | 1.67210 | 1.85768 | -1.11415 | 0.06887 | 0.04062 |
| 05320200 | 1.28556 | 1.01541 | 1.80840 | 0.23682 | 0.32477 |
| 05330550 | 2.21352 | 2.29238 | -0.46507 | 0.03791 | 0.00456 |

Mean sampling error variance: 0.0048
Mean model error variance: 0.0263

For Judicial Ditch 11
2-year peak

| Predicted flow (cfs) | Std. Err. prediction (percent) | Equivalent years | 90% Prediction interval (cfs) | |
|---|---|---|---|---|
| 128. | 46. | 3.42 | 60. | 270. |

*************************************************************************